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Governor

Alabama Department of Environmental Management
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AUG 0 6 2025

MR DANIEL KOMM
SITE VICE PRESIDENT
TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT
POST OFFICE BOX 2000 NAB 2A
DECATUR ALABAMA 35609

RE: DRAFT PERMIT
NPDES PERMIT NUMBER AL0022080

Dear Mr. Komm:

Transmitted herein is a draft of the referenced permit.

We would appreciate your comments on the permit within **30 days** of the date of this letter. Please direct any comments of a technical or administrative nature to the undersigned.

By copy of this letter and the draft permit, we are also requesting comments within the same time frame from EPA.

Our records indicate that you have utilized the Department's web-based electronic environmental (E2) reporting system for submittal of discharge monitoring reports (DMRs). The Department transitioned from the E2 Reporting System to the Alabama Environmental Permitting and Compliance System (AEPACS) for the submittal of DMRs on November 15, 2021. AEPACS is an electronic system that allows facilities to apply for and maintain permits as well as submit other required applications, registrations, and certifications. In addition, the system allows facilities to submit required compliance reports or other information to the Department. The Department has used the E2 User account information to set up a similar User Profile in AEPACS based on the following criteria:

1. The user has logged in to E2 since October 1, 2019; and
2. The E2 user account is set up using a unique email address.

E2 users that met the above criteria will only need to establish an ADEM Web Portal account (https://prd.adem.alabama.gov/awp) under the same email address as their E2 account to have the same permissions in AEPACS as they did in E2. They will also automatically be linked to the same facilities they were in E2.

The Alabama Department of Environmental Management encourages you to voluntarily consider pollution prevention practices and alternatives at your facility. Pollution Prevention may assist you in complying with effluent limitations, and possibly reduce or eliminate monitoring requirements.

If you have questions regarding this permit or monitoring requirements, please contact Theo Pinson by e-mail at **tpinson@adem.alabama.gov** or by phone at **(334) 274-4202.**

Sincerely,

Scott Jackson, Chief
Industrial Section
Industrial/Municipal Branch
Water Division

Enclosure: Draft Permit

pc via website: Montgomery Field Office
EPA Region IV
U.S. Fish & Wildlife Service
AL Historical Commission
Advisory Council on Historic Preservation
Department of Conservation and Natural Resources

Birmingham Office
110 Vulcan Road
Birmingham, AL 35209-4702
(205) 942-6168
(205) 941-1603 (FAX)

Decatur Office
2715 Sandlin Road, S.W.
Decatur, AL 35603-1333
(256) 353-1713
(256) 340-9359 (FAX)

Coastal Office
1615 South Broad Street
Mobile, AL 36605
(251) 450-3400
(251) 479-2593 (FAX)

ADEM
Alabama Department of Environmental Management

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT

PERMITTEE: TENNESSEE VALLEY AUTHORITY

FACILITY LOCATION: TVA BROWNS FERRY NUCLEAR PLANT
10835 SHAW ROAD
ATHENS, ALABAMA 35611
LIMESTONE COUNTY

PERMIT NUMBER: AL0022080

RECEIVING WATERS:
001 - TENNESSEE RIVER (WHEELER LAKE)
005 - TENNESSEE RIVER (WHEELER LAKE)
012 - TENNESSEE RIVER (WHEELER LAKE)
013 - TENNESSEE RIVER (WHEELER LAKE)
013 - TENNESSEE RIVER (WHEELER LAKE)
017 - TENNESSEE RIVER (WHEELER LAKE)
018 - TENNESSEE RIVER (WHEELER LAKE)
019 - TENNESSEE RIVER (WHEELER LAKE)
024 - UNNAMED TRIBUTARY TO THE TENNESSEE RIVER (WHEELER LAKE)

In accordance with and subject to the provisions of the Federal Water Pollution Control Act, as amended, 33 U.S.C. §§1251-1388 (the "FWPCA"), the Alabama Water Pollution Control Act, as amended, Code of Alabama 1975, §§ 22-22-1 to 22-22-14 (the "AWPCA"), the Alabama Environmental Management Act, as amended, Code of Alabama 1975, §§22-22A-1 to 22-22A-17, and rules and regulations adopted thereunder, and subject further to the terms and conditions set forth in this permit, the Permittee is hereby authorized to discharge into the above-named receiving waters.

ISSUANCE DATE:

EFFECTIVE DATE:

EXPIRATION DATE:

DRAFT

Alabama Department of Environmental Management

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PART I: DISCHARGE LIMITATIONS, CONDITIONS, AND REQUIREMENTS

A. DISCHARGE LIMITATIONS AND MONITORING REQUIREMENTS

DSN0011: The diffuser discharge including discharges from the condenser cooling water system, raw water cooling system, fire protection system, turbine building sumps, reactor building cooling water, and Internal Outfall DSN 01B which includes discharges associated with the liquid radwaste system including low volume wastes

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the Permittee is authorized to discharge from the outfall(s) listed above and described more fully in the Permittee's application. Such discharges shall be limited and monitored by the Permittee as specified below: 3/ 10/

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency[2]	Sample Type[1]	Seasonal
Temperature, Water Deg. Fahrenheit (00011) Downstream Monitoring 4/ 7/ 9/ 12/	*****	*****	*****	*****	90 7 Day Average	93 Maximum Daily	deg F	Continuous 6/	Recorder	All Months
Temperature, Water Deg. Fahrenheit (00011) Effluent Gross Value 4/ 7/	*****	*****	*****	*****	(Report) Daily Average	(Report) Maximum Daily	deg F	Continuous 6/	Recorder	All Months
Temperature, Water Deg. Fahrenheit (00011) Upstream Monitoring 4/ 9/	*****	*****	*****	*****	(Report) Daily Average	*****	deg F	Continuous 6/	Recorder	All Months
pH (00400) Effluent Gross Value 11/	*****	*****	*****	6.0 Minimum Daily	*****	8.5 Maximum Daily	S.U.	Weekly	Grab	All Months
Phosphorus, Total (As P) (00665) Effluent Gross Value	*****	(Report) Maximum Daily	lbs/day	*****	*****	(Report) Maximum Daily	mg/l	Monthly	Grab	All Months
Temp Diff Between Up/Down Stream Deg F (03772) Effluent Gross Value 4/ 7/ 8/	*****	*****	*****	*****	10 Daily Average	(Report) Maximum Daily	deg F	Continuous 6/	Recorder	All Months
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	(Report) Monthly Average	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Daily	Pump Log 5/	All Months

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ See Part IV.F. for Upstream and Downstream Temperature Monitoring Requirements.

5/ Pump logs shall be used to determine the daily flow. The method should be calibrated annually by diffuser head measurement and/or other independent flow measurement methods.

6/ "Continuous" as it applies to temperature shall mean a minimum of one recorded measurement taken at least every 15 minutes.

7/ "Maximum Daily" as it applies to temperature shall mean the maximum rolling 1-hour average calculated on a calendar day basis during the monitoring period. See Part IV.F. for Upstream and Downstream Temperature Monitoring Requirements.

8/ The values reported for "Temp Diff Between Up/Down Stream (Deg F)" shall be determined by subtracting the calculated upstream 24-hour calendar day average temperature from the calculated downstream 24-hour calendar day average temperature. See Part IV.F. for Upstream and Downstream Temperature Monitoring Requirements.

9/ When the upstream temperature exceeds 90°F, the downstream temperature may equal but not exceed the upstream temperature.

10/ A "Cooling Anomaly" exists when weather or other events cause cooling of the upstream temperature at a rate of greater than 0.5°F per day based on a 6-hour trend. During a "Cooling Anomaly" the requirements of DSN0012 shall become applicable for that 24-hour calendar day in lieu of the DSN0011 requirements. The calculation of the upstream, downstream, and effluent temperature in addition to the parameter "Temp Diff Between Up/Down Stream (Deg F)" for DSN0011 shall exclude data collected during a "Cooling Anomaly" as this will be reported on DSN0012.

11/ The pH shall not be less than 6.0 S.U. nor greater than 8.5 S.U. unless ambient river conditions prevent compliance within that range. Upstream monitoring by the permittee within one hour of a non-complying effluent pH value shall serve to demonstrate that the ambient river conditions are preventing compliance.

12/ 7 Day Average as it applies to temperature shall mean a rolling arithmetic mean of all continuous temperature measurements collected over a consecutive rolling 7-day (168 hour) period. The rolling 7 Day Average shall be calculated every 15 minutes using data collected during the preceding 672 15-minute intervals where the oldest data point falls off as new data is collected. The Permittee shall report the maximum 7-Day Average calculated during the monitoring period on the DMR. The calculated 7 Day Average values shall be reported for the monitoring period in which the most recent data point used in the calculation occurs.

DSN0012: Cooling Anomaly Permit Tier – The diffuser discharge including discharges from the condenser cooling water system, raw water cooling system, fire protection system, turbine building sumps, reactor building cooling water, and Internal Outfall DSN 01B which includes discharges associated with the liquid radwaste system including low volume wastes

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the Permittee is authorized to discharge from the outfall(s) listed above and described more fully in the Permittee's application. Such discharges shall be limited and monitored by the Permittee as specified below: 3/ 10/ 13/

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency[2]	Sample Type[1]	Seasonal
Temperature, Water Deg. Fahrenheit (00011) Downstream Monitoring 4/ 7/ 9/ 12/	*****	*****	*****	*****	90 7 Day Average	93 Maximum Daily	deg F	Continuous 6/	Recorder	All Months
Temperature, Water Deg. Fahrenheit (00011) Effluent Gross Value 4/ 7/	*****	*****	*****	*****	(Report) Daily Average	(Report) Maximum Daily	deg F	Continuous 6/	Recorder	All Months
Temperature, Water Deg. Fahrenheit (00011) Upstream Monitoring 4/ 9/	*****	*****	*****	*****	(Report) Daily Average	*****	deg F	Continuous 6/	Recorder	All Months
pH (00400) Effluent Gross Value 11/	*****	*****	*****	6.0 Minimum Daily	*****	8.5 Maximum Daily	S.U.	Weekly	Grab	All Months
Phosphorus, Total (As P) (00665) Effluent Gross Value	*****	(Report) Maximum Daily	lbs/day	*****	*****	(Report) Maximum Daily	mg/l	Monthly	Grab	All Months
Temp Diff Between Up/Down Stream Deg F (03772) Effluent Gross Value 4/ 7/ 8/	*****	*****	*****	*****	(Report) Daily Average	(Report) Maximum Daily	deg F	Continuous 6/	Recorder	All Months
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	(Report) Monthly Average	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Daily	Pump Log 5/	All Months

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ See Part IV.F. for Upstream and Downstream Temperature Monitoring Requirements.

5/ Pump logs shall be used to determine the daily flow. The method should be calibrated annually by diffuser head measurement and/or other independent flow measurement methods.

6/ "Continuous" as it applies to temperature shall mean a minimum of one recorded measurement taken at least every 15 minutes.

7/ "Maximum Daily" as it applies to temperature shall mean the maximum rolling 1-hour average calculated on a calendar day basis during the monitoring period. See Part IV.F. for Upstream and Downstream Temperature Monitoring Requirements.

8/ The values reported for "Temp Diff Between Up/Down Stream (Deg F)" shall be determined by subtracting the calculated upstream temperature from the calculated downstream temperature. See Part IV.F. for Upstream and Downstream Temperature Monitoring Requirements.

9/ When the upstream temperature exceeds 90°F, the downstream temperature may equal but not exceed the upstream temperature.

10/ A "Cooling Anomaly" exists when weather or other events cause cooling of the upstream temperature at a rate of greater than 0.5°F per day based on a 6-hour trend. During a "Cooling Anomaly" the requirements of DSN0012 shall become applicable for that 24-hour calendar day in lieu of the DSN0011 requirements. The calculation of the upstream, downstream, and effluent temperature in addition to the parameter "Temp Diff Between Up/Down Stream (Deg F)" for DSN0011 shall exclude data collected during a "Cooling Anomaly" as this will be reported on DSN0012.

11/ The pH shall not be less than 6.0 S.U. nor greater than 8.5 S.U. unless ambient river conditions prevent compliance within that range. Upstream monitoring by the permittee within one hour of a non-complying effluent pH value shall serve to demonstrate that the ambient river conditions are preventing compliance.

12/ 7 Day Average as it applies to temperature shall mean a rolling arithmetic mean of all continuous temperature measurements collected over a consecutive rolling 7-day (168 hour) period. The rolling 7 Day Average shall be calculated every 15 minutes using data collected during the preceding 672 15-minute intervals where the oldest data point falls off as new data is collected. The Permittee shall report the maximum 7-Day Average calculated during the monitoring period on the DMR. The calculated 7 Day Average values shall be reported for the monitoring period in which the most recent data point used in the calculation occurs.

13/ If a "Cooling Anomaly" as defined by footnote 10/ does not occur during the monitoring period, *9 should be reported on the eDMR to indicate the no data indicator (NODI) Code for "Conditional Monitoring – Not Required This Period".

DSN001Q: The diffuser discharge including discharges from the condenser cooling water system, raw water cooling system, fire protection system, turbine building sumps, reactor building cooling water, and Internal Outfall DSN 01B which includes discharges associated with the liquid radwaste system including low volume wastes 3/

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the Permittee is authorized to discharge from the outfall(s) listed above and described more fully in the Permittee's application. Such discharges shall be limited and monitored by the Permittee as specified below:

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency[2]	Sample Type[1]	Seasonal
Chlorine, Total Residual (50060) Effluent Gross Value 4/ 5/	*****	*****	*****	*****	0.024 Monthly Average	0.031 Maximum Daily	mg/l	Quarterly	Grab	All Months

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ Total residual chlorine (TRC) and free available chlorine (FAC) may not be discharged from any single generating unit for more than 2 hours per day unless the permittee demonstrates (with records retained on-site) to the Department that discharge for more than 2 hours is required for macro invertebrate control.

5/ A measurement of Total Residual Chlorine below 0.05 mg/L shall be considered in compliance with the permit limitations and should be reported as NODI=B or *B on the discharge monitoring report.

DSN001T: The diffuser discharge including discharges from the condenser cooling water system, raw water cooling system, fire protection system, turbine building sumps, reactor building cooling water, and Internal Outfall DSN 01B which includes discharges associated with the liquid radwaste system including low volume wastes 3/ 4/

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the Permittee is authorized to discharge from the outfall(s) listed above and described more fully in the Permittee's application. Such discharges shall be limited and monitored by the Permittee as specified below:

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency[2]	Sample Type[1]	Seasonal
Toxicity, Ceriodaphnia Chronic (61426) Effluent Gross Value	*****	0 Maximum Daily	pass=0;fail=1	*****	*****	*****	*****	Annually	24-Hr Composite	All Months
Toxicity, Pimephales Chronic (61428) Effluent Gross Value	*****	0 Maximum Daily	pass=0;fail=1	*****	*****	*****	*****	Annually	24-Hr Composite	All Months

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ See Part IV.C for Effluent Toxicity Limitations and Biomonitoring Requirements.

DSN001Y: The diffuser discharge including discharges from the condenser cooling water system, raw water cooling system, fire protection system, turbine building sumps, reactor building cooling water, and Internal Outfall DSN 01B which includes discharges associated with the liquid radwaste system including low volume wastes 3/

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the Permittee is authorized to discharge from the outfall(s) listed above and described more fully in the Permittee's application. Such discharges shall be limited and monitored by the Permittee as specified below:

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency[2]	Sample Type[1]	Seasonal
Annual Certification Statement (51930) 4/ Effluent Gross Value	*****	*****	*****	*****	*****	0 Maximum Daily	Yes=0;No=1	Annually	See Permit Requirements	All Months

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ By reporting 0 which equals Yes, the Permittee certifies that the facility has operated and maintained the cooling water intake structure and cooling water heat dissipation system in a manner that minimizes impingement, entrainment, and adverse environmental impacts.

DSN01B1: Internal Outfall for discharges associated with the Liquid Radwaste System including low volume wastes 3/

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the Permittee is authorized to discharge from the outfall(s) listed above and described more fully in the Permittee's application. Such discharges shall be limited and monitored by the Permittee as specified below:

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency[2]	Sample Type[1]	Seasonal
pH (00400) Effluent Gross Value	*****	*****	*****	6.0 Minimum Daily	*****	9.0 Maximum Daily	S.U.	Monthly	Grab	All Months
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	30.0 Monthly Average	100.0 Maximum Daily	mg/l	Monthly	Grab	All Months
Oil & Grease (00556) Effluent Gross Value	*****	*****	*****	*****	15.0 Monthly Average	20.0 Maximum Daily	mg/l	Monthly	Grab	All Months
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	*****	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Monthly	Estimate	All Months

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

DSN0051: Discharges associated with the Residual Heat Removal Service Water System 3/

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the Permittee is authorized to discharge from the outfall(s) listed above and described more fully in the Permittee's application. Such discharges shall be limited and monitored by the Permittee as specified below:

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency[2]	Sample Type[1]	Seasonal
Temperature, Water Deg. Fahrenheit (00011) Effluent Gross Value	*****	*****	*****	*****	(Report) Monthly Average	(Report) Maximum Daily	deg F	2X Monthly 4/	Grab	All Months
pH (00400) Effluent Gross Value	*****	*****	*****	6.0 Minimum Daily	*****	8.5 Maximum Daily	S.U.	2X Monthly 4/	Grab	All Months
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	(Report) Monthly Average	*****	MGD	*****	*****	*****	*****	2X Monthly 4/	Estimate	All Months

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ 2X Monthly monitoring shall be conducted so that two samples are collected in the same month at least 10 days apart.

DSN012: Discharges associated with the intake screen backwash system and emergency equipment cooling waters 1/

DSN014: Stormwater runoff from the north perimeter of the site generally not associated with industrial activity including run on from surrounding agricultural areas 1/

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the Permittee is authorized to discharge from the outfall(s) listed above and described more fully in the Permittee's application. Such discharges shall be limited and monitored by the Permittee as specified below:

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

DSN013Y: Stormwater runoff associated with electric power generation including runoff from administrative buildings, parking lots, drainage areas around the sedimentation ponds, grassy areas of the plant yard, and

Internal Outfall DSN 13A which includes stormwater discharges associated with electric power generation including runoff from the 4 kV operator yard, the main plant transformer yard, the switchyard, parking lots, grassy areas of the plant yard and also including discharges from the wastewater lagoon system which includes treated sanitary wastewaters, photo development wastewaters, metal processing lab wastewaters, medical lab wastewaters, chiller blowdown, stand-by liquid control system waters, cooler/air compressor cleaning waters, filtered asbestos abatement wastewaters, and stormwater runoff,

Internal Outfall DSN 13B which includes low volume wastewater discharges from the sedimentation pond including the intake building sumps, diesel generator sumps, DI water filter backwash, DI water filtration system wastewaters, miscellaneous low volume wastes, and stormwater runoff associated with electric power generation, and

Internal Outfall DSN 13C which includes discharges from the wastewater lagoon system which consists of treated sanitary wastewaters, photo development wastewaters, metal processing lab wastewaters, medical lab wastewaters, chiller blowdown, stand-by liquid control system waters, cooler/air compressor cleaning waters, filtered asbestos abatement wastewaters, and stormwater runoff associated with electric power generation including runoff from the 4 kV operator yard, the main plant transformer yard, the switchyard, parking lots, grassy areas of the plant yard

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the Permittee is authorized to discharge from the outfall(s) listed above and described more fully in the Permittee's application. Such discharges shall be limited and monitored by the Permittee as specified below: 3/

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency[2]	Sample Type[1]	Seasonal
pH (00400) Effluent Gross Value	*****	*****	*****	(Report) Minimum Daily	*****	(Report) Maximum Daily	S.U.	Annually	Grab	All Months
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	mg/l	Annually	Grab	All Months
Oil & Grease (00556) Effluent Gross Value	*****	*****	*****	*****	*****	15.0 Maximum Daily	mg/l	Annually	Grab	All Months
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	*****	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Annually	Estimate	All Months

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ See Part IV.B for Stormwater Measurement and Sampling Requirements.

5/ Monitoring for DSN013Y is to be conducted at the culvert discharging into the Outfall 013 conveyance located to the south of the sedimentation ponds and west of the nearby plant road going to the training center.

DSN13AY: Internal Outfall to monitor stormwater discharges associated with electric power generation including runoff from the 4 kV operator yard, the main plant transformer yard, the switchyard, parking lots, grassy areas of the plant yard and also including discharges from the wastewater lagoon system which includes treated sanitary wastewaters, photo development wastewaters, metal processing lab wastewaters, medical lab wastewaters, chiller blowdown, stand-by liquid control system waters, cooler/air compressor cleaning waters, filtered asbestos abatement wastewaters, and stormwater runoff 3/ 4/ 5/

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the Permittee is authorized to discharge from the outfall(s) listed above and described more fully in the Permittee's application. Such discharges shall be limited and monitored by the Permittee as specified below:

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency[2]	Sample Type[1]	Seasonal
pH (00400) Effluent Gross Value	*****	*****	*****	(Report) Minimum Daily	*****	(Report) Maximum Daily	S.U.	Annually	Grab	All Months
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	mg/l	Annually	Grab	All Months
Oil & Grease (00556) Effluent Gross Value	*****	*****	*****	*****	*****	15.0 Maximum Daily	mg/l	Annually	Grab	All Months
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	*****	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Annually	Estimate	All Months

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ See Part IV.B for Stormwater Measurement and Sampling Requirements.

5/ Monitoring for the DSN13AY requirements shall be performed during a qualifying storm event.

DSN13B1: Internal Outfall to monitor low volume wastewater discharges from the sedimentation pond including the intake building sumps, diesel generator sumps, DI water filter backwash, DI water filtration system wastewaters, miscellaneous low volume wastes, and stormwater runoff associated with electric power generation 3/

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the Permittee is authorized to discharge from the outfall(s) listed above and described more fully in the Permittee's application. Such discharges shall be limited and monitored by the Permittee as specified below:

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency[2]	Sample Type[1]	Seasonal
pH (00400) Effluent Gross Value	*****	*****	*****	6.0 Minimum Daily	*****	9.0 Maximum Daily	S.U.	Once per batch	Grab	All Months
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	30.0 Monthly Average	100.0 Maximum Daily	mg/l	Once per batch	Grab	All Months
Oil & Grease (00556) Effluent Gross Value	*****	*****	*****	*****	15.0 Monthly Average	20.0 Maximum Daily	mg/l	Once per batch	Grab	All Months
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	(Report) Monthly Average	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Once per batch	Measured	All Months

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

DSN13C1: Internal Outfall to monitor discharges from the wastewater lagoon system which includes treated sanitary wastewaters, photo development wastewaters, metal processing lab wastewaters, medical lab wastewaters, chiller blowdown, stand-by liquid control system waters, cooler/air compressor cleaning waters, filtered asbestos abatement wastewaters, and stormwater runoff associated with electric power generation including runoff from the 4 kV operator yard, the main plant transformer yard, the switchyard, parking lots, grassy areas of the plant yard 3/ 5/

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the Permittee is authorized to discharge from the outfall(s) listed above and described more fully in the Permittee's application. Such discharges shall be limited and monitored by the Permittee as specified below:

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency[2]	Sample Type[1]	Seasonal
BOD, 5-Day (20 Deg. C) (00310) Effluent Gross Value	*****	*****	*****	*****	30.0 Monthly Average	45.0 Maximum Daily	mg/l	2X Monthly 4/	Grab	All Months
pH (00400) Effluent Gross Value	*****	*****	*****	6.0 Minimum Daily	*****	9.0 Maximum Daily	S.U.	2X Monthly 4/	Grab	All Months
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	90.0 Monthly Average	135.0 Maximum Daily	mg/l	2X Monthly 4/	Grab	All Months
Phosphorus, Total (As P) (00665) Effluent Gross Value	*****	*****	*****	*****	(Report) Monthly Average	(Report) Maximum Daily	mg/l	2X Monthly 4/	Grab	All Months
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	(Report) Monthly Average	(Report) Maximum Daily	MGD	*****	*****	*****	*****	2X Monthly 4/	Instantaneous	All Months

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ 2X Monthly monitoring shall be conducted so that two samples are collected in the same month at least 10 days apart.

5/ The DSN13C monitoring location is the same physical location as DSN13AY. The DSN13C samples shall be collected during dry weather (NOT during a qualifying storm event).

DSN017Y: Fire system test/flush waters and stormwater runoff from administrative building, parking lots, non-industrial areas of the plant property 3/ 4/

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the Permittee is authorized to discharge from the outfall(s) listed above and described more fully in the Permittee's application. Such discharges shall be limited and monitored by the Permittee as specified below:

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency[2]	Sample Type[1]	Seasonal
pH (00400) Effluent Gross Value	*****	*****	*****	(Report) Minimum Daily	*****	(Report) Maximum Daily	S.U.	Annually	Grab	All Months
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	mg/l	Annually	Grab	All Months
Oil & Grease (00556) Effluent Gross Value	*****	*****	*****	*****	*****	15.0 Maximum Daily	mg/l	Annually	Grab	All Months
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	*****	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Annually	Calculated	All Months
Chlorine, Total Residual (50060) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	mg/l	Annually	Grab	All Months

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ Monitoring at DSN017Y is only required if a discharge of fire system flush waters occurs during a non-storm event.

DSN018Y: Stormwater runoff associated with electric power generation including runoff from the Materials and Procurement Complex parking lot, the firing range parking lot, the facilities maintenance area, the vehicle fuel dispensing area, and grassy areas of the plant yard 3/ 4/

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the Permittee is authorized to discharge from the outfall(s) listed above and described more fully in the Permittee's application. Such discharges shall be limited and monitored by the Permittee as specified below:

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency[2]	Sample Type[1]	Seasonal
pH (00400) Effluent Gross Value	*****	*****	*****	(Report) Minimum Daily	*****	(Report) Maximum Daily	S.U.	Annually	Grab	All Months
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	mg/l	Annually	Grab	All Months
Oil & Grease (00556) Effluent Gross Value	*****	*****	*****	*****	*****	15.0 Maximum Daily	mg/l	Annually	Grab	All Months
Toluene (34010) Effluent Gross Value	*****	*****	*****	*****	*****	8723 Maximum Daily	ug/l	Annually	Grab	All Months
Benzene (34030) Effluent Gross Value	*****	*****	*****	*****	*****	15.47 Maximum Daily	ug/l	Annually	Grab	All Months
Ethylbenzene (34371) Effluent Gross Value	*****	*****	*****	*****	*****	1244 Maximum Daily	ug/l	Annually	Grab	All Months
Naphthalene (34696) Effluent Gross Value	*****	*****	*****	*****	*****	600 Maximum Daily	ug/l	Annually	Grab	All Months
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	*****	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Annually	Estimate	All Months
Xylene (81551) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	ug/l	Annually	Grab	All Months

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ See Part IV.B for Stormwater Measurement and Sampling Requirements.

DSN019Y: Stormwater runoff associated with electric power generation including runoff from the borrow pit, the fire training area, the low level radwaste storage facility, the inert landfill, and the 180-day hazardous waste storage area. 3/ 4/

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the Permittee is authorized to discharge from the outfall(s) listed above and described more fully in the Permittee's application. Such discharges shall be limited and monitored by the Permittee as specified below:

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency[2]	Sample Type[1]	Seasonal
pH (00400) Effluent Gross Value	*****	*****	*****	(Report) Minimum Daily	*****	(Report) Maximum Daily	S.U.	Annually	Grab	All Months
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	mg/l	Annually	Grab	All Months
Oil & Grease (00556) Effluent Gross Value	*****	*****	*****	*****	*****	15.0 Maximum Daily	mg/l	Annually	Grab	All Months
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	*****	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Annually	Estimate	All Months
Chemical Oxygen Demand (COD) (81017) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	mg/l	Annually	Grab	All Months

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ See Part IV.B for Stormwater Measurement and Sampling Requirements.

DSN024Y: Stormwater runoff associated with electric power generation including runoff from the northeast and east property perimeter, the vehicle service and mechanic shop, and stormwater run on from adjacent grassland and farmland 3/ 4/

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the Permittee is authorized to discharge from the outfall(s) listed above and described more fully in the Permittee's application. Such discharges shall be limited and monitored by the Permittee as specified below:

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency[2]	Sample Type[1]	Seasonal
pH (00400) Effluent Gross Value	*****	*****	*****	(Report) Minimum Daily	*****	(Report) Maximum Daily	S.U.	Annually	Grab	All Months
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	mg/l	Annually	Grab	All Months
Oil & Grease (00556) Effluent Gross Value	*****	*****	*****	*****	*****	15.0 Maximum Daily	mg/l	Annually	Grab	All Months
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	*****	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Annually	Estimate	All Months

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ See Part IV.B for Stormwater Measurement and Sampling Requirements.

B. Discharge Monitoring and Record Keeping Requirements

1. Representative Sampling

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge and shall be in accordance with the provisions of this permit.

2. Test Procedures

For the purpose of reporting and compliance, permittees shall use one of the following procedures:

a. For parameters with an EPA established Minimum Level (ML), report the measured value if the analytical result is at or above the ML and report "0" for values below the ML. Test procedures for the analysis of pollutants shall conform to 40 CFR Part 136 and guidelines published pursuant to Section 304(h) of the FWPCA, 33 U.S.C. Section 1314(h). If more than one method for analysis of a substance is approved for use, a method having a minimum level lower than the permit limit shall be used. If the minimum level of all methods is higher than the permit limit, the method having the lowest minimum level shall be used and a report of less than the minimum level shall be reported as zero and will constitute compliance; however, should EPA approve a method with a lower minimum level during the term of this permit the permittee shall use the newly approved method.

b. For pollutants parameters without an established ML, an interim ML may be utilized. The interim ML shall be calculated as 3.18 times the Method Detection Level (MDL) calculated pursuant to 40 CFR Part 136, Appendix B.

Permittees may develop an effluent matrix-specific ML, where an effluent matrix prevents attainment of the established ML. However, a matrix specific ML shall be based upon proper laboratory method and technique. Matrix-specific MLs must be approved by the Department, and may be developed by the permittee during permit issuance, reissuance, modification, or during compliance schedule.

In either case the measured value should be reported if the analytical result is at or above the ML and "0" reported for values below the ML.

c. For parameters without an EPA established ML, interim ML, or matrix-specific ML, a report of less than the detection limit shall constitute compliance if the detection limit of all analytical methods is higher than the permit limit using the most sensitive EPA approved method. For the purpose of calculating a monthly average, "0" shall be used for values reported less than the detection limit.

The Minimum Level utilized for procedures A and B above shall be reported on the permittee's DMR. When an EPA approved test procedure for analysis of a pollutant does not exist, the Director shall approve the procedure to be used.

3. Recording of Results

For each measurement or sample taken pursuant to the requirements of this permit, the permittee shall record the following information:

a. The facility name and location, point source number, date, time and exact place of sampling;

b. The name(s) of person(s) who obtained the samples or measurements;

c. The dates and times the analyses were performed;

d. The name(s) of the person(s) who performed the analyses;

e. The analytical techniques or methods used, including source of method and method number; and

f. The results of all required analyses.

4. Records Retention and Production

The permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by the permit, and records of all data used to complete the above reports or the application for this permit, for a period of at least three years from the date of the sample measurement, report or application. This period may be extended by request of the Director at any time. If litigation or other enforcement action, under the AWPCA and/or the FWPCA, is ongoing which involves any of the above records, the records shall be kept until the litigation is resolved. Upon the written request of the Director or his designee, the

permittee shall provide the Director with a copy of any record required to be retained by this paragraph. Copies of these records shall not be submitted unless requested.

All records required to be kept for a period of three years shall be kept at the permitted facility or an alternate location approved by the Department in writing and shall be available for inspection.

5. Monitoring Equipment and Instrumentation

All equipment and instrumentation used to determine compliance with the requirements of this permit shall be installed, maintained, and calibrated in accordance with the manufacturer's instructions or, in the absence of manufacturer's instructions, in accordance with accepted practices. The permittee shall develop and maintain quality assurance procedures to ensure proper operation and maintenance of all equipment and instrumentation. The quality assurance procedures shall include the proper use, maintenance, and installation, when appropriate, of monitoring equipment at the plant site.

C. DISCHARGE REPORTING REQUIREMENTS

1. Reporting of Monitoring Requirements

a. The permittee shall conduct the required monitoring in accordance with the following schedule:

MONITORING REQUIRED MORE FREQUENTLY THAN MONTHLY AND MONTHLY shall be conducted during the first full month following the effective date of coverage under this permit and every month thereafter.

QUARTERLY MONITORING shall be conducted at least once during each calendar quarter. Calendar quarters are the periods of January through March, April through June, July through September, and October through December. The permittee shall conduct the quarterly monitoring during the first complete calendar quarter following the effective date of this permit and is then required to monitor once during each quarter thereafter. Quarterly monitoring may be done anytime during the quarter, unless restricted elsewhere in this permit, but it should be submitted with the last DMR due for the quarter, i.e., (March, June, September and December DMR's).

SEMIANNUAL MONITORING shall be conducted at least once during the period of January through June and at least once during the period of July through December. The permittee shall conduct the semiannual monitoring during the first complete calendar semiannual period following the effective date of this permit and is then required to monitor once during each semiannual period thereafter. Semiannual monitoring may be done anytime during the semiannual period, unless restricted elsewhere in this permit, but it should be submitted with the last DMR for the month of the semiannual period, i.e. (June and December DMR's).

ANNUAL MONITORING shall be conducted at least once during the period of January through December. The permittee shall conduct the annual monitoring during the first complete calendar annual period following the effective date of this permit and is then required to monitor once during each annual period thereafter. Annual monitoring may be done anytime during the year, unless restricted elsewhere in this permit, but it should be submitted with the December DMR.

b. The permittee shall submit discharge monitoring reports (DMRs) on the forms provided by the Department and in accordance with the following schedule:

REPORTS OF MORE FREQUENTLY THAN MONTHLY AND MONTHLY TESTING shall be submitted on a **monthly** basis. The first report is due on the **28th day of (MONTH, YEAR).** The reports shall be submitted so that they are received by the Department no later than the 28th day of the month following the reporting period.

REPORTS OF QUARTERLY TESTING shall be submitted on a **quarterly** basis. The first report is due on the **28th day of [Month, Year].** The reports shall be submitted so that they are received by the Department no later than the 28th day of the month following the reporting period.

REPORTS OF SEMIANNUAL TESTING shall be submitted on a semiannual basis. The reports are due on the 28th day of JANUARY and the 28th day of JULY. The reports shall be submitted so that they are received by the Department no later than the 28th day of the month following the reporting period.

REPORTS OF ANNUAL TESTING shall be submitted on an annual basis. The first report is due on the 28th day of JANUARY. The reports shall be submitted so that they are received by the Department no later than the 28th day of the month following the reporting period.

c. Except as allowed by Provision I.C.1.c.(1) or (2), the permittee shall submit all Discharge Monitoring Reports (DMRs) required by Provision I.C.1.b electronically.

(1) If the permittee is unable to complete the electronic submittal of DMR data due to technical problems originating with the Department's electronic system (this could include entry/submittal issues with an entire set of DMRs or individual parameters), the permittee is not relieved of their obligation to submit DMR data to the Department by the date specified in Provision I.C.1.b, unless otherwise directed by the Department.

If the Department's electronic system is down on the 28th day of the month in which the DMR is due or is down for an extended period of time, as determined by the Department, when a DMR is required to be submitted, the permittee may submit the data in an alternate manner and format acceptable to the Department. Preapproved alternate acceptable methods include faxing, e-mailing, mailing, or hand-delivery of data such that they are received by the required reporting date. Within 5 calendar days of the Department's electronic system resuming operation, the permittee shall enter the data into the Department's electronic system, unless an alternate timeframe is approved by the Department. A comment should be included on the electronic DMR submittal verifying the original submittal date (date of the fax, copy of the dated e-mail, or hand-delivery stamped date), if applicable.

(2) The permittee may submit a request to the Department for a temporary electronic reporting waiver for DMR submittals. The waiver request should include the permit number; permittee name; facility/site name; facility address; name, address, and contact information for the responsible official or duly authorized representative; a detailed statement regarding the basis for requesting such a waiver; and the duration for which the waiver is requested. Approved electronic reporting waivers are not transferrable.

Permittees with an approved electronic reporting waiver for DMRs may submit hard copy DMRs for the period that the approved electronic reporting waiver request is effective. The permittee shall submit the Department-approved DMR forms to the address listed in Provision I.C.1.e.

(3) If a permittee is allowed to submit a hard copy DMR, the DMR must be legible and bear an original signature. Photo and electronic copies of the signature are not acceptable and shall not satisfy the reporting requirements of this permit.

(4) If the permittee, using approved analytical methods as specified in Provision I.B.2, monitors any discharge from a point source for a limited substance identified in Provision I.A. of this permit more frequently than required by this permit, the results of such monitoring shall be included in the calculation and reporting of values on the DMR and the increased frequency shall be indicated on the DMR.

(5) In the event no discharge from a point source identified in Provision I.A. of this permit and described more fully in the permittee's application occurs during a monitoring period, the permittee shall report "No Discharge" for such period on the appropriate DMR.

d. All reports and forms required to be submitted by this permit, the AWPCA and the Department's Rules, shall be electronically signed (or, if allowed by the Department, traditionally signed) by a "responsible official" of the permittee as defined in ADEM Administrative Code Rule 335-6-6-.09 or a "duly authorized representative" of such official as defined in ADEM Administrative Code Rule 335-6-6-.09 and shall bear the following certification:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

e. Discharge Monitoring Reports required by this permit, the AWPCA, and the Department's Rules that are being submitted in hard copy shall be addressed to:

Alabama Department of Environmental Management
Water Division
Office of Water Services
Post Office Box 301463
Montgomery, Alabama 36130-1463

Certified and Registered Mail containing Discharge Monitoring Reports shall be addressed to:

Alabama Department of Environmental Management
Water Division
Office of Water Services
1400 Coliseum Boulevard
Montgomery, Alabama 36110-2400

f. All other correspondence and reports required to be submitted by this permit, the AWPCA, and the Department's Rules shall be addressed to:

Alabama Department of Environmental Management`
Water Division
Post Office Box 301463
Montgomery, Alabama 36130-1463

Certified and Registered Mail shall be addressed to:

Alabama Department of Environmental Management
Water Division
1400 Coliseum Boulevard
Montgomery, Alabama 36110-2400

g. If this permit is a re-issuance, then the permittee shall continue to submit DMRs in accordance with the requirements of their previous permit until such time as DMRs are due as discussed in Part I.C.1.b above.

2. Noncompliance Notification

a. 24-Hour Noncompliance Reporting

The permittee shall report to the Director, within 24-hours of becoming aware of the noncompliance, any noncompliance which may endanger health or the environment. This shall include but is not limited to the following circumstances:

(1) does not comply with any daily minimum or maximum discharge limitation for an effluent characteristic specified in Provision I. A. of this permit which is denoted by an "(X)";

(2) threatens human health or welfare, fish or aquatic life, or water quality standards;

(3) does not comply with an applicable toxic pollutant effluent standard or prohibition established under Section 307(a) of the FWPCA, 33 U.S.C. Section 1317(a);

(4) contains a quantity of a hazardous substance which has been determined may be harmful to public health or welfare under Section 311(b)(4) of the FWPCA, 33 U.S.C. Section 1321(b)(4);

(5) exceeds any discharge limitation for an effluent characteristic as a result of an unanticipated bypass or upset; and

(6) is an unpermitted direct or indirect discharge of a pollutant to a water of the state (unpermitted discharges properly reported to the Department under any other requirement are not required to be reported under this provision).

The permittee shall orally report the occurrence and circumstances of such discharge to the Director within 24-hours after the permittee becomes aware of the occurrence of such discharge. In addition to the oral report, the permittee shall submit to the Director or Designee a written report as provided in Part I.C.2.c no later than five (5) days after becoming aware of the occurrence of such discharge.

b. If for any reason, the permittee's discharge does not comply with any limitation of this permit, the permittee shall submit to the Director or Designee a written report as provided in Part I.C.2.c below, such report shall be submitted with the next Discharge Monitoring Report required to be submitted by Part I.C.1 of this permit after becoming aware of the occurrence of such noncompliance.

c. Any written report required to be submitted to the Director or Designee by Part I.C.2 a. or b. shall be submitted using a Noncompliance Notification Form (ADEM Form 421) available on the Department's website (http://adem.alabama.gov/DeptForms/Form421.pdf) and include the following information:

(1) A description of the discharge and cause of noncompliance;

(2) The period of noncompliance, including exact dates and times or, if not corrected, the anticipated time the noncompliance is expected to continue; and

(3) A description of the steps taken and/or being taken to reduce or eliminate the noncomplying discharge and to prevent its recurrence.

D. OTHER REPORTING AND NOTIFICATION REQUIREMENTS

1. Anticipated Noncompliance

The permittee shall give the Director written advance notice of any planned changes or other circumstances regarding a facility which may result in noncompliance with permit requirements.

2. Termination of Discharge

The permittee shall notify the Director, in writing, when all discharges from any point source(s) identified in Provision I. A. of this permit have permanently ceased. This notification shall serve as sufficient cause for instituting procedures for modification or termination of the permit.

3. Updating Information

a. The permittee shall inform the Director of any change in the permittee's mailing address, telephone number or in the permittee's designation of a facility contact or office having the authority and responsibility to prevent and abate violations of the AWPCA, the Department's Rules, and the terms and conditions of this permit, in writing, no later than ten (10) days after such change. Upon request of the Director or his designee, the permittee shall furnish the Director with an update of any information provided in the permit application.

b. If the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the Director, it shall promptly submit such facts or information with a written explanation for the mistake and/or omission.

4. Duty to Provide Information

The permittee shall furnish to the Director, within a reasonable time, any information which the Director or his designee may request to determine whether cause exists for modifying, revoking and re-issuing, suspending, or terminating this permit, in whole or in part, or to determine compliance with this permit.

5. Cooling Water and Boiler Water Additives

a. The permittee shall notify the Director in writing not later than thirty (30) days prior to instituting the use of any biocide corrosion inhibitor or chemical additive in a cooling or boiler system, not identified in the application for this permit, from which discharge is allowed by this permit. Notification is not required for additives that do not contain a heavy metal(s) as an active ingredient and that pass through a wastewater treatment system prior to discharge nor is notification required for additives that should not reasonably be expected to cause the cooling water or boiler water to exhibit toxicity as determined by analysis of manufacturer's data or testing by the permittee. Such notification shall include:

(1) name and general composition of biocide or chemical;

(2) 96-hour median tolerance limit data for organisms representative of the biota of the waterway into which the discharge will ultimately reach;

(3) quantities to be used.

(4) frequencies of use;

(5) proposed discharge concentrations; and

(6) EPA registration number, if applicable.

b. The use of a biocide or additive containing tributyl tin, tributyl tin oxide, zinc, chromium or related compounds in cooling or boiler system(s), from which a discharge regulated by this permit occurs, is prohibited except as exempted below. The use of a biocide or additive containing zinc, chromium or related compounds may be used in special circumstances if (1) the permit contains limits for these substances, or (2) the applicant demonstrates during the application process that the use of zinc, chromium or related compounds as a biocide or additive will not pose a reasonable potential to violate the applicable State water quality standards for these substances. The use of any additive, not identified in this permit or in the

application for this permit or not exempted from notification under this permit is prohibited, prior to a determination by the Department that permit modification to control discharge of the additive is not required or prior to issuance of a permit modification controlling discharge of the additive.

6. **Permit Issued Based on Estimated Characteristics**

   a. If this permit was issued based on estimates of the characteristics of a process discharge reported on an EPA NPDES Application Form 2D (EPA Form 3510-2D), the permittee shall complete and submit an EPA NPDES Application Form 2C (EPA Form 3510-2C) no later than two years after the date that discharge begins. Sampling required for completion of the Form 2C shall occur when a discharge(s) from the process(s) causing the new or increased discharge is occurring. If this permit was issued based on estimates concerning the composition of a stormwater discharge(s), the permittee shall perform the sampling required by EPA NPDES Application Form 2F (EPA Form 3510-2F) no later than one year after the industrial activity generating the stormwater discharge has been fully initiated.

   b. This permit shall be reopened if required to address any new information resulting from the completion and submittal of the Form 2C and or 2F.

E. SCHEDULE OF COMPLIANCE

1. The permittee shall achieve compliance with the discharge limitations specified in Provision I. A. in accordance with the following schedule:

COMPLIANCE SHALL BE ATTAINED ON THE EFFECTIVE DATE OF THIS PERMIT

2. **Within 180 days of the effective date of this Permit, the Permittee shall submit to the Department the chosen alternative provided at § 125.94(c) for compliance with the Best Technology Available (BTA) standards for impingement. The submittal must provide an implementation schedule for installation of equipment necessary to meet the requirements of the chosen compliance alternative.**

3. **The Permittee shall conduct a 316(a) study during the permit cycle. A 316(a) study plan shall be submitted to the Department for review within 365 days of the effective date of this permit and shall be revised as soon as practical based upon subsequent receipt of comments from the Department. After the study plan has been approved by the Department, the Permittee shall complete the study and submit the results to the Department no later than 365 days prior to the expiration date of this permit. The study submittal shall also include a request for continuation of the CWA Section 316(a) variance for the thermal component of the discharge in accordance with the requirements of 40 CFR Part 125.70 Subpart H – Criteria for Determining Alternative Effluent Limitations Under Section 316(a) of the Act and 40 CFR 122.21(m)(6) Subpart B – Permit Application and Special NPDES Program Requirements, Variance Requests by Non-POTWs.**

4. No later than 14 calendar days following a date identified in the above schedule of compliance, the permittee shall submit either a report of progress or, in the case of specific actions being required by identified dates, a written notice of compliance or noncompliance. In the latter case, the notice shall include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirement.

PART II: OTHER REQUIREMENTS, RESPONSIBILITIES, AND DUTIES

A. Operational and Management Requirements

1. Facilities Operation and Maintenance

The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of the permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process controls, including appropriate quality assurance procedures. This provision requires the operation of backup or auxiliary facilities only when necessary to achieve compliance with the conditions of the permit.

2. Best Management Practices

a. Dilution water shall not be added to achieve compliance with discharge limitations except when the Director or his designee has granted prior written authorization for dilution to meet water quality requirements.

b. The permittee shall prepare, implement, and maintain a Spill Prevention, Control and Countermeasures (SPCC) Plan in accordance with 40 C.F.R. Section 112 if required thereby.

c. The permittee shall prepare, submit for approval and implement a Best Management Practices (BMP) Plan for containment of any or all process liquids or solids, in a manner such that these materials do not present a significant potential for discharge, if so required by the Director or his designee. When submitted and approved, the BMP Plan shall become a part of this permit and all requirements of the BMP Plan shall become requirements of this permit.

3. Spill Prevention, Control, and Management

The permittee shall provide spill prevention, control, and/or management sufficient to prevent any spills of pollutants from entering a water of the state or a publicly or privately owned treatment works. Any containment system used to implement this requirement shall be constructed of materials compatible with the substance(s) contained and which shall prevent the contamination of groundwater and such containment system shall be capable of retaining a volume equal to 110 percent of the capacity of the largest tank for which containment is provided.

B. Other Responsibilities

1. Duty to Mitigate Adverse Impacts

The permittee shall promptly take all reasonable steps to mitigate and minimize or prevent any adverse impact on human health or the environment resulting from noncompliance with any discharge limitation specified in Provision I. A. of this permit, including such accelerated or additional monitoring of the discharge and/or the receiving waterbody as necessary to determine the nature and impact of the noncomplying discharge.

2. Right of Entry and Inspection

The permittee shall allow the Director, or an authorized representative, upon the presentation of proper credentials and other documents as may be required by law to:

a. enter upon the permittee's premises where a regulated facility or activity or point source is located or conducted, or where records must be kept under the conditions of the permit;

b. have access to and copy, at reasonable times, any records that must be kept under the conditions of the permit;

c. inspect any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under the permit; and

d. sample or monitor, for the purposes of assuring permit compliance or as otherwise authorized by the AWPCA, any substances or parameters at any location.

C. Bypass and Upset

1. Bypass

a. Any bypass is prohibited except as provided in b. and c. below:

b. A bypass is not prohibited if:

(1) It does not cause any discharge limitation specified in Provision I. A. of this permit to be exceeded;

(2) It enters the same receiving stream as the permitted outfall; and

(3) It is necessary for essential maintenance of a treatment or control facility or system to assure efficient operation of such facility or system.

c. A bypass is not prohibited and need not meet the discharge limitations specified in Provision I. A. of this permit if:

(1) It is unavoidable to prevent loss of life, personal injury, or severe property damage;

(2) There are no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime (this condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance); and

(3) The permittee submits a written request for authorization to bypass to the Director at least ten (10) days prior to the anticipated bypass (if possible), the permittee is granted such authorization, and the permittee complies with any conditions imposed by the Director to minimize any adverse impact on human health or the environment resulting from the bypass.

d. The permittee has the burden of establishing that each of the conditions of Provision II.C.1.b. or c. have been met to qualify for an exception to the general prohibition against bypassing contained in a. and an exemption, where applicable, from the discharge limitations specified in Provision I. A. of this permit.

2. Upset

a. A discharge which results from an upset need not meet the discharge limitations specified in Provision I. A. of this permit if:

(1) No later than 24-hours after becoming aware of the occurrence of the upset, the permittee orally reports the occurrence and circumstances of the upset to the Director or his designee; and

(2) No later than five (5) days after becoming aware of the occurrence of the upset, the permittee furnishes the Director with evidence, including properly signed, contemporaneous operating logs, or other relevant evidence, demonstrating that (i) an upset occurred; (ii) the permittee can identify the specific cause(s) of the upset; (iii) the permittee's facility was being properly operated at the time of the upset; and (iv) the permittee promptly took all reasonable steps to minimize any adverse impact on human health or the environment resulting from the upset.

b. The permittee has the burden of establishing that each of the conditions of Provision II. C.2.a. of this permit have been met to qualify for an exemption from the discharge limitations specified in Provision I.A. of this permit.

D. Duty to Comply with Permit, Rules, and Statutes

1. Duty to Comply

a. The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the AWPCA and the FWPCA and is grounds for enforcement action, for permit termination, revocation and reissuance, suspension, modification; or denial of a permit renewal application.

b. The necessity to halt or reduce production or other activities in order to maintain compliance with the conditions of the permit shall not be a defense for a permittee in an enforcement action.

c. The discharge of a pollutant from a source not specifically identified in the permit application for this permit and not specifically included in the description of an outfall in this permit is not authorized and shall constitute noncompliance with this permit.

d. The permittee shall take all reasonable steps, including cessation of production or other activities, to minimize or prevent any violation of this permit or to minimize or prevent any adverse impact of any permit violation.

e. Nothing in this permit shall be construed to preclude and negate the permittee's responsibility or liability to apply for, obtain, or comply with other ADEM, Federal, State, or Local Government permits, certifications, licenses, or other approvals.

2. Removed Substances

Solids, sludges, filter backwash, or any other pollutant or other waste removed in the course of treatment or control of wastewaters shall be disposed of in a manner that complies with all applicable Department Rules.

3. Loss or Failure of Treatment Facilities

Upon the loss or failure of any treatment facilities, including but not limited to the loss or failure of the primary source of power of the treatment facility, the permittee shall, where necessary to maintain compliance with the discharge limitations specified in Provision I. A. of this permit, or any other terms or conditions of this permit, cease, reduce, or otherwise control production and/or all discharges until treatment is restored. If control of discharge during loss or failure of the primary source of power is to be accomplished by means of alternate power sources, standby generators, or retention of inadequately treated effluent, the permittee must furnish to the Director within six months a certification that such control mechanisms have been installed.

4. Compliance with Statutes and Rules

a. This permit has been issued under ADEM Administrative Code, Chapter 335-6-6. All provisions of this chapter, that are applicable to this permit, are hereby made a part of this permit. A copy of this chapter may be obtained for a small charge from the Office of General Counsel, Alabama Department of Environmental Management, 1400 Coliseum Blvd., Montgomery, AL 36130.

b. This permit does not authorize the noncompliance with or violation of any Laws of the State of Alabama or the United States of America or any regulations or rules implementing such laws. FWPCA, 33 U.S.C. Section 1319, and Code of Alabama 1975, Section 22-22-14.

E. PERMIT TRANSFER, MODIFICATION, SUSPENSION, REVOCATION, AND REISSUANCE

1. Duty to Reapply or Notify of Intent to Cease Discharge

a. If the permittee intends to continue to discharge beyond the expiration date of this permit, the permittee shall file a complete permit application for reissuance of this permit at least 180 days prior to its expiration. If the permittee does not intend to continue discharge beyond the expiration of this permit, the permittee shall submit written notification of this intent which shall be signed by an individual meeting the signatory requirements for a permit application as set forth in ADEM Administrative Code Rule 335-6-6-.09.

b. Failure of the permittee to apply for reissuance at least 180 days prior to permit expiration will void the automatic continuation of the expiring permit provided by ADEM Administrative Code Rule 335-6-6-.06 and should the permit not be reissued for any reason any discharge after expiration of this permit will be an unpermitted discharge.

2. Change in Discharge

a. The permittee shall apply for a permit modification at least 180 days in advance of any facility expansion, production increase, process change, or other action that could result in the discharge of additional pollutants or increase the quantity of a discharged pollutant such that existing permit limitations would be exceeded or that could result in an additional discharge point. This requirement applies to pollutants that are or that are not subject to discharge limitations in this permit. No new or increased discharge may begin until the Director has authorized it by issuance of a permit modification or a reissued permit.

b. The permittee shall notify the Director as soon as it is known or there is reason to believe:

(1) That any activity has occurred or will occur which would result in the discharge on a routine or frequent basis, of any toxic pollutant which is not limited in this permit, if that discharge will exceed the highest of the following notification levels:

(i) one hundred micrograms per liter;

(ii) two hundred micrograms per liter for acrolein and acrylonitrile; five hundred micrograms per liter for 2,4-dinitrophenol and for 2-methyl-4,6-dini-trophenol; and one milligram per liter for antimony;

(iii) five times the maximum concentration value reported for that pollutant in the permit application; or

(2) That any activity has occurred or will occur which would result in any discharge, on a non-routine or infrequent basis, of a toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following notification levels:

(i) five hundred micrograms per liter;

(ii) one milligram per liter for antimony;

(iii) ten times the maximum concentration value reported for that pollutant in the permit application.

3. Transfer of Permit

This permit may not be transferred or the name of the permittee changed without notice to the Director and subsequent modification or revocation and reissuance of the permit to identify the new permittee and to incorporate any other changes as may be required under the FWPCA or AWPCA. In the case of a change in name, ownership or control of the permittee's premises only, a request for permit modification in a format acceptable to the Director is required at least 30 days prior to the change. In the case of a change in name, ownership or control of the permittee's premises accompanied by a change or proposed change in effluent characteristics, a complete permit application is required to be submitted to the Director at least 180 days prior to the change. Whenever the Director is notified of a change in name, ownership or control, he may decide not to modify the existing permit and require the submission of a new permit application.

4. Permit Modification and Revocation

a. This permit may be modified or revoked and reissued, in whole or in part, during its term for cause, including but not limited to, the following:

(1) If cause for termination under Provision II. E. 5. of this permit exists, the Director may choose to revoke and reissue this permit instead of terminating the permit;

(2) If a request to transfer this permit has been received, the Director may decide to revoke and reissue or to modify the permit; or

(3) If modification or revocation and reissuance is requested by the permittee and cause exists, the Director may grant the request.

b. This permit may be modified during its term for cause, including but not limited to, the following:

(1) If cause for termination under Provision II. E. 5. of this permit exists, the Director may choose to modify this permit instead of terminating this permit;

(2) There are material and substantial alterations or additions to the facility or activity generating wastewater which occurred after permit issuance which justify the application of permit conditions that are different or absent in the existing permit;

(3) The Director has received new information that was not available at the time of permit issuance and that would have justified the application of different permit conditions at the time of issuance;

(4) A new or revised requirement(s) of any applicable standard or limitation is promulgated under Sections 301(b)(2)(C), (D), (E), and (F), and 307(a)(2) of the FWPCA;

(5) Errors in calculation of discharge limitations or typographical or clerical errors were made;

(6) To the extent allowed by ADEM Administrative Code, Rule 335-6-6-.17, when the standards or regulations on which the permit was based have been changed by promulgation of amended standards or regulations or by judicial decision after the permit was issued;

(7) To the extent allowed by ADEM Administrative Code, Rule 335-6-6-.17, permits may be modified to change compliance schedules;

(8) To agree with a granted variance under 30l(c), 30l(g), 30l(h), 30l(k), or 3l6(a) of the FWPCA or for fundamentally different factors;

(9) To incorporate an applicable 307(a) FWPCA toxic effluent standard or prohibition;

(10) When required by the reopener conditions in this permit;

(11) When required under 40 CFR 403.8(e) (compliance schedule for development of pretreatment program);

(12) Upon failure of the state to notify, as required by Section 402(b)(3) of the FWPCA, another state whose waters may be affected by a discharge permitted by this permit;

(13) When required to correct technical mistakes, such as errors in calculation, or mistaken interpretations of law made in determining permit conditions; or

(14) When requested by the permittee and the Director determines that the modification has cause and will not result in a violation of federal or state law, regulations or rules.

5. Permit Termination

This permit may be terminated during its term for cause, including but not limited to, the following:

a. Violation of any term or condition of this permit;

b. The permittee's misrepresentation or failure to disclose fully all relevant facts in the permit application or during the permit issuance process or the permittee's misrepresentation of any relevant facts at any time;

c. Materially false or inaccurate statements or information in the permit application or the permit;

d. A change in any condition that requires either a temporary or permanent reduction or elimination of the permitted discharge;

e. The permittee's discharge threatens human life or welfare or the maintenance of water quality standards;

f. Permanent closure of the facility generating the wastewater permitted to be discharged by this permit or permanent cessation of wastewater discharge;

g. New or revised requirements of any applicable standard or limitation that is promulgated under Sections 301(b)(2)(C), (D), (E), and (F), and 307(a)(2) of the FWPCA that the Director determines cannot be complied with by the permittee; or

h. Any other cause allowed by the ADEM Administrative Code, Chapter 335-6-6.

6. Permit Suspension

This permit may be suspended during its term for noncompliance until the permittee has taken action(s) necessary to achieve compliance.

7. Request for Permit Action Does Not Stay Any Permit Requirement

The filing of a request by the permittee for modification, suspension or revocation of this permit, in whole or in part, does not stay any permit term or condition.

F. Compliance with Toxic Pollutant Standard or Prohibition

If any applicable effluent standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) is established under Section 307(a) of the FWPCA, 33 U.S.C. Section 1317(a), for a toxic pollutant discharged by the permittee and such standard or prohibition is more stringent than any discharge limitation on the pollutant specified in Provision I. A. of this permit, or controls a pollutant not limited in Provision I. A. of this permit, this permit shall be modified to conform to the toxic pollutant effluent standard or prohibition and the permittee shall be notified of such modification. If this permit has not been modified to conform to the toxic pollutant effluent standard or prohibition before the effective date of such standard or prohibition, the permittee shall attain compliance with the requirements of the standard or prohibition within the time period required by the standard or prohibition and shall continue to comply with the standard or prohibition until this permit is modified or reissued.

G. Discharge of Wastewater Generated by Others

The discharge of wastewater, generated by any process, facility, or by any other means not under the operational control of the permittee or not identified in the application for this permit or not identified specifically in the description of an outfall in this permit is not authorized by this permit.

PART III: OTHER PERMIT CONDITIONS

A. CIVIL AND CRIMINAL LIABILITY

1. Tampering

Any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained or performed under the permit shall, upon conviction, be subject to penalties as provided by the AWPCA.

2. False Statements

Any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance shall, upon conviction, be subject to penalties as provided by the AWPCA.

3. Permit Enforcement

a. Any NPDES permit issued or reissued by the Department is a permit for the purpose of the AWPCA and the FWPCA and as such any terms, conditions, or limitations of the permit are enforceable under state and federal law.

b. Any person required to have a NPDES permit pursuant to ADEM Administrative Code Chapter 335-6-6 and who discharges pollutants without said permit, who violates the conditions of said permit, who discharges pollutants in a manner not authorized by the permit, or who violates applicable orders of the Department or any applicable rule or standard of the Department, is subject to any one or combination of the following enforcement actions under applicable state statutes.

(1) An administrative order requiring abatement, compliance, mitigation, cessation, clean-up, and/or penalties;

(2) An action for damages;

(3) An action for injunctive relief; or

(4) An action for penalties.

c. If the permittee is not in compliance with the conditions of an expiring or expired permit the Director may choose to do any or all of the following provided the permittee has made a timely and complete application for reissuance of the permit:

(1) initiate enforcement action based upon the permit which has been continued;

(2) issue a notice of intent to deny the permit reissuance. If the permit is denied, the owner or operator would then be required to cease the activities authorized by the continued permit or be subject to enforcement action for operating without a permit;

(3) reissue the new permit with appropriate conditions; or

(4) take other actions authorized by these rules and AWPCA.

4. Relief from Liability

Except as provided in Provision II.C.1 (Bypass) and Provision II.C.2 (Upset), nothing in this permit shall be construed to relieve the permittee of civil or criminal liability under the AWPCA or FWPCA for noncompliance with any term or condition of this permit.

B. OIL AND HAZARDOUS SUBSTANCE LIABILITY

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities or penalties to which the permittee is or may be subject under Section 311 of the FWPCA, 33 U.S.C. Section 1321.

C. PROPERTY AND OTHER RIGHTS

This permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to persons or property or invasion of other private rights, trespass, or any infringement of federal, state, or local laws or regulations, nor does it authorize or approve the construction of any physical structures or facilities or the undertaking of any work in any waters of the state or of the United States.

D. AVAILABILITY OF REPORTS

Except for data determined to be confidential under Code of Alabama 1975, Section 22-22-9(c), all reports prepared in accordance with the terms of this permit shall be available for public inspection at the offices of the Department. Effluent data shall not be considered confidential.

E. EXPIRATION OF PERMITS FOR NEW OR INCREASED DISCHARGES

1. If this permit was issued for a new discharger or new source, this permit shall expire eighteen months after the issuance date if construction of the facility has not begun during the eighteen-month period.

2. If this permit was issued or modified to allow the discharge of increased quantities of pollutants to accommodate the modification of an existing facility and if construction of this modification has not begun during the eighteen month period after issuance of this permit or permit modification, this permit shall be modified to reduce the quantities of pollutants allowed to be discharged to those levels that would have been allowed if the modification of the facility had not been planned.

3. Construction has begun when the owner or operator has:

   a. begun, or caused to begin as part of a continuous on-site construction program:

      (1) any placement, assembly, or installation of facilities or equipment; or

      (2) significant site preparation work including clearing, excavation, or removal of existing buildings, structures, or facilities which is necessary for the placement, assembly, or installation of new source facilities or equipment; or

   b. entered into a binding contractual obligation for the purpose of placement, assembly, or installation of facilities or equipment which are intended to be used in its operation within a reasonable time. Options to purchase or contracts which can be terminated or modified without substantial loss, and contracts for feasibility, engineering, and design studies do not constitute a contractual obligation under the paragraph. The entering into a lease with the State of Alabama for exploration and production of hydrocarbons shall also be considered beginning construction.

F. COMPLIANCE WITH WATER QUALITY STANDARDS

1. On the basis of the permittee's application, plans, or other available information, the Department has determined that compliance with the terms and conditions of this permit should assure compliance with the applicable water quality standards.

2. Compliance with permit terms and conditions notwithstanding, if the permittee's discharge(s) from point sources identified in Provision I. A. of this permit cause or contribute to a condition in contravention of state water quality standards, the Department may require abatement action to be taken by the permittee in emergency situations or modify the permit pursuant to the Department's Rules, or both.

3. If the Department determines, on the basis of a notice provided pursuant to this permit or any investigation, inspection or sampling, that a modification of this permit is necessary to assure maintenance of water quality standards or compliance with other provisions of the AWPCA or FWPCA, the Department may require such modification and, in cases of emergency, the Director may prohibit the discharge until the permit has been modified.

G. GROUNDWATER

Unless specifically authorized under this permit, this permit does not authorize the discharge of pollutants to groundwater. Should a threat of groundwater contamination occur, the Director may require groundwater monitoring to properly assess the degree of the problem and the Director may require that the Permittee undertake measures to abate any such discharge and/or contamination.

H. DEFINITIONS

1. Average monthly discharge limitation - means the highest allowable average of "daily discharges" over a calendar month, calculated as the sum of all "daily discharges" measured during a calendar month divided by the number of "daily discharges" measured during that month (zero discharge days shall not be included in the number of "daily discharges" measured and a less than detectable test result shall be treated as a concentration of zero if the most sensitive EPA approved method was used).

2. Average weekly discharge limitation - means the highest allowable average of "daily discharges" over a calendar week, calculated as the sum of all "daily discharges" measured during a calendar week divided by the number of "daily discharges" measured during that week (zero discharge days shall not be included in the number of "daily discharges" measured and a less than detectable test result shall be treated as a concentration of zero if the most sensitive EPA approved method was used).

3. Arithmetic Mean – means the summation of the individual values of any set of values divided by the number of individual values.

4. AWPCA - means the Alabama Water Pollution Control Act.

5. BOD – means the five-day measure of the pollutant parameter biochemical oxygen demand.

6. Bypass - means the intentional diversion of waste streams from any portion of a treatment facility.

7. CBOD – means the five-day measure of the pollutant parameter carbonaceous biochemical oxygen demand.

8. Daily discharge - means the discharge of a pollutant measured during any consecutive 24-hour period in accordance with the sample type and analytical methodology specified by the discharge permit.

9. Daily maximum - means the highest value of any individual sample result obtained during a day.

10. Daily minimum - means the lowest value of any individual sample result obtained during a day.

11. Day - means any consecutive 24-hour period.

12. Department - means the Alabama Department of Environmental Management.

13. Director - means the Director of the Department.

14. Discharge - means "[t]he addition, introduction, leaking, spilling or emitting of any sewage, industrial waste, pollutant or other wastes into waters of the state". Code of Alabama 1975, Section 22-22-1(b)(8).

15. Discharge Monitoring Report (DMR) - means the form approved by the Director to accomplish reporting requirements of an NPDES permit.

16. DO – means dissolved oxygen.

17. 8HC – means 8-hour composite sample, including any of the following:

    a. The mixing of at least 5 equal volume samples collected at constant time intervals of not more than 2 hours over a period of not less than 8 hours between the hours of 6:00 a.m. and 6:00 p.m. If the sampling period exceeds 8 hours, sampling may be conducted beyond the 6:00 a.m. to 6:00 p.m. period.

    b. A sample continuously collected at a constant rate over period of not less than 8 hours between the hours of 6:00 a.m. and 6:00 p.m. If the sampling period exceeds 8 hours, sampling may be conducted beyond the 6:00 a.m. to 6:00 p.m. period.

18. EPA - means the United States Environmental Protection Agency.

19. FC – means the pollutant parameter fecal coliform.

20. Flow – means the total volume of discharge in a 24-hour period.

21. FWPCA - means the Federal Water Pollution Control Act.

22. Geometric Mean – means the Nth root of the product of the individual values of any set of values where N is equal to the number of individual values. The geometric mean is equivalent to the antilog of the arithmetic mean of the logarithms of the individual values. For purposes of calculating the geometric mean, values of zero (0) shall be considered one (1).

23. Grab Sample – means a single influent or effluent portion which is not a composite sample. The sample(s) shall be collected at the period(s) most representative of the discharge.

24. Indirect Discharger – means a nondomestic discharger who discharges pollutants to a publicly owned treatment works or a privately owned treatment facility operated by another person.

25. Industrial User – means those industries identified in the Standard Industrial Classification manual, Bureau of the Budget 1967, as amended and supplemented, under the category "Division D – Manufacturing" and such other classes of significant waste producers as, by regulation, the Director deems appropriate.

26. MGD – means million gallons per day.

27. Monthly Average – means, other than for fecal coliform bacteria, the arithmetic mean of the entire composite or grab samples taken for the daily discharges collected in one month period. The monthly average for fecal coliform bacteria is the geometric mean of daily discharge samples collected in a one month period. The monthly average for flow is the arithmetic mean of all flow measurements taken in a one month period.

28. New Discharger – means a person, owning or operating any building, structure, facility or installation:

    a. from which there is or may be a discharge of pollutants;

    b. that did not commence the discharge of pollutants prior to August 13, 1979, and which is not a new source; and

    c. which has never received a final effective NPDES permit for dischargers at that site.

29. NH3-N – means the pollutant parameter ammonia, measured as nitrogen.

30. Permit application - means forms and additional information that is required by ADEM Administrative Code Rule 335-6-6-.08 and applicable permit fees.

31. Point source - means "any discernible, confined and discrete conveyance, including but not limited to any pipe, channel, ditch, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, . . . from which pollutants are or may be discharged." Section 502(14) of the FWPCA, 33 U.S.C. Section 1362(14).

32. Pollutant - includes for purposes of this permit, but is not limited to, those pollutants specified in Code of Alabama 1975, Section 22-22-1(b)(3) and those effluent characteristics specified in Provision I. A. of this permit.

33. Privately Owned Treatment Works – means any devices or system which is used to treat wastes from any facility whose operator is not the operator of the treatment works, and which is not a "POTW".

34. Publicly Owned Treatment Works – means a wastewater collection and treatment facility owned by the State, municipality, regional entity composed of two or more municipalities, or another entity created by the State or local authority for the purpose of collecting and treating municipal wastewater.

35. Receiving Stream – means the "waters" receiving a "discharge" from a "point source".

36. Severe property damage - means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

37. Significant Source – means a source which discharges 0.025 MGD or more to a POTW or greater than five percent of the treatment work's capacity, or a source which is a primary industry as defined by the U.S. EPA or which discharges a priority or toxic pollutant.

38. Solvent – means any virgin, used or spent organic solvent(s) identified in the F-Listed wastes (F001 through F005) specified in 40 CFR 261.31 that is used for the purpose of solubilizing other materials.

39. TKN – means the pollutant parameter Total Kjeldahl Nitrogen.

40. TON – means the pollutant parameter Total Organic Nitrogen.

41. TRC – means Total Residual Chlorine.

42. TSS – means the pollutant parameter Total Suspended Solids.

43. 24HC – means 24-hour composite sample, including any of the following:

    a. the mixing of at least 12 equal volume samples collected at constant time intervals of not more than 2 hours over a period of 24 hours;

    b. a sample collected over a consecutive 24-hour period using an automatic sampler composite to one sample. As a minimum, samples shall be collected hourly and each shall be no more than one twenty-fourth (1/24) of the total sample volume collected; or

    c. a sample collected over a consecutive 24-hour period using an automatic composite sampler composited proportional to flow.

44. Upset - means an exceptional incident in which there is an unintentional and temporary noncompliance with technology-based permit discharge limitations because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

45. Waters - means "[a]ll waters of any river, stream, watercourse, pond, lake, coastal, ground or surface water, wholly or partially within the state, natural or artificial. This does not include waters which are entirely confined and retained completely upon the property of a single individual, partnership or corporation unless such waters are used in interstate commerce." Code of Alabama 1975, Section 22-22-1(b)(2). Waters "include all navigable waters" as defined in Section 502(7) of the FWPCA, 22 U.S.C. Section 1362(7), which are within the State of Alabama.

46. Week - means the period beginning at twelve midnight Saturday and ending at twelve midnight the following Saturday.

47. Weekly (7-day and calendar week) Average – is the arithmetic mean of all samples collected during a consecutive 7-day period or calendar week, whichever is applicable. The calendar week is defined as beginning on Sunday and ending on Saturday. Weekly averages shall be calculated for all calendar weeks with Saturdays in the month. If a calendar week overlaps two months (i.e., the Sunday is in one month and the Saturday in the following month), the weekly average calculated for the calendar week shall be included in the data for the month that contains the Saturday.

I. SEVERABILITY

The provisions of this permit are severable, and if any provision of this permit or the application of any provision of this permit to any circumstance is held invalid, the application of such provision to other circumstances, and the remainder of this permit, shall not be affected thereby.

PART IV: ADDITIONAL REQUIREMENTS, CONDITIONS, AND LIMITATIONS

A. BEST MANAGEMENT PRACTICES (BMP) PLAN REQUIREMENTS

1. BMP Plan

The permittee shall develop and implement a Best Management Practices (BMP) Plan which prevents, or minimizes the potential for, the release of pollutants from ancillary activities, including material storage areas; plant site runoff; in-plant transfer, process and material handling areas; loading and unloading operations, and sludge and waste disposal areas, to the waters of the State through plant site runoff; spillage or leaks; sludge or waste disposal; or drainage from raw material storage.

2. Plan Content

The permittee shall prepare and implement a best management practices (BMP) plan, which shall:

a. Establish specific objectives for the control of pollutants:

(1) Each facility component or system shall be examined for its potential for causing a release of significant amounts of pollutants to waters of the State due to equipment failure, improper operation, natural phenomena such as rain or snowfall, etc.

(2) Where experience indicates a reasonable potential for equipment failure (e.g., a tank overflow or leakage), natural condition (e.g. precipitation), or circumstances to result in significant amounts of pollutants reaching surface waters, the plan should include a prediction of the direction, rate of flow, and total quantity of pollutants which could be discharged from the facility as a result of each condition or circumstance.

b. Establish specific best management practices to meet the objectives identified under paragraph a. of this section, addressing each component or system capable of causing a release of significant amounts of pollutants to the waters of the State, and identifying specific preventative or remedial measures to be implemented;

c. Establish a program to identify and repair leaking equipment items and damaged containment structures, which may contribute to contaminated stormwater runoff. This program must include regular visual inspections of equipment, containment structures and of the facility in general to ensure that the BMP is continually implemented and effective;

d. Prevent the spillage or loss of fluids, oil, grease, gasoline, etc. from vehicle and equipment maintenance activities and thereby prevent the contamination of stormwater from these substances;

e. Prevent or minimize stormwater contact with material stored on site;

f. Designate by position or name the person or persons responsible for the day to day implementation of the BMP;

g. Provide for routine inspections, on days during which the facility is manned, of any structures that function to prevent stormwater pollution or to remove pollutants from stormwater and of the facility in general. Routine inspections should be done at a frequency to ensure that the BMP is continually implemented and effective and in no case less frequent than once per year;

h. Provide for the use and disposal of any material used to absorb spilled fluids that could contaminate stormwater;

i. Develop a solvent management plan, if solvents are used on site. The solvent management plan shall include as a minimum lists of the solvents on site; the disposal method of solvents used instead of dumping, such as reclamation, contract hauling; and the procedures for assuring that solvents do not routinely spill or leak into the stormwater;

j. Provide for the disposal of all used oils, hydraulic fluids, firefighting foams, solvent degreasing material, etc. in accordance with good management practices and any applicable state or federal regulations;

k. Include a diagram of the facility showing the locations where stormwater exits the facility, the locations of any structure or other mechanisms intended to prevent pollution of stormwater or to remove pollutants from stormwater, the locations of any collection and handling systems;

l. Provide control sufficient to prevent or control pollution of stormwater by soil particles to the degree required to maintain compliance with the water quality standard for turbidity applicable to the waterbody(s) receiving discharge(s) under this permit;

m. Provide spill prevention, control, and/or management sufficient to prevent or minimize contaminated stormwater runoff. Any containment system used to implement this requirement shall be constructed of materials compatible with the

substance(s) contained and shall prevent the contamination of groundwater. The containment system shall also be capable of retaining a volume equal to 110 percent of the capacity of the largest tank for which containment is provided;

n. Provide and maintain curbing, diking or other means of isolating process areas to the extent necessary to allow segregation and collection for treatment of contaminated stormwater from process areas;

o. Be reviewed by plant engineering staff and the plant manager; and

p. Bear the signature of the plant manager.

3. Compliance Schedule

The permittee shall have reviewed (and revised if necessary) and fully implemented the BMP plan as soon as practicable but no later than six months after the effective date of this permit.

4. Department Review

a. When requested by the Director or his designee, the permittee shall make the BMP available for Department review.

b. The Director or his designee may notify the permittee at any time that the BMP is deficient and require correction of the deficiency.

c. The permittee shall correct any BMP deficiency identified by the Director or his designee within 30 days of receipt of notification and shall certify to the Department that the correction has been made and implemented.

5. Administrative Procedures

a. A copy of the BMP shall be maintained at the facility and shall be available for inspection by representatives of the Department.

b. A log of the routine inspection required above shall be maintained at the facility and shall be available for inspection by representatives of the Department. The log shall contain records of all inspections performed for the last three years and each entry shall be signed by the person performing the inspection.

c. The permittee shall provide training for any personnel required to implement the BMP and shall retain documentation of such training at the facility. This documentation shall be available for inspection by representatives of the Department. Training shall be performed prior to the date that implementation of the BMP is required.

d. BMP Plan Modification. The permittee shall amend the BMP plan whenever there is a change in the facility or change in operation of the facility which materially increases the potential for the ancillary activities to result in a discharge of significant amounts of pollutants.

e. BMP Plan Review. The permittee shall complete a review and evaluation of the BMP plan at least once every three years from the date of preparation of the BMP plan. Documentation of the BMP Plan review and evaluation shall be signed and dated by the Plant Manager.

B. Stormwater Flow Measurement and Sampling Requirements

1. Stormwater Flow Measurement

a. All stormwater samples shall be collected from the discharge resulting from a storm event that is greater than 0.1 inches.

b. The total volume of stormwater discharged for the event must be monitored, including the date and duration (in hours) and rainfall (in inches) for storm event(s) sampled. The duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event must be a minimum of 72 hours. This information must be recorded as part of the sampling procedure and records retained according to Part I.B. of this permit.

c. The volume may be measured using flow measuring devices, or estimated based on a modification of the Rational Method using total depth of rainfall, the size of the drainage area serving a stormwater outfall, and an estimate of the runoff coefficient of the drainage area. This information must be recorded as part of the sampling procedure and records retained according to Part I.B. of this permit.

2. Stormwater Sampling

a. A grab sample, if required by this permit, shall be taken during the first thirty minutes of the discharge (or as soon thereafter as practicable); and a flow-weighted composite sample, if required by this permit, shall be taken for the entire event or for the first three hours of the event.

b. All test procedures will be in accordance with part I.B. of this permit.

C. EFFLUENT TOXICITY LIMITATIONS AND BIOMONITORING REQUIREMENTS

1. The permittee shall perform short-term chronic toxicity tests on the wastewater discharges required to be tested for chronic toxicity by Part I of this permit.

a. Test Requirements (Definitive Test)

(1) The effluent shall be tested with appropriate replicates of 49% effluent, a control and a minimum of four serial dilutions of 13, 25, 49, 75, and 100% effluent.

(2) Any test result that shows a statistically significant reduction in survival, growth or reproduction between the control and the test at the 95% confidence level indicate chronic toxicity and constitute noncompliance with this permit.

(3) Noncompliance with the toxicity limit will be demonstrated if the IC_{25} (Inhibition Concentration) for reproduction or growth is less than the IWC. The average reproduction for Ceriodaphnia shall be calculated by dividing the total number of live Ceriodaphnia young in each concentration by the total number of organisms used to initiate that concentration; the average growth for the fathead minnows shall be calculated by dividing the total weight of the surviving minnow larvae in each replicate by the total number of organisms used to initiate that replicate.

b. General Test Requirements

(1) A minimum of three (3) 24-hour composite samples shall be obtained for use in the above biomonitoring tests and collected every other day so that the laboratory receives water samples on the first, third, and fifth day of the seven-day test period. The holding time for each composite sample shall not exceed 36 hours. The control water shall be a water prepared in the laboratory in accordance with the EPA procedure described in EPA 821-R-02-013 or the most current edition or another control water selected by the permittee and approved by the Department.

(2) Effluent toxicity tests in which the control survival is less than 80%, P. promelas dry weight per surviving control organism is less than 0.25 mg, Ceriodaphnia number of young per surviving control organism is less than 15, Ceriodaphnia reproduction where less than 60% of surviving control females produce three broods or in which the other requirements of the EPA Test Procedure are not met shall be unacceptable and the permittee shall rerun the tests as soon as practical within the monitoring period.

(3) In the event of an invalid test, upon subsequent completion of a valid test, the results of all tests, valid and invalid, are reported with an explanation of the tests performed and results.

c. Reporting Requirements

(1) The permittee shall notify the Department in writing within 48 hours after toxicity has been demonstrated by the scheduled test(s).

(2) Biomonitoring test results obtained during each monitoring period shall be summarized and reported using the appropriate Discharge Monitoring Report (DMR) form approved by the Department. In accordance with Section 2 of this part, an effluent toxicity report containing the information in Section 2 shall be included with the DMR. Two copies of the test results must be submitted to the Department no later than 28 days after the month in which the tests were performed.

d. Additional Testing Requirements

(1) If chronic toxicity is indicated (noncompliance with permit limit), the permittee shall perform two additional valid chronic toxicity tests in accordance with these procedures to determine the extent and duration of the toxic condition. The toxicity tests shall run consecutively beginning on the first calendar week following the date on which the permittee became aware of the permit noncompliance and the results of these tests shall be submitted no later than 28 days following the month in which the tests were performed.

(2) After evaluation of the results of the follow-up tests, the Department will determine if additional action is appropriate and may require additional testing and/or toxicity reduction measures. The permittee may be required to perform a Toxicity Identification Evaluation (TIE) and/or a Toxicity Reduction Evaluation (TRE). The TIE/TRE shall be performed in accordance with the most recent protocols/guidance outlined by EPA (e.g., EPA/600/2-88/062, EPA/600/R-92/080, EPA/600/R-91-003, EPA/600/R-92/081, EPA/833/B-99/022 and/or EPA/600/6-91/005F, etc.)

e. Test Methods

(1) The tests shall be performed in accordance with the latest edition of the "EPA Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Freshwater Organisms". The Larval Survival and Growth Test, Methods 1000.0, shall be used for the fathead minnow (*Pimephales promelas*) test and the Survival and Reproduction Test, Method 1002.0, shall be used for the cladoceran (*Ceriodaphnia dubia*) test.

2. Effluent Toxicity Testing Reports

The following information shall be submitted with each discharge monitoring report unless otherwise directed by the Department. The Department may at any time suspend or reinstate these requirements or may decrease or increase the frequency of submittals.

a. Introduction

(1) Facility name, location, and county

(2) Permit number

(3) Toxicity testing requirements of permit

(4) Name of receiving water body

(5) Contract laboratory information (if tests are performed under contract)

(a) Name of firm
(b) Telephone number
(c) Address

(6) Objective of test.

b. Plant Operation

(1) Discharge Operating schedule (if other than continuous)

(2) Volume of discharge during sample collection to include Mean daily discharge on sample collection dates (MGD, CFS, GPM)

(3) Design flow of treatment facility at time of sampling

c. Source of Effluent and Dilution Water

(1) Effluent samples

(a) Sampling point
(b) Sample collection dates and times (to include composite sample start and finish times)
(c) Sample collection method
(d) Physical and chemical data of undiluted effluent samples (water temperature, pH, alkalinity, hardness, specific conductance, total residual chlorine (if applicable), etc.)
(e) Lapsed time from sample collection to delivery
(f) Lapsed time from sample collection to test initiation
(g) Sample temperature when received at the laboratory

(2) Dilution Water

(a) Source
(b) Collection/preparation date(s) and time(s)
(c) Pretreatment (if applicable)
(d) Physical and chemical characteristics (water temperature, pH, alkalinity, hardness, specific conductance, etc.)

d. Test Conditions

(1) Toxicity test method utilized

(2) End point(s) of test

(3) Deviations from referenced method, if any, and reason(s)

(4) Date and time test started

(5) Date and time test terminated

(6) Type and volume of test chambers

(7) Volume of solution per chamber

(8) Number of organisms per test chamber

(9) Number of replicate test chambers per treatment

(10) Test temperature, pH, and dissolved oxygen as recommended by the method (to include ranges)

(11) Specify if aeration was needed

(12) Feeding frequency, amount, and type of food

(13) Specify if (and how) pH control measures were implemented

(14) Light intensity (mean)

e. Test Organisms

(1) Scientific name

(2) Life stage and age

(3) Source

(4) Disease(s) treatment (if applicable)

f. Quality Assurance

(1) Reference toxicant utilized and source

(2) Date and time of most recent chronic reference toxicant test(s), raw data and current control chart(s). The most recent chronic reference toxicant test shall be conducted within 30 days of the routine.

(3) Dilution water utilized in reference toxicant test

(4) Results of reference toxicant test(s) (NOEC, IC25, PASS/FAIL, etc.), report concentration response relationship and evaluate test sensitivity

(5) Physical and chemical methods utilized

g. Results

(1) Provide raw toxicity data in tabular form, including daily records of affected organisms in each concentration (including controls) and replicate

(2) Provide table of endpoints: NOECs, IC25s, PASS/FAIL, etc. (as required in the applicable NPDES permit)

(3) Indicate statistical methods used to calculate endpoints

(4) Provide all physical and chemical data required by method

(5) Results of test(s) (NOEC, IC25, PASS/FAIL, etc.), report concentration-response relationship (definitive test only), report percent minimum significant difference (PMSD) calculated for sub-lethal endpoints determined by hypothesis testing.

h. Conclusions and Recommendations

(1) Relationship between test endpoints and permit limits

(2) Actions to be taken

1/ Adapted from "Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms", Fourth Edition, October 2002 (EPA 821-R-02-013), Section 10, Report Preparation

D. COOLING WATER INTAKE STRUCTURE (CWIS) REQUIREMENTS

1. The cooling water intake structure used by the Permittee has been evaluated using available information. At this time, the Department has determined that the cooling water intake structure represents the best technology available (40 CFR 125.98(b)(6)) for entrainment to minimize adverse environmental impact in accordance with Section 316(b) of the Federal Clean Water Act (33 U.S.C. section 1326).

2. The Permittee is required to operate and maintain the cooling water intake structure in a manner that minimizes impingement and entrainment levels. Documentation detailing the steps that have and are being taken to minimize the impingement and entrainment levels shall be maintained on site and made available upon request.

3. Nothing in this permit authorizes take for the purposes of a facility's compliance with the "Endangered Species Act."

4. The Permittee shall submit the information required by the applicable provisions of 40 CFR 122.21(r) at least 180 days prior to the expiration date of this permit. The Permittee may request to reduce the information required, if conditions at the facility and in the waterbody remain substantially unchanged since the previous application so long as the relevant previously submitted information remains representative of current source water, intake structure, cooling water system, and operating conditions. Any habitat designated as critical or species listed as threatened or endangered after issuance of the current permit whose range of habitat or designated critical habit includes waters where a facility intake is located constitutes potential for a substantial change that must be addressed by the owner/operator in subsequent permit applications, unless the facility received an exemption pursuant to 16 U.S.C. 1536(o) or a permit pursuant to 16 U.S.C. 1539(a) or there is no reasonable expectation of take. The Permittee must submit its request for reduced cooling water intake structure and waterbody application information to the Director at least two years and six months prior to the expiration of the NPDES permit. The Permittee's request must identify each element that it determines has not substantially changed since the previous permit application and the basis for the determination. The Director has the discretion to accept or reject any part of the request.

5. The Permittee must keep records of all submissions that are part of the permit application pertaining to the cooling water intake structure until the subsequent permit is issued to the Permittee.

6. The Permittee's permit application must contain readily available information, at the time of permit application development, in identifying all Federally-listed threatened and endangered species and/or designated critical habitat that are or may be present in the action area.

7. The Permittee must conduct weekly visual inspections or employ remote monitoring devices during the period the cooling water intake structures are in operation. This condition is only applicable if control technologies are being employed to comply with final BTA for impingement mortality.

8. The Permittee is required to submit an Annual Certification to the Department no later than January 28th of each year. The Annual Certification shall detail if any changes have been made to impact the operation of the cooling water intake structure.

E. 316(A) THERMAL VARIANCE CONTINUANCE

As specified by Part I.E.3 of the Permit, the Permittee shall conduct a 316(a) study during the permit cycle and submit the results to the Department no later than 365 days prior to the expiration date of this permit. The study submittal shall also include a request for continuation of the CWA Section 316(a) variance for the thermal component of the discharge in accordance with the requirements of 40 CFR Part 125.70 Subpart H – Criteria for Determining Alternative Effluent Limitations Under Section 316(a) of the Act and 40 CFR 122.21(m)(6) Subpart B – Permit Application and Special NPDES Program Requirements, Variance Requests by Non-POTWs.

F. UPSTREAM AND DOWNSTREAM TEMPERATURE MONITORING REQUIREMENTS

1. Upstream Temperature Monitoring Requirements

The Ambient Upstream River Temperature (Deg F) shall be determined by an upstream monitor located in the main channel at approximately River Mile 297.8. Measurements shall be made at 3-foot, 5-foot, and 7-foot depths at least every 15 minutes and then averaged to obtain one "5-foot depth" measurement. In the event of a failure of this monitor, the "5-foot depth" temperature at the monitor located at approximately River Mile 296.1 shall serve as the backup for determining the ambient upstream temperature. The upstream temperatures measurements shall be averaged and reported on a 24-hour calendar day basis.

2. Downstream Temperature Monitoring Requirements

Compliance with the downstream average, maximum, and temp diff between up/down stream (delta) temperature limitations is to be measured at the edge of the mixing zone which shall not exceed the following dimensions:

(1) A maximum length of 2400 feet downstream of the diffusers,
(2) a maximum width of 2,000 feet, and
(3) a maximum length of 150 feet upstream of the diffusers to the top of the diffuser pipes and extends to the bottom downstream of the diffusers.

The downstream temperature measurements are to be made by three monitors located in a line across the reservoir at approximately River Mile 293.45. Temperature measurements are to be recorded at least every 15 minutes at 3-foot, 5-foot, and 7-foot depths and then averaged to obtain a "5-foot depth" measurement. Temperatures at each monitor will be temporally averaged together to determine a singular downstream temperature to be used for determining compliance with the permit requirements.

Edward F. Poolos
Director

Jeffery W. Kitchens
Deputy Director

Kay Ivey
Governor

Alabama Department of Environmental Management
adem.alabama.gov
1400 Coliseum Blvd. 36110-2400 ▪ Post Office Box 301463
Montgomery, Alabama 36130-1463
(334) 271-7700 ▪ FAX (334) 271-7950

FACT SHEET

APPLICATION FOR NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT TO DISCHARGE POLLUTANTS TO WATERS OF THE STATE OF ALABAMA

Date: August 1, 2025

Prepared By: Theo Pinson

NPDES Permit No. AL0022080

1. **Name and Address of Applicant:**

   Tennessee Valley Authority
   Post Office Box 2000, NAB 2A
   Decatur, Alabama 35609

2. **Name and Address of Facility:**

   TVA Browns Ferry Nuclear Plant
   10835 Shaw Road
   Athens, Alabama 35611

3. **Description of Applicant's Type of Facility and/or Activity Generating the Discharge:**

   The facility is a nuclear power plant which generates electricity utilizing three boiling water reactors. A nuclear reaction is used to produce steam which is then used to spin a generator to produce electricity. The total generating capacity of the plant is approximately 3,952 MW.

4. **Applicant's Receiving Waters**

   Receiving Waters Classification

Feature ID	Receiving Water	Classification
001	Tennessee River (Wheeler Lake)	Swimming (S), Fish and Wildlife (F&W)
005	Tennessee River (Wheeler Lake)	Swimming (S), Fish and Wildlife (F&W)
012	Tennessee River (Wheeler Lake)	Swimming (S), Fish and Wildlife (F&W)
013	Tennessee River (Wheeler Lake)	Swimming (S), Fish and Wildlife (F&W)
014	Tennessee River (Wheeler Lake)	Swimming (S), Fish and Wildlife (F&W)
017	Tennessee River (Wheeler Lake)	Swimming (S), Fish and Wildlife (F&W)
018	Tennessee River (Wheeler Lake)	Swimming (S), Fish and Wildlife (F&W)
019	Tennessee River (Wheeler Lake)	Swimming (S), Fish and Wildlife (F&W)
024	Unnamed Tributary to the Tennessee River (Wheeler Lake)	Fish and Wildlife (F&W)

   For the Outfall latitude and longitude, see the permit application.

5. **Permit Conditions:**

   See attached Rationale and Draft Permit.

6. **PROCEDURES FOR THE FORMULATION OF FINAL DETERMINATIONS**

a. Comment Period

The Alabama Department of Environmental Management proposes to issue this NPDES permit subject to the limitations and special conditions outlined above. This determination is tentative.

Interested persons are invited to submit written comments on the draft permit to the following address:

Daphne Y. Lutz, Chief
ADEM-Water Division
1400 Coliseum Blvd
[Mailing Address: Post Office Box 301463; Zip 36130-1463]
Montgomery, Alabama 36110-2400
(334) 271-7823
water-permits@adem.alabama.gov

All comments received prior to the closure of the public notice period (see public notice for date) will be considered in the formulation of the final determination with regard to this permit.

b. Public Hearing

A written request for a public hearing may be filed within the public notice period and must state the nature of the issues proposed to be raised in the hearing. A request for a hearing should be filed with the Department at the following address:

Daphne Y. Lutz, Chief
ADEM-Water Division
1400 Coliseum Blvd
[Mailing Address: Post Office Box 301463; Zip 36130-1463]
Montgomery, Alabama 36110-2400
(334) 271-7823
water-permits@adem.alabama.gov

The Director shall hold a public hearing whenever it is found, on the basis of hearing requests, that there exists a significant degree of public interest in a permit application or draft permit. The Director may hold a public hearing whenever such a hearing might clarify one or more issues involved in the permit decision. Public notice of such a hearing will be made in accordance with ADEM Admin. Code r. 335-6-6-.21.

c. Issuance of the Permit

All comments received during the public comment period shall be considered in making the final permit decision. At the time that any final permit decision is issued, the Department shall prepare a response to comments in accordance with ADEM Admin. Code r. 335-6-6-.21. **The permit record, including the response to comments, will be available to the public via the eFile System** http://app.adem.alabama.gov/eFile/ **or an appointment to review the record may be made by writing the Permits and Services Division at the above address.**

Unless a request for a stay of a permit or permit provision is granted by the Environmental Management Commission, the proposed permit contained in the Director's determination shall be issued and effective, and such issuance will be the final administrative action of the Alabama Department of Environmental Management.

d. Appeal Procedures

As allowed under ADEM Admin. Code chap. 335-2-1, any person aggrieved by the Department's final administrative action may file a request for hearing to contest such action. Such requests should be received by the Environmental Management Commission within thirty days of issuance of the permit. Requests should be filed with the Commission at the following address:

Alabama Environmental Management Commission
1400 Coliseum Blvd
[Mailing Address: Post Office Box 301463; Zip 36130-1463]
Montgomery, Alabama 36110-2400

All requests must be in writing and shall contain the information provided in ADEM Admin. Code r. 335-2-1-.04.

ADEM PERMIT RATIONALE

PREPARED DATE: August 1, 2025
REVISED DATE: September 3, 2025
PREPARED BY: Theo Pinson

Permittee Name: Tennessee Valley Authority

Facility Name: TVA Browns Ferry Nuclear Plant

Permit Number: AL0022080

PERMIT IS A REISSUANCE DUE TO EXPIRATION

DISCHARGE SERIAL NUMBERS (DSN) & DESCRIPTIONS:

DSN	Description
001	The diffuser discharge including discharges from the condenser cooling water system, raw water cooling system, fire protection system, turbine building sumps, reactor building cooling water, and Internal Outfall DSN 01B which includes discharges associated with the liquid radwaste system including low volume wastes
01B	Internal Outfall for discharges associated with the liquid radwaste system including low volume wastes
005	Discharges associated with the residual heat removal service water system
012	Discharges associated with the intake screen backwash system and emergency equipment cooling waters
013	Stormwater runoff associated with electric power generation including runoff from administrative buildings, parking lots, drainage areas around the sedimentation ponds, grassy areas of the plant yard, and Internal Outfalls DSN13A, DSN13B, and DSN13C
13A	Internal Outfall to monitor stormwater discharges associated with electric power generation including runoff from the 4 kV operator yard, the main plant transformer yard, the switchyard, parking lots, grassy areas of the plant yard and also including discharges from the wastewater lagoon system which includes treated sanitary wastewaters, photo development wastewaters, metal processing lab wastewaters, medical lab wastewaters, chiller blowdown, stand-by liquid control system waters, cooler/air compressor cleaning waters, filtered asbestos abatement wastewaters, and stormwater runoff
13B	Internal Outfall to monitor low volume wastewater discharges from the sedimentation pond including the intake building sumps, diesel generator sumps, DI water filter backwash, DI water filtration system wastewaters, miscellaneous low volume wastes, and stormwater runoff associated with electric power generation
13C	Internal Outfall to monitor discharges from the wastewater lagoon system which includes treated sanitary wastewaters, photo development wastewaters, metal processing lab wastewaters, medical lab wastewaters, chiller blowdown, stand-by liquid control system waters, cooler/air compressor cleaning waters, filtered asbestos abatement wastewaters, and stormwater runoff associated with electric power generation including runoff from the 4 kV operator yard, the main plant transformer yard, the switchyard, parking lots, grassy areas of the plant yard
014	Stormwater runoff from the north perimeter of the site generally not associated with industrial activity including run on from surrounding agricultural areas
017	Fire system test/flush waters and stormwater runoff from administrative building, parking lots, non-industrial areas of the plant property
018	Stormwater runoff associated with electric power generation including runoff from the Materials and Procurement Complex parking lot, the firing range parking lot, the facilities maintenance area, the vehicle fuel dispensing area, and grassy areas of the plant yard
019	Stormwater runoff associated with electric power generation including runoff from the borrow pit, the fire training area, the low level radwaste storage facility, the inert landfill, and the 180-day hazardous waste storage area
024	Stormwater runoff associated with electric power generation including runoff from the northeast and east property perimeter, the vehicle service and mechanic shop, and stormwater run on from adjacent grassland and farmland

INDUSTRIAL CATEGORY: 40 CFR Part 423 Steam Electric Power Generating Point Source Category
§423.12 Best Practicable Control Technology Currently Available (BPT)
§423.13 Best Available Technology Economically Achievable (BAT)

MAJOR: **Yes**

STREAM INFORMATION:

Outfalls:	001, 005, 012, 013, 017, 018, 019	024
Receiving Stream:	Tennessee River (Wheeler Lake)	Unnamed Tributary to the Tennessee River (Wheeler Lake)
Classification:	Swimming, Fish and Wildlife	Fish and Wildlife
River Basin:	Tennessee	Tennessee
7Q10:	7,398.85 cfs	0 cfs
7Q2:	11,710.51 cfs	0 cfs
1Q10:	4,696.71 cfs	0 cfs
Annual Average Flow:	46,126.04 cfs	-
303(d) List:	Yes	No
Impairment:	Nutrients, PFOS	Within 24 Hour Travel Time to impairment for Nutrients and PFOS
TMDL:	No	No

DISCUSSION:
The Tennessee Valley Authority Browns Ferry Nuclear Plant generates electricity utilizing three boiling water reactors. A nuclear reaction is used to produce steam which is then used to spin a generator to produce electricity. The total generating capacity of the plant is approximately 3,952 MW.

ADEM Administrative Rule 335-6-10-.12 requires applicants to new or expanded discharges to Tier II waters demonstrate that the proposed discharge is necessary for important economic or social development in the area in which the waters are located. The application submitted by the facility is not for a new or expanded discharge to a Tier II water; therefore, the applicant is not required to demonstrate that the discharge is necessary for economic and social development.

DSN 0011: The diffuser discharge including discharges from the condenser cooling water system, raw water cooling system, fire protection system, turbine building sumps, reactor building cooling water, and Internal Outfall DSN01B which includes discharges associated with the liquid radwaste system including low volume wastes

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency	Sample Type	Seasonal	Basis
Temperature, Water Deg. Fahrenheit (00011) Downstream Monitoring	*****	*****	*****	*****	90 7 Day Average	93 Maximum Daily	deg F	Continuous	Recorder	All Months	316(a)
Temperature, Water Deg. Fahrenheit (00011) Effluent Gross Value	*****	*****	*****	*****	(Report) Daily Average	(Report) Maximum Daily	deg F	Continuous	Recorder	All Months	316(a)
Temperature, Water Deg. Fahrenheit (00011) Upstream Monitoring	*****	*****	*****	*****	(Report) Daily Average	*****	deg F	Continuous	Recorder	All Months	316(a)
pH (00400) Effluent Gross Value	*****	*****	*****	6.0 Minimum Daily	*****	8.5 Maximum Daily	S.U.	Weekly	Grab	All Months	WQBEL
Phosphorus, Total (As P) (00665) Effluent Gross Value	*****	(Report) Maximum Daily	lbs/day	*****	*****	(Report) Maximum Daily	mg/l	Monthly	Grab	All Months	303(d)
Temp Diff Between Up/Down Stream Deg F (03772) Effluent Gross Value	*****	*****	*****	*****	10 Daily Average	(Report) Maximum Daily	deg F	Continuous	Recorder	All Months	316(a)
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	(Report) Monthly Average	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Daily	Pump Log	All Months	BPJ

DSN 0012: Cooling Anomaly Permit Tier - The diffuser discharge including discharges from the condenser cooling water system, raw water cooling system, fire protection system, turbine building sumps, reactor building cooling water, and Internal Outfall DSN01B which includes discharges associated with the liquid radwaste system including low volume wastes

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency	Sample Type	Seasonal	Basis
Temperature, Water Deg. Fahrenheit (00011) Downstream Monitoring	*****	*****	*****	*****	90 7 Day Average	93 Maximum Daily	deg F	Continuous	Recorder	All Months	316(a)
Temperature, Water Deg. Fahrenheit (00011) Effluent Gross Value	*****	*****	*****	*****	(Report) Daily Average	(Report) Maximum Daily	deg F	Continuous	Recorder	All Months	316(a)
Temperature, Water Deg. Fahrenheit (00011) Upstream Monitoring	*****	*****	*****	*****	(Report) Daily Average	*****	deg F	Continuous	Recorder	All Months	316(a)
pH (00400) Effluent Gross Value	*****	*****	*****	6.0 Minimum Daily	*****	8.5 Maximum Daily	S.U.	Weekly	Grab	All Months	WQBEL
Phosphorus, Total (As P) (00665) Effluent Gross Value	*****	(Report) Maximum Daily	lbs/day	*****	*****	(Report) Maximum Daily	mg/l	Monthly	Grab	All Months	303(d)
Temp Diff Between Up/Down Stream Deg F (03772) Effluent Gross Value	*****	*****	*****	*****	(Report) Daily Average	(Report) Maximum Daily	deg F	Continuous	Recorder	All Months	316(a)
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	(Report) Monthly Average	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Daily	Pump Log	All Months	BPJ

DSN 001Q: The diffuser discharge including discharges from the condenser cooling water system, raw water cooling system, fire protection system, turbine building sumps, reactor building cooling water, and Internal Outfall DSN01B which includes discharges associated with the liquid radwaste system including low volume wastes

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency	Sample Type	Seasonal	Basis
Chlorine, Total Residual (50060) Effluent Gross Value	*****	*****	*****	*****	0.024 Monthly Average	0.031 Maximum Daily	mg/l	Quarterly	Grab	All Months	BPJ

DSN 001T: The diffuser discharge including discharges from the condenser cooling water system, raw water cooling system, fire protection system, turbine building sumps, reactor building cooling water, and Internal Outfall DSN01B which includes discharges associated with the liquid radwaste system including low volume wastes

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency	Sample Type	Seasonal	Basis
Toxicity, Ceriodaphnia Chronic (61426) Effluent Gross Value	*****	0 Maximum Daily	pass=0;fail=1	*****	*****	*****	*****	Annually	24-Hr Composite	All Months	WQBEL
Toxicity, Pimephales Chronic (61428) Effluent Gross Value	*****	0 Maximum Daily	pass=0;fail=1	*****	*****	*****	*****	Annually	24-Hr Composite	All Months	WQBEL

DSN 001Y: The diffuser discharge including discharges from the condenser cooling water system, raw water cooling system, fire protection system, turbine building sumps, reactor building cooling water, and Internal Outfall DSN01B which includes discharges associated with the liquid radwaste system including low volume wastes

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency	Sample Type	Seasonal	Basis
Annual Certification Statement (51930) Effluent Gross Value	*****	*****	*****	*****	*****	0 Maximum Daily	Yes=0;No=1	Annually	See Permit Requirements	All Months	BPJ

DSN 01B1: Internal Outfall for discharges associated with the Liquid Radwaste System including low volume wastes

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency	Sample Type	Seasonal	Basis
pH (00400) Effluent Gross Value	*****	*****	*****	6.0 Minimum Daily	*****	9.0 Maximum Daily	S.U.	Monthly	Grab	All Months	ELG
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	30.0 Monthly Average	100.0 Maximum Daily	mg/l	Monthly	Grab	All Months	ELG
Oil & Grease (00556) Effluent Gross Value	*****	*****	*****	*****	15.0 Monthly Average	20.0 Maximum Daily	mg/l	Monthly	Grab	All Months	ELG
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	*****	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Monthly	Estimate	All Months	BPJ

DSN 0051: Discharges associated with the Residual Heat Removal Service Water System

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency	Sample Type	Seasonal	Basis
Temperature, Water Deg. Fahrenheit (00011) Effluent Gross Value	*****	*****	*****	*****	(Report) Monthly Average	(Report) Maximum Daily	deg F	2X Monthly	Grab	All Months	BPJ
pH (00400) Effluent Gross Value	*****	*****	*****	6.0 Minimum Daily	*****	8.5 Maximum Daily	S.U.	2X Monthly	Grab	All Months	WQBEL
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	(Report) Monthly Average	*****	MGD	*****	*****	*****	*****	2X Monthly	Estimate	All Months	BPJ

DSN 013Y: Stormwater runoff associated with electric power generation including runoff from administrative buildings, parking lots, drainage areas around the sedimentation ponds, grassy areas of the plant yard, and Internal Outfalls DSN13A, DSN13B, and DSN13C

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency	Sample Type	Seasonal	Basis
pH (00400) Effluent Gross Value	*****	*****	*****	(Report) Minimum Daily	*****	(Report) Maximum Daily	S.U.	Annually	Grab	All Months	BPJ
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	mg/l	Annually	Grab	All Months	BPJ
Oil & Grease (00556) Effluent Gross Value	*****	*****	*****	*****	*****	15.0 Maximum Daily	mg/l	Annually	Grab	All Months	BPJ
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	*****	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Annually	Estimate	All Months	BPJ

DSN 13AY: Internal Outfall to monitor stormwater discharges associated with electric power generation including runoff from the 4 kV operator yard, the main plant transformer yard, the switchyard, parking lots, grassy areas of the plant yard and also including discharges from the wastewater lagoon system which includes treated sanitary wastewaters, photo development wastewaters, metal processing lab wastewaters, medical lab wastewaters, chiller blowdown, stand-by liquid control system waters, cooler/air compressor cleaning waters, filtered asbestos abatement wastewaters, and stormwater runoff

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency	Sample Type	Seasonal	Basis
pH (00400) Effluent Gross Value	*****	*****	*****	(Report) Minimum Daily	*****	(Report) Maximum Daily	S.U.	Annually	Grab	All Months	BPJ
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	mg/l	Annually	Grab	All Months	BPJ
Oil & Grease (00556) Effluent Gross Value	*****	*****	*****	*****	*****	15.0 Maximum Daily	mg/l	Annually	Grab	All Months	BPJ
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	*****	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Annually	Estimate	All Months	BPJ

DSN 13B1: Internal Outfall to monitor low volume wastewater discharges from the sedimentation pond including the intake building sumps, diesel generator sumps, DI water filter backwash, DI water filtration system wastewaters, miscellaneous low volume wastes, and stormwater runoff associated with electric power generation

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency	Sample Type	Seasonal	Basis
pH (00400) Effluent Gross Value	*****	*****	*****	6.0 Minimum Daily	*****	9.0 Maximum Daily	S.U.	Once per batch	Grab	All Months	ELG
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	30.0 Monthly Average	100.0 Maximum Daily	mg/l	Once per batch	Grab	All Months	ELG
Oil & Grease (00556) Effluent Gross Value	*****	*****	*****	*****	15.0 Monthly Average	20.0 Maximum Daily	mg/l	Once per batch	Grab	All Months	ELG
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	(Report) Monthly Average	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Once per batch	Measured	All Months	BPJ

DSN 13C1: Internal Outfall to monitor discharges from the wastewater lagoon system which includes treated sanitary wastewaters, photo development wastewaters, metal processing lab wastewaters, medical lab wastewaters, chiller blowdown, stand-by liquid control system waters, cooler/air compressor cleaning waters, filtered asbestos abatement wastewaters, and stormwater runoff associated with electric power generation including runoff from the 4 kV operator yard, the main plant transformer yard, the switchyard, parking lots, grassy areas of the plant yard

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency	Sample Type	Seasonal	Basis
BOD, 5-Day (20 Deg. C) (00310) Effluent Gross Value	*****	*****	*****	*****	30.0 Monthly Average	45.0 Maximum Daily	mg/l	2X Monthly	Grab	All Months	EGL
pH (00400) Effluent Gross Value	*****	*****	*****	6.0 Minimum Daily	*****	9.0 Maximum Daily	S.U.	2X Monthly	Grab	All Months	WQBEL/ BPJ
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	90.0 Monthly Average	135.0 Maximum Daily	mg/l	2X Monthly	Grab	All Months	EGL
Phosphorus, Total (As P) (00665) Effluent Gross Value	*****	*****	*****	*****	(Report) Monthly Average	(Report) Maximum Daily	mg/l	2X Monthly	Grab	All Months	303(d)
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	(Report) Monthly Average	(Report) Maximum Daily	MGD	*****	*****	*****	*****	2X Monthly	Instantaneous	All Months	BPJ

DSN 017Y: Fire system test/flush waters and stormwater runoff from administrative building, parking lots, non-industrial areas of the plant property

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency	Sample Type	Seasonal	Basis
pH (00400) Effluent Gross Value	*****	*****	*****	(Report) Minimum Daily	*****	(Report) Maximum Daily	S.U.	Annually	Grab	All Months	BPJ
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	mg/l	Annually	Grab	All Months	BPJ
Oil & Grease (00556) Effluent Gross Value	*****	*****	*****	*****	*****	15.0 Maximum Daily	mg/l	Annually	Grab	All Months	BPJ
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	*****	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Annually	Calculated	All Months	BPJ
Chlorine, Total Residual (50060) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	mg/l	Annually	Grab	All Months	BPJ

DSN 018Y: Stormwater runoff associated with electric power generation including runoff from the Materials and Procurement Complex parking lot, the firing range parking lot, the facilities maintenance area, the vehicle fuel dispensing area, and grassy areas of the plant yard

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency	Sample Type	Seasonal	Basis
pH (00400) Effluent Gross Value	*****	*****	*****	(Report) Minimum Daily	*****	(Report) Maximum Daily	S.U.	Annually	Grab	All Months	BPJ
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	mg/l	Annually	Grab	All Months	BPJ
Oil & Grease (00556) Effluent Gross Value	*****	*****	*****	*****	*****	15.0 Maximum Daily	mg/l	Annually	Grab	All Months	BPJ
Toluene (34010) Effluent Gross Value	*****	*****	*****	*****	*****	8723 Maximum Daily	ug/l	Annually	Grab	All Months	BPJ
Benzene (34030) Effluent Gross Value	*****	*****	*****	*****	*****	15.47 Maximum Daily	ug/l	Annually	Grab	All Months	BPJ
Ethylbenzene (34371) Effluent Gross Value	*****	*****	*****	*****	*****	1244 Maximum Daily	ug/l	Annually	Grab	All Months	BPJ
Naphthalene (34696) Effluent Gross Value	*****	*****	*****	*****	*****	600 Maximum Daily	ug/l	Annually	Grab	All Months	BPJ
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	*****	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Annually	Estimate	All Months	BPJ
Xylene (81551) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	ug/l	Annually	Grab	All Months	BPJ

DSN 019Y: Stormwater runoff associated with electric power generation including runoff from the borrow pit, the fire training area, the low level radwaste storage facility, the inert landfill, and the 180-day hazardous waste storage area.

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency	Sample Type	Seasonal	Basis
pH (00400) Effluent Gross Value	*****	*****	*****	(Report) Minimum Daily	*****	(Report) Maximum Daily	S.U.	Annually	Grab	All Months	BPJ
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	mg/l	Annually	Grab	All Months	BPJ
Oil & Grease (00556) Effluent Gross Value	*****	*****	*****	*****	*****	15.0 Maximum Daily	mg/l	Annually	Grab	All Months	BPJ
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	*****	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Annually	Estimate	All Months	BPJ
Chemical Oxygen Demand (COD) (81017) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	mg/l	Annually	Grab	All Months	BPJ

DSN 024Y: Stormwater runoff associated with electric power generation including runoff from the northeast and east property perimeter, the vehicle service and mechanic shop, and stormwater run on from adjacent grassland and farmland

Parameter	Quantity or Loading		Units	Quality or Concentration			Units	Sample Frequency	Sample Type	Seasonal	Basis
pH (00400) Effluent Gross Value	*****	*****	*****	(Report) Minimum Daily	*****	(Report) Maximum Daily	S.U.	Annually	Grab	All Months	BPJ
Solids, Total Suspended (00530) Effluent Gross Value	*****	*****	*****	*****	*****	(Report) Maximum Daily	mg/l	Annually	Grab	All Months	BPJ
Oil & Grease (00556) Effluent Gross Value	*****	*****	*****	*****	*****	15.0 Maximum Daily	mg/l	Annually	Grab	All Months	BPJ
Flow, In Conduit or Thru Treatment Plant (50050) Effluent Gross Value	*****	(Report) Maximum Daily	MGD	*****	*****	*****	*****	Annually	Estimate	All Months	BPJ

*Basis for Permit Limitation

- BPJ – Best Professional Judgment
- WQBEL – Water Quality Based Effluent Limits
- EGL – Federal Effluent Guideline Limitations
- 316(a) – Thermal Variance
- 303(d) – 303(d) List of Impaired Waters

Best Professional Judgment (BPJ)
The parameters of concern based upon BPJ for this facility are based on the parameters of concern listed in the permit application and from the current permit. These parameters are consistent with similar facilities in the state and have been proven to be reflective of the operations at this facility.

Water Quality Based Effluent Limits (WQBEL)
The parameters of concern based upon WQBEL have requirements that have been developed based on specific water quality criteria.

Federal Effluent Guideline Limitations (EGL)
The parameters of concern based upon ELG have had effluent guidelines established under 40 CFR Part 423.12 and 40 CFR Part 423.13. In accordance with 40 CFR Part 423, there shall be no discharge of polychlorinated biphenyl compounds such as those commonly used for transformer fluid. The Department believes that monitoring for PCBs is not necessary to determine compliance with the PCB prohibition since the expected source of PCBs in the discharge would be due to leaks or spills which are addressed by the BMP and SPCC permit conditions.

303(d) List of Impaired Waters/Total Maximum Daily Load (TMDL)
The Tennessee River is listed on the 303(d) List of Impaired Waters for nutrients and PFOS. The discharge is not expected to contribute to the PFOS impairment. The Department has proposed phosphorus monitoring requirements on the 0011, 0012, and 13C1 monitoring points to evaluate the discharge of nutrients from the facility.

Best Management Practices (BMPs)
BMPs are believed to be the most effective way to control the contamination of stormwater from areas of industrial activities. This facility is required to maintain a BMP plan. The requirements of the BMP plan call for minimization of stormwater contact with waste materials, products and by-products, and for prevention of spills or loss of fluids from equipment maintenance activities. The effectiveness of the BMPs will be measured through the monitoring of the pollutants of concern.

Outfall DSN001
Monitoring Points: 0011, 0012, 001Q, 001T, 001Y
Internal Monitoring Point: 01B1
Outfall DSN001 is discharged through a diffuser system to the Tennessee River and includes discharges from the condenser cooling water system, raw water cooling system, fire protection system, turbine building sumps, reactor building cooling water, and Liquid Radwaste System (DSN01B). The purpose of Monitoring Points 0011 and 0012 is to provide a permit tier for differing temperature requirements for which applicability is dependent on the upstream temperature conditions. Internal Monitoring Point 01B1 has been proposed to be continued to demonstrate compliance with effluent guideline limitations for low volume wastewaters prior to comingling with other wastewaters. The Department completed a numeric reasonable potential analysis of the 001 discharge and determined that no additional parameters are expected to exceed water quality criteria.

The facility utilizes a once-through condenser circulating water (CCW) system with seven helper cooling towers to dissipate waste heat, withdrawing cooling water from the Tennessee River through an intake structure and discharging the cooling waters back to the Tennessee River through a multiport diffuser system. The maximum flow rate of the CCW system for all three units is approximately 3,171 MGD. The long-term average discharge of the system is approximately 3044.2 MGD.

Temperature – 316(a) Thermal Variance
The proposed temperature limitations are based on a Clean Water Act (CWA) Section 316(a) Thermal Variance. State and Federal regulations provide that the Department may impose alternative and less stringent thermal limitations after demonstration by the Permittee that such limitations will assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife, in and on the body of water to which the discharge is made. The permit application included a demonstration justifying continuation of the thermal variance. Based on the information required to be submitted to the Department to justify continuance of the variance, the Department has determined that a balanced and indigenous population (BIP) is being maintained in and on the Tennessee River (Wheeler Lake) in the vicinity of the discharge.

The proposed alternative thermal limits for Outfall DSN001 are based on a 316(a) Thermal Variance that was previously approved by EPA and requirements based on the variance have been incorporated into subsequent permit reissuances. The proposed alternate thermal limitations include

- A rolling 7 - day average of 90 °F,
- A maximum 1-hour average of 93 °F, and
- A maximum delta temperature rise of 10 °F over upstream ambient temperature based on the daily 24-hour calendar day average with a permit tier to account for natural cooling anomaly conditions.

Previously, the 90° F average temperature has been applied as a 24-hour average. The Permittee has requested that the 90° F average limitation be applied as a rolling 7-day average to be consistent with available guidance for thermal variances and requirements in other NPDES permits. Additionally, the Permittee provided documentation supporting the request which has been included with the permit application. 7 Day Average as it applies to temperature means a rolling arithmetic mean of all continuous temperature measurements collected over a consecutive rolling 7-day (168 hour) period. The rolling 7 Day Average is to be calculated every 15 minutes using data collected during the preceding 672 15-minute intervals where the oldest data point falls off as new data is collected. The Permittee shall report the maximum 7-Day Average calculated during the monitoring period on the DMR. The calculated 7 Day Average values shall be reported for the monitoring period in which the most recent data point used in the calculation occurs.

Compliance with the downstream average, maximum, and delta temperature limitations is to be measured at the edge of the mixing zone which shall not exceed the following dimensions:

(1) A maximum length of 2400 feet downstream of the diffusers,
(2) a maximum width of 2,000 feet, and
(3) a maximum length of 150 feet upstream of the diffusers to the top of the diffuser pipes and extends to the bottom downstream of the diffusers.

The downstream temperature measurements are to be made by three monitors located in a line across the reservoir at approximate river mile 293.45. Temperature measurements are to be recorded at least every 15 minutes at 3-, 5-, and 7-foot depths and then averaged to obtain a 5-foot depth measurement. Temperatures at each monitor will be temporally averaged together to determine a singular downstream temperature to be used for compliance with the permit requirements.

The Ambient Upstream River Temperature (Deg F) shall be determined by an upstream monitor located in the main channel at approximately River Mile 297.8. Measurements shall be made at 3-foot, 5-foot, and 7-foot depths at least every 15 minutes and then averaged to obtain one "5-foot depth" measurement. In the event of a failure of this monitor, the "5-foot" depth temperature at the monitor located at approximately River Mile 296.1 shall serve as the backup for determining the ambient upstream temperature. The upstream temperatures measurements shall be averaged and reported on a 24-hour calendar day basis.

The permit proposes two permit tiers which determine the applicability of the delta 10°F temperature limitation. Permit Tier 0011 includes a delta limitation of 10°F for the rise of the downstream temperature over the ambient upstream temperature. Permit Tier 0012 does not require the delta 10°F limitation. Permit Tier 0011 is generally expected to be applicable the majority of the time. Permit Tier DSN0012 has been proposed to be continued in this reissuance to account for natural cooling anomaly conditions that may occur in the receiving stream upstream of the discharge effecting the measured upstream ambient water temperature. When weather or other events cause cooling of the ambient upstream river temperature at a rate of greater than 0.5°F per day based on a 6-hour trend, a cooling anomaly condition exists and the requirements of DSN0012 are applicable. The duration of this exclusion shall be limited to a point in time 6 hours from the time of the last upstream ambient measurement that indicates a qualifying cooling anomaly condition.

The Department believes that the monitoring previously completed by the Permittee and proposed in this permit at the established sampling locations and the Permittee's 316(a) studies are sufficient to make a determination that a BIP is being maintained; however, the Department is requiring the Permittee to conduct another 316(a) study during the permit cycle to justify further continuance of the variance in future permits.

Part I.E.3 of the proposed Permit requires that a 316(a) study plan be submitted to the Department for review within 365 days of the effective date of this permit and be revised as soon as practical based upon subsequent receipt of comments from the Department. After the study plan has been approved by the Department, the Permittee is to complete the study and submit the results to the Department no later than 365 days prior to the expiration date of this permit. The study submittal is required to include a request for continuation of the CWA Section 316(a) variance for the thermal component of the discharge in accordance with the requirements of 40 CFR Part 125.70 Subpart H – Criteria for Determining Alternative Effluent Limitations Under Section 316(a) of the Act and 40 CFR 122.21(m)(6) Subpart B – Permit Application and Special NPDES Program Requirements, Variance Requests by Non-POTWs.

Certification Statement – 001Y

The Department has proposed the submittal of an annual certification statement whereby the Permittee certifies that the facility has operated and maintained the cooling water intake structure and cooling water heat dissipation system in a manner that minimizes impingement, entrainment, and adverse environmental impacts. The certification should take into account the operation and performance efficiency of the cooling towers while balancing the need for maintenance outages, unanticipated equipment failures, safety concerns, and cost benefit analysis. The facility should utilize best management practices and standard operating procedures to optimize performance of the cooling water intake and heat dissipation systems to ensure the facility meets its cooling needs at maximum operation under adverse environmental conditions such as warm source waterbody temperatures.

pH

ADEM Administrative Code, Division 6 Regulations, specifically 335-6-10-.09(3)(c)2 – Specific Water Quality for Swimming, Fish and Wildlife classified streams states: "Sewage, industrial waste or other wastes shall not cause the pH to deviate more than one unit from then normal or natural pH, nor be less than 6.0, nor greater than 8.5 standard units."

Total Residual Chlorine (TRC),

The average and maximum TRC limitations are based on BPJ and have been proposed to be continued from the previous permit. The limitations are more stringent than limitations calculated based on EPA's recommended water quality criteria which considers the available dilution in the receiving stream.

$$\text{Acute Instream Waste Concentration (AIWC)} = \frac{Qw}{1Q10 + Qw}$$

$$\text{AIWC} = 0.5007 = \frac{3044.2 \text{ MGD}}{3035.56 \text{ MGD} + 3044.2 \text{ MGD}}$$

TRC Maximum = 0.019/AIWC 0.019/0.5007 = 0.0379 mg/l

The maximum limitation of 0.031 mg/l from the previous permit is more stringent and has been proposed to be continued.

$$\text{Chronic Instream Waste Concentration (CIWC)} = \frac{Qw}{7Q10 + Qw}$$

$$\text{CIWC} = 0.389 = \frac{3044.2 \text{ MGD}}{4782 \text{ MGD} + 3044.2 \text{ MGD}}$$

TRC Average = 0.011/CIWC 0.011/0.389 = 0.0283 mg/l

The average limitation of 0.024 mg/l from the previous permit is more stringent and has been proposed to be continued.

In accordance with a letter dated August 11, 1998 from EPA Headquarters and a 1991 memorandum from EPA Region 4's Environmental Services Division (ESD), due to testing and method detection limitations, a Total Residual Chlorine measurement below 0.05 mg/L shall be considered below detection for compliance purposes.

Chlorination Duration

40 CFR Parts 423.12 and 423.13 state, "Neither free available chlorine nor total residual chlorine may be discharged from any unit for more than two hours in any one day and not more than one unit in any plant may discharge free available or total residual chlorine at any one time unless the utility can demonstrate to the Regional Administrator or State, if the State has NPDES permit issuing authority, that the units in a particular location cannot operate at or below this level or chlorination." The Permittee has indicated that more frequent chlorination may be needed to combat microbiological growth in the cooling water system.

Free Available Chlorine

40 CFR Parts 423.12 and 423.13 stipulate free available chlorine limitations for once through cooling waters and cooling tower blowdown. The proposed total residual chlorine limitations are significantly more stringent than the guideline free available chlorine limitations. The Department believes that compliance with the proposed BPJ based total residual chlorine limitations is expected to demonstrate that the Permittee is in compliance with the less stringent free available chlorine effluent guidelines.

Chronic Toxicity Biomonitoring

Testing is proposed diluted to the instream waste concentration (IWC) expressed as a percentage which has been rounded up for toxicity testing purposes. The Department has proposed continuing the IWC of 49% from the previous permit because it is more stringent than the IWC calculated based on the permit application. Chronic toxicity testing has been proposed because the IWC is greater than 1%.

The discharge of biocides and corrosion inhibitors with cooling tower blowdown can introduce the potential for toxicity in receiving waters. The facility is expected to verify that the use of these chemicals will not present potential toxic effects to representative organisms in the receiving waters and to ensure that the chemicals are used in a manner that is consistent with their labeling and standard industry practices. The Permittee should refer to Part I.D.5 of the permit for further requirements regarding Cooling Water and Boiler Water Additives.

Phosphorus

Monitoring requirements have been proposed based on the 303(d) listing of the receiving stream for nutrients.

Internal Outfall 01B

Outfall 01B is an Internal Outfall to the Outfall 001 diffuser discharge for demonstrating compliance with the effluent guidelines for low volume wastes prior to comingling with the cooling water discharge. The proposed limitations for TSS, Oil and Grease, and pH are consistent with the 40 CFR Part 423.12 (BPT) requirements for low volume wastes.

Outfall DSN005

Monitoring Point: 0051

Discharges associated with the Residual Heat Removal Service Water System are monitored and discharged through Outfall DSN005. The Residual Heat Removal Service Water System is used during shutdown operations to remove heat from process equipment. This is an intermittent discharge. The waters are in a close loop system and typically, the water in the system is discharged/replaced on a quarterly basis. The wording used for the monitoring frequency has been updated from "Bi-Weekly" to "2X Monthly" to provide greater clarity on the proposed requirements. A footnote has been proposed stating that twice per month monitoring shall be conducted so that two samples are collected in the same month at least 10 days apart.

pH

ADEM Administrative Code, Division 6 Regulations, specifically 335-6-10-.09(3)(c)2 – Specific Water Quality for Swimming, Fish and Wildlife classified streams states: "Sewage, industrial waste or other wastes shall not cause the pH to deviate more than one unit from then normal or natural pH, nor be less than 6.0, nor greater than 8.5 standard units."

Chlorine

The Permittee indicated that chlorine is not expected to be present in the discharge on the permit application. It was previously determined that categorical effluent guideline requirements for chlorine are not applicable to this discharge.

Temperature

Temperature is not expected to be a parameter of concern for the Residual Heat Removal Service Water System discharge based on the temperature data submitted in the permit application and the intermittent nature of the discharge. The waters are in a close loop system and typically, the water in the system is discharged/replaced on a quarterly basis. The application indicated that the waters should be expected to be around ambient temperature when discharged.

Outfall DSN012

Monitoring Point: No Sampling Requirements Proposed

Discharges associated with the intake screen backwash system and emergency equipment cooling waters are discharged through Outfall 012. Monitoring requirements have not been proposed other than narrative requirements that the discharge shall have no sheen, and there shall be no discharge of visible oil, floating solids or visible foam in other than trace amounts. There are no pollutants of concern expected to be added to the discharge from the backwash operations. The backwash system does not utilize chemical treatment. The Permittee indicated that there may be small quantities (<10% of flow) of treated emergency equipment cooling water which also discharge through this outfall.

Outfall DSN013

Monitoring Point: 013Y

Internal Monitoring Points: 13AY, 13B1, 013C1

The Outfall 013 discharge includes stormwater runoff associated with electric power generation including runoff from administrative buildings, parking lots, drainage areas around the sedimentation ponds, grassy areas of the plant yard, and Internal Outfalls DSN13A, DSN13B, and DSN13C. The Permittee operates a lagoon system to treat sanitary wastewaters and a sedimentation pond to treat low volume wastewaters generated from a water treatment process. The wastewaters from the sedimentation pond are discharged through 13B and the wastewaters from the lagoon system are discharged through 13A/13C. It should be noted that Internal Outfalls 13A and 13C correspond to the same physical location with 13A to be collected during a storm event and 13C not to be captured during a storm event. Additionally, it should be noted that while Internal Outfalls 13A, 13B, and 13C are internal and not at the final Outfall 013 discharge location; however, they have been evaluated as final Outfalls because the Permittee is not able to monitor Outfall 013 after the combination of each Internal Outfall. 13A, 13B, and 13C have been included in the description of discharge for Outfall 013; however, those internal outfalls have not yet discharged to the conveyance at the location where Outfall 013 is sampled. The Department completed a numeric reasonable potential analysis of both the 13A/13C and 13B discharges and determined that no additional parameters are expected to exceed water quality criteria.

Requirements for Outfall 013 are proposed to evaluate stormwater discharges associated with electric power generation. At the Outfall 013 monitoring location, the discharge is comprised entirely of stormwater runoff (the internal outfalls enter the conveyance after this location). The Department has proposed annual monitoring requirements to be collected during a qualifying storm event as described in Part IV.B of the Permit. Monitoring for DSN013Y is to be conducted at the culvert discharging into the Outfall 013 conveyance located to the south of the sedimentation ponds and west of the nearby plant road going to the training center.

Requirements for Internal Outfall 13A are proposed to evaluate stormwater discharges associated with electric power generation including runoff from the 4 kV operator yard, the main plant transformer yard, the switchyard, parking lots, grassy areas of the plant yard and also including discharges from the wastewater lagoon system which includes

treated sanitary wastewaters, photo development wastewaters, metal processing lab wastewaters, medical lab wastewaters, chiller blowdown, stand-by liquid control system waters, cooler/air compressor cleaning waters, filtered asbestos abatement wastewaters, and stormwater runoff. The capacitor yard, the transformer yard, and the switchyard contain only non-PCB, oil-filled equipment. The transformer yard contains two 37,000-gallon mineral oil tanks (abandoned in place) and one 1,500-gallon above-ground diesel storage tank. Outfall 013A has a concrete oil skimmer and weir to provide secondary containment to prevent oily discharges. The Department has proposed annual monitoring requirements to be collected during a qualifying storm event as described in Part IV.B of the Permit.

Requirements for Internal Outfall 13B are proposed to evaluate low volume wastewater discharges from the sedimentation pond including the intake building sumps, diesel generator sumps, DI water filter backwash, DI water filtration system wastewaters, miscellaneous low volume wastes, and stormwater runoff associated with electric power generation. The Department completed a numeric reasonable potential analysis of the 13B discharge and determined that no additional parameters are expected to exceed water quality criteria.

Requirements for Internal Outfall 13C are proposed to evaluate discharges from the wastewater lagoon system which includes treated sanitary wastewaters, photo development wastewaters, metal processing lab wastewaters, medical lab wastewaters, chiller blowdown, stand-by liquid control system waters, cooler/air compressor cleaning waters, filtered asbestos abatement wastewaters, and stormwater runoff associated with electric power generation including runoff from the 4 kV operator yard, the main plant transformer yard, the switchyard, parking lots, grassy areas of the plant yard. The Permittee indicated that further treatment is provided after discharge from the lagoon system and prior to discharge at Outfall 13A; therefore, the monitoring location for 13C is the same as 13A with the caveat that 13C samples should be collected during dry weather. Due to the nature of the discharge conveyance, stormwater may still be expected to always be in the discharge; however, the purpose of the 13C monitoring requirements is to evaluate the treatment of process wastewater discharges. The Department completed a numeric reasonable potential analysis of the 13C discharge and determined that no additional parameters are expected to exceed water quality criteria.

Oil & Grease

The Outfall 13A daily maximum limit for Oil and Grease should prevent the occurrence of a visible sheen in the stream and has been shown to be achievable through the use of proper BMPs.

BOD and TSS

Specific limitations for BOD and TSS have been applied at Outfall 13C based on secondary treatment standards as required under ADEM Admin. Code r. 335-6-10-.08 in accordance with the 40 CFR 133.102 requirements. The maximum limitations have been proposed as a daily maximum value in lieu of a 7-day average based on the required sampling frequency.

pH

ADEM Administrative Code, Division 6 Regulations, specifically 335-6-10-.09(3)(c)2 – Specific Water Quality for Swimming, Fish and Wildlife classified streams states: "Sewage, industrial waste or other wastes shall not cause the pH to deviate more than one unit from then normal or natural pH, nor be less than 6.0, nor greater than 8.5 standard units." An upper limitation 9.0 S.U. has been proposed at Outfall 13B and 13C based on the available dilution in the receiving stream and is consistent with the 40 CFR Part 423 effluent guideline requirements.

Low Volume Waste Guidelines

The proposed 13B limitations for TSS, Oil and Grease, and pH are consistent with the 40 CFR Part 423.12 (BPT) requirements for low volume wastes.

Outfall DSN014

Monitoring Point: No Sampling Requirements Proposed

Outfall 014 includes stormwater runoff from the north perimeter of the site generally not associated with industrial activity including run on from surrounding agricultural areas. Outfall 014 is located northwest of the cooling towers, and receives drainage from two roads (approximately 5 acres), grassland (approximately 174 acres), and offsite farmland located on the north and northwest sides of the facility. Monitoring requirements have not been proposed other than narrative requirements that the discharge shall have no sheen, and there shall be no discharge of visible oil, floating solids or visible foam in other than trace amounts.

Outfall DSN017

Monitoring Point: 017Y

Outfall 017 discharges fire system test/flush waters and stormwater runoff from administrative building, parking lots, non-industrial areas of the plant property. The outfall discharges stormwater runoff from an approximately 6-acre area (approximately 3 acres of which is impervious area) which includes the Training Center and the Live Well Center parking lots, the Training Center roof, and grassed/wooded land. In addition to stormwater, DSN 017 receives fire system flush waters. Monitoring has been proposed on an annual basis during non-storm events to evaluate discharges of the fire system flush waters. The application indicated that this fire protection system is flushed at least annually, and the source of the water used for fire protection is potable water. Flow rates during flushes are approximately 150 gallons per minute and typically last between 15 and 30 minutes for an approximate maximum discharge of 5,000 gallons per day. Lower volume discharges may be expected to occur as needed after system operation testing or fire protection system maintenance.

Oil & Grease

The daily maximum limit for Oil and Grease should prevent the occurrence of a visible sheen in the stream and has been shown to be achievable through the use of proper BMPs.

Monitor Only Parameters

Monitoring has been proposed without numeric limitations for indicator parameters to evaluate the effectiveness of the facility BMP plan.

Chlorine

Chlorine is not expected to be a parameter of concern based on the infrequent nature of the discharge and the expected discharge volume.

Outfall DSN018

Monitoring Point: 018Y

Outfall 018 discharges stormwater runoff associated with electric power generation including runoff from the Materials and Procurement Complex parking lot, the firing range parking lot, the facilities maintenance area, the vehicle fuel dispensing area, and grassy areas of the plant yard.

Oil & Grease

The daily maximum limit for Oil and Grease should prevent the occurrence of a visible sheen in the stream and has been shown to be achievable through the use of proper BMPs.

Benzene, Toluene, Ethylbenzene, Xylene, Naphthalene

Stormwater monitoring for benzene, toluene, ethylbenzene, xylene and naphthalene is due to the presence of diesel fueling and storage operations in the Outfall DSN0018 drainage area. Spills from petroleum handling areas have been shown to contain levels of volatile organics, specifically naphthalene, benzene, toluene, ethylbenzene and xylene (BTEX). The proposed limitations are based on BPJ and are consistent with the requirements for similar activities at similar facilities in the state. The previous permit required reporting a combined BTEX calculated number which was a sum of naphthalene, benzene, toluene, ethylbenzene and xylene. The Department has proposed reporting each of the individual BTEX components separately.

Monitor Only Parameters

Monitoring has been proposed without numeric limitations for indicator parameters to evaluate the effectiveness of the facility BMP plan.

Outfall DSN019

Monitoring Point: 019Y

Outfall 019 discharges stormwater runoff associated with electric power generation including runoff from the borrow pit, the fire training area, the low level radwaste storage facility, the inert landfill, and the 180 day hazardous waste storage area. These areas contain kerosene, gasoline, and diesel tanks; a flammable storage area; Facilities Satellite Storage area; a diesel fire pump and fuel tank; oil and used drum storage areas; and hazardous and mixed waste storage area.

Oil & Grease
The daily maximum limit for Oil and Grease should prevent the occurrence of a visible sheen in the stream and has been shown to be achievable through the use of proper BMPs.

Monitor Only Parameters
Monitoring has been proposed without numeric limitations for indicator parameters to evaluate the effectiveness of the facility BMP plan.

Outfall DSN024
Monitoring Point: 024Y
Outfall 024 discharges stormwater runoff associated with electric power generation including runoff from the northeast and east property perimeter, the vehicle service and mechanic shop, and stormwater run on from adjacent grassland and farmland. The shop includes a covered storage area for solvents, oils, and lubricants.

Oil & Grease
The daily maximum limit for Oil and Grease should prevent the occurrence of a visible sheen in the stream and has been shown to be achievable through the use of proper BMPs.

Monitor Only Parameters
Monitoring has been proposed without numeric limitations for indicator parameters to evaluate the effectiveness of the facility BMP plan.

Cooling Water Intake Structure (CWIS) Requirements
Section 316(b) of the Clean Water Act requires that facilities minimize adverse environmental impacts resulting from the operation of cooling water intake structures (CWIS) by using the "Best Technology Available" (BTA). All of those facilities including those not specifically addressed by the rules, must be evaluated for 316(b) compliance. For those facilities not addressed in Phase I, II, or III rules, a BTA determination must be made using "Best Professional Judgment" (BPJ) under the authority of 40 CFR §§ 125 Subpart J and 401.14. The Department has made a determination that the CWIS utilized by the Permittee is subject to the 316(b) Phase II requirements.

The CWIS has a maximum capacity to withdraw 3,171 MGD which is approximately 11% of the annual average flow of the Tennessee River. The actual long term average intake flow is approximately 3044.2 MGD. The intake channel extends approximately 500 ft from the intake structure to Gate Structure No. 3, which acts as a skimmer wall for cooling water drawn into the plant. Water is drawn into the intake channel through the lower portion of the wall through three 40-ft wide by about 24-ft high sections, enabling the facility to withdraw cooler water from the lower stratum. The three open sections have movable, motor-operated wheel gates with bottom elevations that can vary between 527 ft msl and 547 ft msl. The intake pumping station is comprised of a concrete pumping structure 232 ft long by 117 ft wide and 47 ft high, and includes 18 bays, 6 per unit, each having a traveling screen. Each bay has a net opening of 8 ft 8 inches (in) by 20 ft. The bottom elevation of the pumping station is at 517 ft msl. Each unit has three vertical, nonpullout-type, single-stage, mixed-flow, wet-pit-type circulating water pumps. Suction for these pumps is provided to 532 ft msl. Each pump discharge is equipped with motor-operated butterfly valves. The pumps are installed in separate pump bays that are each covered by two trash racks and two traveling screens. The screens are each 7.5 ft wide with 3/8 in mesh openings.

The flow velocity through the skimmer wall openings varies depending on the gate position. When the gates are in a full open position, the average flow velocity through the openings is about 0.6 fps for the operation of one unit, 1.1 fps for the operation of two units, and 1.7 fps for the operation of all three units. The traveling screens and screen wash system can be operated automatically or manually. The design through-screen velocity is 2.1 fps at normal minimum pool and 1.6 fps at normal high pool. Differential pressure across each pair of traveling screens for a given pump is monitored. When operating the system in the automatic mode, the screen wash pump is started when a preset differential pressure of water is reached across any of the three pairs of screens. When a preset pressure is established at the screen wash nozzles, the screen motors are automatically started and the screens are washed. In either manual or automatic mode, the pump and screens run until manually stopped. The discharges of the three pumps are brought together in a steel trifurcation transition to a single tunnel. A debris filter is installed in the 78-in inlet pipe of the CCW piping into one condenser water box per condenser. The debris filter is provided with a backwash line that

permits manual or automatic operation of the backwash system. The backwash line bypasses the condenser and discharges directly into the condenser water box outlet piping for each of the units.

Facilities that are subject to the 316(b) Phase II requirements must submit the information described in 40 CFR 122.21(r)(2) through (r)(8) in order for the Department to make a BTA determination. In addition, facilities that have a design intake flowrate of greater than 125 MGD must also submit specific information detailed in 40 CFR 122.21(r)(9) through (r)(13).

The Permittee submitted the required information stipulated by 122.21(r)(2) through (r)(13) with the permit application. At this time, the Department has made a determination that the cooling water intake structure represents the BTA for entrainment to minimize adverse environmental impact in accordance with Section 316(b) of the Federal Clean Water Act (33 U.S.C. section 1326). The Department has made this determination based on consideration of the factors listed in 40 CFR 125.98(f)(2) and 40 CFR 125.98(f)(3). The Permittee is required to operate and maintain the cooling water intake structure in a manner that minimizes both impingement and entrainment levels. Documentation detailing the steps that have and are being taken to minimize the impingement and entrainment levels shall be maintained on-site and made available upon request during inspections.

The following schedule of compliance has been proposed in Part I.E.2 of the Permit:

Within 180 days of the effective date of this Permit, the Permittee shall submit to the Department the chosen alternative provided at § 125.94(c) for compliance with the BTA standards for impingement. The submittal must provide an implementation schedule for installation of equipment necessary to meet the requirements of the chosen compliance alternative.

The following conditions have been proposed in Part IV.D of the Permit:

1. The cooling water intake structure used by the Permittee has been evaluated using available information. At this time, the Department has determined that the cooling water intake structure represents the best technology available (40 CFR 125.98(b)(6)) for entrainment to minimize adverse environmental impact in accordance with Section 316(b) of the Federal Clean Water Act (33 U.S.C. section 1326).

2. The Permittee is required to operate and maintain the cooling water intake structure in a manner that minimizes impingement and entrainment levels. Documentation detailing the steps that have and are being taken to minimize the impingement and entrainment levels shall be maintained on site and made available upon request.

3. Nothing in this permit authorizes take for the purposes of a facility's compliance with the "Endangered Species Act."

4. The Permittee shall submit the information required by the applicable provisions of 40 CFR 122.21(r) at least 180 days prior to the expiration date of this permit. The Permittee may request to reduce the information required, if conditions at the facility and in the waterbody remain substantially unchanged since the previous application so long as the relevant previously submitted information remains representative of current source water, intake structure, cooling water system, and operating conditions. Any habitat designated as critical or species listed as threatened or endangered after issuance of the current permit whose range of habitat or designated critical habit includes waters where a facility intake is located constitutes potential for a substantial change that must be addressed by the owner/operator in subsequent permit applications, unless the facility received an exemption pursuant to 16 U.S.C. 1536(o) or a permit pursuant to 16 U.S.C. 1539(a) or there is no reasonable expectation of take. The Permittee must submit its request for reduced cooling water intake structure and waterbody application information to the Director at least two years and six months prior to the expiration of the NPDES permit. The Permittee's request must identify each element that it determines has not substantially changed since the previous permit application and the basis for the determination. The Director has the discretion to accept or reject any part of the request.

5. The Permittee must keep records of all submissions that are part of the permit application pertaining to the cooling water intake structure until the subsequent permit is issued to the Permittee.

6. The Permittee's permit application must contain readily available information, at the time of permit application development, in identifying all Federally-listed threatened and endangered species and/or designated critical habitat that are or may be present in the action area.

7. The Permittee must conduct weekly visual inspections or employ remote monitoring devices during the period the cooling water intake structures are in operation. This condition is only applicable if control technologies are being employed to comply with final BTA for impingement mortality.

8. The Permittee is required to submit an Annual Certification to the Department no later than January 28th of each year. The Annual Certification shall detail if any changes have been made to impact the operation of the cooling water intake structure.

Revision September 3, 2025

The Department has updated the BMP language located in Part IV.A.2.g of the Permit. The Permit Condition now states "Provide for routine inspections, on days during which the facility is manned, of any structures that function to prevent stormwater pollution or to remove pollutants from stormwater and of the facility in general. Routine inspections should be done at a frequency to ensure that the BMP is continually implemented and effective and in no case less frequent than once per year." This clarification was added to be consistent with 40 CFR Part 122.43(c).

Additionally, the Department has clarified in Part IV.D of the Permit that a determination has been made that the cooling water intake structure represents the best technology available for entrainment to minimize adverse environmental impact in accordance with Section 316(b) of the Federal Clean Water Act (33 U.S.C. section 1326). The Permit includes a schedule of compliance for submission of the chosen alternative provided at § 125.94(c) for compliance with the BTA standards for impingement.

Finally, the Department has made revisions to the descriptions of discharge on the limitation pages in Part I.A of the Permit and in the ADEM Permit Rationale to ensure they match.

Facility Name: **TVA Browns Ferry Nuclear Plant DSN001**

NPDES No.: **AL0022080**

$Q_d*C_d + Q_{d2}*C_{d2} + Q_s*C_s = Q_r*C_r$

ID	Pollutant	Carcinogen "yes"	Type	Background from upstream source (C_{d2}) Daily Max	Background from upstream source (C_{d2}) Monthly Ave	Background Instream (C_s) Daily Max	Background Instream (C_s) Monthly Ave	**Enter** Max Daily Discharge as reported by Applicant (C_d) Max	**Enter** Avg Daily Discharge as reported by Applicant (C_d) Ave	Partition Coefficient (Stream / Lake)
				µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	
1	Antimony		Metals	0	0	0	0	0	0	-
2	**Arsenic*,****	YES	Metals	0	0	0	0	0	0	0.574
3	Berylium		Metals	0	0	0	0	0	0	-
4	Cadmium**		Metals	0	0	0	0	0	0	0.200
5	Chromium / Chromium III**		Metals	0	0	0	0	0	0	0.125
6	Chromium / Chromium VI**		Metals	0	0	0	0	0	0	
7	Copper**		Metals	0	0	0	0	1.54	1.54	0.230
8	Lead**		Metals	0	0	0	0	0	0	0.206
9	Mercury**		Metals	0	0	0	0	0.0009	0.0009	0.400
10	Nickel**		Metals	0	0	0	0	0	0	0.235
11	Selenium		Metals	0	0	0	0	0	0	-
12	Silver		Metals	0	0	0	0	0	0	-
13	Thallium		Metals	0	0	0	0	0	0	-
14	Zinc**		Metals	0	0	0	0	4.57	4.57	0.152
15	Cyanide		Metals	0	0	0	0	0	0	-
16	Total Phenolic Compounds		Metals	0	0	0	0	0	0	-
17	Hardness (As CaCO3)		Metals	0	0	0	0	0	0	-
18	Acrolein		VOC	0	0	0	0	0	0	-
19	**Acrylonitrile***	YES	VOC	0	0	0	0	0	0	-
20	**Aldrin**	YES	VOC	0	0	0	0	0	0	-
21	**Benzene***	YES	VOC	0	0	0	0	0	0	-
22	**Bromoform***	YES	VOC	0	0	0	0	0	0	-
23	**Carbon Tetrachloride***	YES	VOC	0	0	0	0	0	0	-
24	**Chlordane**	YES	VOC	0	0	0	0	0	0	-
25	Clorobenzene		VOC	0	0	0	0	0	0	-
26	**Chlorodibromo-Methane***	YES	VOC	0	0	0	0	0	0	-
27	Chloroethane		VOC	0	0	0	0	0	0	-
28	2-Chloro-Ethylvinyl Ether		VOC	0	0	0	0	0	0	-
29	**ChloroForm***	YES	VOC	0	0	0	0	0	0	-
30	**4,4'-DDD**	YES	VOC	0	0	0	0	0	0	-
31	**4,4'-DDE**	YES	VOC	0	0	0	0	0	0	-
32	**4,4'-DDT**	YES	VOC	0	0	0	0	0	0	-
33	**Dichlorobromo-Methane***	YES	VOC	0	0	0	0	0	0	-
34	1, 1-Dichloroethane		VOC	0	0	0	0	0	0	-
35	**1, 2-Dichloroethane***	YES	VOC	0	0	0	0	0	0	-
36	Trans-1, 2-Dichloro-Ethylene		VOC	0	0	0	0	0	0	-
37	**1, 1-Dichloroethylene***	YES	VOC	0	0	0	0	0	0	-
38	1, 2-Dichloropropane		VOC	0	0	0	0	0	0	-
39	1, 3-Dichloro-Propylene		VOC	0	0	0	0	0	0	-
40	**Dieldrin**	YES	VOC	0	0	0	0	0	0	-
41	Ethylbenzene		VOC	0	0	0	0	0	0	-
42	Methyl Bromide		VOC	0	0	0	0	0	0	-
43	Methyl Chloride		VOC	0	0	0	0	0	0	-
44	**Methylene Chloride***	YES	VOC	0	0	0	0	0	0	-
45	**1, 1, 2, 2-Tetrachloro-Ethane***	YES	VOC	0	0	0	0	0	0	-
46	**Tetrachloro-Ethylene***	YES	VOC	0	0	0	0	0	0	-
47	Toluene		VOC	0	0	0	0	0	0	-
48	**Toxaphene**	YES	VOC	0	0	0	0	0	0	-
49	**Tributyltine (TBT)**	YES	VOC	0	0	0	0	0	0	-
50	1, 1, 1-Trichloroethane		VOC	0	0	0	0	0	0	-
51	**1, 1, 2-Trichloroethane***	YES	VOC	0	0	0	0	0	0	-
52	**Trichlorethylene***	YES	VOC	0	0	0	0	0	0	-
53	**Vinyl Chloride***	YES	VOC	0	0	0	0	0	0	-
54	P-Chloro-M-Cresol		Acids	0	0	0	0	0	0	-
55	2-Chlorophenol		Acids	0	0	0	0	0	0	-
56	2, 4-Dichlorophenol		Acids	0	0	0	0	0	0	-
57	2, 4-Dimethylphenol		Acids	0	0	0	0	0	0	-
58	4, 6-Dinitro-O-Cresol		Acids	0	0	0	0	0	0	-
59	2, 4-Dinitrophenol		Acids	0	0	0	0	0	0	-
60	**4,6-Dintro-2-methylophenol**	YES	Acids	0	0	0	0	0	0	-
61	**Dioxin (2,3,7,8-TCDD)**	YES	Acids	0	0	0	0	0	0	-
62	2-Nitrophenol		Acids	0	0	0	0	0	0	-
63	4-Nitrophenol		Acids	0	0	0	0	0	0	-
64	**Pentachlorophenol***	YES	Acids	0	0	0	0	0	0	-
65	Phenol		Acids	0	0	0	0	0	0	-
66	**2, 4, 6-Trichlorophenol***	YES	Acids	0	0	0	0	0	0	-
67	Acenaphthene		Bases	0	0	0	0	0	0	-
68	Acenaphthylene		Bases	0	0	0	0	0	0	-
69	Anthracene		Bases	0	0	0	0	0	0	-
70	Benzidine		Bases	0	0	0	0	0	0	-
71	**Benzo(A)Anthracene***	YES	Bases	0	0	0	0	0	0	-
72	**Benzo(A)Pyrene***	YES	Bases	0	0	0	0	0	0	-
73	3, 4 Benzo-Fluoranthene		Bases	0	0	0	0	0	0	-
74	Benzo(GHI)Perylene		Bases	0	0	0	0	0	0	-
75	Benzo(K)Fluoranthene		Bases	0	0	0	0	0	0	-
76	Bis (2-Chloroethoxy) Methane		Bases	0	0	0	0	0	0	-
77	**Bis (2-Chloroethyl)-Ether***	YES	Bases	0	0	0	0	0	0	-
78	Bis (2-Chloroiso-Propyl) Ether		Bases	0	0	0	0	0	0	-
79	**Bis (2-Ethylhexyl) Phthalate***	YES	Bases	0	0	0	0	0	0	-
80	4-Bromophenyl Phenyl Ether		Bases	0	0	0	0	0	0	-
81	Butyl Benzyl Phthalate		Bases	0	0	0	0	0	0	-
82	2-Chloronaphthalene		Bases	0	0	0	0	0	0	-
83	4-Chlorophenyl Phenyl Ether		Bases	0	0	0	0	0	0	-
84	**Chrysene***	YES	Bases	0	0	0	0	0	0	-
85	Di-N-Butyl Phthalate		Bases	0	0	0	0	0	0	-
86	Di-N-Octyl Phthalate		Bases	0	0	0	0	0	0	-
87	**Dibenzo(A,H)Anthracene***	YES	Bases	0	0	0	0	0	0	-
88	1, 2-Dichlorobenzene		Bases	0	0	0	0	0	0	-
89	1, 3-Dichlorobenzene		Bases	0	0	0	0	0	0	-
90	1, 4-Dichlorobenzene		Bases	0	0	0	0	0	0	-
91	**3, 3-Dichlorobenzidine***	YES	Bases	0	0	0	0	0	0	-
92	Diethyl Phthalate		Bases	0	0	0	0	0	0	-
93	Dimethyl Phthalate		Bases	0	0	0	0	0	0	-
94	**2, 4-Dinitrotoluene***	YES	Bases	0	0	0	0	0	0	-
95	2, 6-Dinitrotoluene		Bases	0	0	0	0	0	0	-
96	1,2-Diphenylhydrazine		Bases	0	0	0	0	0	0	-
97	**Endosulfan (alpha)**	YES	Bases	0	0	0	0	0	0	-
98	**Endosulfan (beta)**	YES	Bases	0	0	0	0	0	0	-
99	**Endosulfan sulfate**	YES	Bases	0	0	0	0	0	0	-
100	**Endrin**	YES	Bases	0	0	0	0	0	0	-
101	**Endrin Aldeyhide**	YES	Bases	0	0	0	0	0	0	-
102	Fluoranthene		Bases	0	0	0	0	0	0	-
103	Fluorene		Bases	0	0	0	0	0	0	-
104	Heptochlor	YES	Bases	0	0	0	0	0	0	-
105	Heptachlor Epoxide	YES	Bases	0	0	0	0	0	0	-
106	**Hexachlorobenzene***	YES	Bases	0	0	0	0	0	0	-
107	**Hexachlorobutadiene***	YES	Bases	0	0	0	0	0	0	-
108	**Hexachlorocyclohexan (alpa)**	YES	Bases	0	0	0	0	0	0	-
109	**Hexachlorocyclohexan (beta)**	YES	Bases	0	0	0	0	0	0	-
110	**Hexachlorocyclohexan (gamma)**	YES	Bases	0	0	0	0	0	0	-
111	HexachlorocycloPentadiene		Bases	0	0	0	0	0	0	-
112	Hexachloroethane		Bases	0	0	0	0	0	0	-
113	**Indeno(1, 2, 3-CK)Pyrene***	YES	Bases	0	0	0	0	0	0	-
114	Isophorone		Bases	0	0	0	0	0	0	-
115	Naphthalene		Bases	0	0	0	0	0	0	-
116	Nitrobenzene		Bases	0	0	0	0	0	0	-
117	**N-Nitrosodi-N-Propylamine***	YES	Bases	0	0	0	0	0	0	-
118	**N-Nitrosodi-N-Methylamine***	YES	Bases	0	0	0	0	0	0	-
119	**N-Nitrosodi-N-Phenylamine***	YES	Bases	0	0	0	0	0	0	-
120	**PCB-1016**	YES	Bases	0	0	0	0	0	0	-
121	**PCB-1221**	YES	Bases	0	0	0	0	0	0	-
122	**PCB-1232**	YES	Bases	0	0	0	0	0	0	-
123	**PCB-1242**	YES	Bases	0	0	0	0	0	0	-
124	**PCB-1248**	YES	Bases	0	0	0	0	0	0	-
125	**PCB-1254**	YES	Bases	0	0	0	0	0	0	-
126	**PCB-1260**	YES	Bases	0	0	0	0	0	0	-
127	Phenanthrene		Bases	0	0	0	0	0	0	-
128	Pyrene		Bases	0	0	0	0	0	0	-
129	1, 2, 4-Trichlorobenzene		Bases	0	0	0	0	0	0	-

3044.2	**Enter** Q_d = wastewater discharge flow from facility (MGD)
4710.07452	Q_d = wastewater discharge flow (cfs) (this value is caluclated from the MGD)
0	**Enter flow from upstream discharge** Qd2 = background stream flow in MGD above point of discharge
0	Qd2 = background stream flow from upstream source (cfs)
7398.85	**Enter 7Q10,** Q_s = background stream flow in cfs above point of discharge
4696.71	**Enter or estimated, 1Q10,** Q_s = background stream flow in cfs above point of discharge (1Q10 estimated at 75% of 7Q10)
46126.04	**Enter Mean Annual Flow**, Q_s = background stream flow in cfs above point of discharge
11710.51	**Enter 7Q2**, Q_s = background stream flow in cfs above point of discharge (For LWF class streams)
Enter to Left	**Enter C_s** = background in-stream pollutant concentration in µg/l (assuming this is zero "0" unless there is data)
Q_d +Qd2+Q_s	Q_r = resultant in-stream flow, after discharge
Calculated on other	C_r = resultant in-stream pollutant concentration in µg/l in the stream (after complete mixing occurs)
100	**Enter**, Background Hardness above point of discharge (assumed 50 South of Birmingham and 100 North of Birmingham)
7.00 s.u.	**Enter**, Background pH above point of discharge
No	**Enter**, Is discharge to a stream? "YES" Other option would be to a Lake. (This changes the partition coefficients for the metals)

** Using Partition Coefficients

July 9, 2025

Facility Name: **TVA Browns Ferry Nuclear Plant DSN001**

NPDES No.: **AL0022080**

Freshwater F&W classification.						Freshwater Acute (µg/l) Q_s =1Q10						Freshwater Chronic (µg/l) Q_s = 7Q10					Human Health Consumption Fish only (µg/l) Carcinogen Q_s = Annual Average Non-Carcinogen Q_s = 7Q10			
ID	Pollutant	RP?	Carcinogen yes	Background from upstream source (Cd2) Daily Max	Max Daily Discharge as reported by Applicant (C_{dmax})	Water Quality Criteria (C_T)	Draft Permit Limit (C_{dmax})	20% of Draft Permit Limit	RP?	Background from upstream source (Cd2) Monthly Ave	Avg Daily Discharge as reported by Applicant (C_{davg})	Water Quality Criteria (C_T)	Draft Permit Limit (C_{davg})	20% of Draft Permit Limit	RP?		Water Quality Criteria (C_T)	Draft Permit Limit (C_{davg})	20% of Draft Permit Limit	RP?
1	Antimony			0	0	-	-	-	-	0	0	-	-	-	-		3.73E+02	9.60E+02	1.92E+02	No
2	Arsenic		YES	0	0	592.334	1182.988	236.598	No	0	0	261.324	671.827	134.365	No		3.03E-01	3.27E+00	6.54E-01	No
3	Beryllium			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
4	Cadmium			0	0	10.069	20.109	4.022	No	0	0	1.230	3.162	0.632	No		-	-	-	-
5	Chromium/ Chromium III			0	0	4558.108	9103.282	1820.656	No	0	0	592.916	1524.302	304.860	No		-	-	-	-
6	Chromium/ Chromium VI			0	0	16.000	31.955	6.391	No	0	0	11.000	28.279	5.656	No		-	-	-	-
7	Copper			0	1.54	58.431	116.696	23.339	No	0	1.54	38.938	100.104	20.021	No		-	-	-	-
8	Lead			0	0	313.502	626.114	125.223	No	0	0	12.217	31.407	6.281	No		-	-	-	-
9	Mercury			0	0.0009	2.400	4.793	0.959	No	0	0.0009	0.012	0.031	0.006	No		4.24E-02	1.09E-01	2.18E-02	No
10	Nickel			0	0	1992.493	3979.332	795.866	No	0	0	221.304	568.942	113.788	No		9.93E+02	2.55E+03	5.11E+02	No
11	Selenium			0	0	20.000	39.943	7.989	No	0	0	5.000	12.854	2.571	No		2.43E+03	6.25E+03	1.25E+03	No
12	Silver			0	0	3.217	6.424	1.285	No	0	0	-	-	-	-		-	-	-	-
13	Thallium			0	0	-	-	-	-	0	0	-	-	-	-		2.74E-01	7.03E-01	1.41E-01	No
14	Zinc			0	4.57	770.924	1539.661	307.932	No	0	4.57	777.230	1998.147	399.629	No		1.49E+04	3.83E+04	7.66E+03	No
15	Cyanide			0	0	22.000	43.938	8.788	No	0	0	5.200	13.368	2.674	No		9.33E+03	2.40E+04	4.80E+03	No
16	Total Phenolic Compounds			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
17	Hardness (As CaCO3)			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
18	Acrolein			0	0	-	-	-	-	0	0	-	-	-	-		5.43E+00	1.40E+01	2.79E+00	No
19	Acrylonitrile		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.44E-01	1.55E+00	3.11E-01	No
20	Aldrin		YES	0	0	3.000	5.991	1.198	No	0	0	-	-	-	-		2.94E-05	3.17E-04	6.34E-05	No
21	Benzene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.55E+01	1.67E+02	3.34E+01	No
22	Bromoform		YES	0	0	-	-	-	-	0	0	-	-	-	-		7.88E+01	8.50E+02	1.70E+02	No
23	Carbon Tetrachloride		YES	0	0	-	-	-	-	0	0	-	-	-	-		9.57E-01	1.03E+01	2.07E+00	No
24	Chlordane		YES	0	0	2.400	4.793	0.959	No	0	0	0.0043	0.011	0.002	No		4.73E-04	5.10E-03	1.02E-03	No
25	Clorobenzene			0	0	-	-	-	-	0	0	-	-	-	-		9.06E+02	2.33E+03	4.66E+02	No
26	Chlorodibromo-Methane		YES	0	0	-	-	-	-	0	0	-	-	-	-		7.41E+00	7.99E+01	1.60E+01	No
27	Chloroethane			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
28	2-Chloro-Ethylvinyl Ether			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
29	ChloroForm		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.02E+02	1.10E+03	2.20E+02	No
30	4,4' - DDD		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.81E-04	1.96E-03	3.92E-04	No
31	4,4' - DDE		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.28E-04	1.38E-03	2.76E-04	No
32	4,4' - DDT		YES	0	0	1.100	2.197	0.439	No	0	0	0.001	0.003	0.001	No		1.28E-04	1.38E-03	2.76E-04	No
33	Dichlorobromo-Methane		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.00E+01	1.08E+02	2.17E+01	No
34	1, 1-Dichloroethane			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
35	1, 2-Dichloroethane		YES	0	0	-	-	-	-	0	0	-	-	-	-		2.14E+01	2.31E+02	4.61E+01	No
36	Trans-1, 2-Dichloro-Ethylene			0	0	-	-	-	-	0	0	-	-	-	-		5.91E+03	1.52E+04	3.04E+03	No
37	1, 1-Dichloroethylene		YES	0	0	-	-	-	-	0	0	-	-	-	-		4.17E+03	4.50E+04	8.99E+03	No
38	1, 2-Dichloropropane			0	0	-	-	-	-	0	0	-	-	-	-		8.49E+00	2.18E+01	4.37E+00	No
39	1, 3-Dichloro-Propylene			0	0	-	-	-	-	0	0	-	-	-	-		1.23E+01	3.16E+01	6.31E+00	No
40	Dieldrin		YES	0	0	0.240	0.479	0.096	No	0	0	0.056	0.144	0.029	No		3.12E-05	3.37E-04	6.74E-05	No
41	Ethylbenzene			0	0	-	-	-	-	0	0	-	-	-	-		1.24E+03	3.20E+03	6.40E+02	No
42	Methyl Bromide			0	0	-	-	-	-	0	0	-	-	-	-		8.71E+02	2.24E+03	4.48E+02	No
43	Methyl Chloride			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
44	Methylene Chloride		YES	0	0	-	-	-	-	0	0	-	-	-	-		3.46E+02	3.73E+03	7.46E+02	No
45	1, 1, 2, 2-Tetrachloro-Ethane		YES	0	0	-	-	-	-	0	0	-	-	-	-		2.33E+00	2.52E+01	5.04E+00	No
46	Tetrachloro-Ethylene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.92E+00	2.07E+01	4.14E+00	No
47	Toluene			0	0	-	-	-	-	0	0	-	-	-	-		8.72E+03	2.24E+04	4.48E+03	No
48	Toxaphene		YES	0	0	0.730	1.458	0.292	No	0	0	0.0002	0.001	0.000	No		1.62E-04	1.75E-03	3.50E-04	No
49	Tributyltin (TBT)		YES	0	0	0.460	0.919	0.184	No	0	0	0.072	0.185	0.037	No		-	-	-	-
50	1, 1, 1-Trichloroethane			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
51	1, 1, 2-Trichloroethane		YES	0	0	-	-	-	-	0	0	-	-	-	-		9.10E+00	9.82E+01	1.96E+01	No
52	Trichlorethylene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.75E+01	1.89E+02	3.77E+01	No
53	Vinyl Chloride		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.42E+00	1.54E+01	3.07E+00	No
54	P-Chloro-M-Cresol			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
55	2-Chlorophenol			0	0	-	-	-	-	0	0	-	-	-	-		8.71E+01	2.24E+02	4.48E+01	No
56	2, 4-Dichlorophenol			0	0	-	-	-	-	0	0	-	-	-	-		1.72E+02	4.42E+02	8.84E+01	No
57	2, 4-Dimethylphenol			0	0	-	-	-	-	0	0	-	-	-	-		4.98E+02	1.28E+03	2.56E+02	No
58	4, 6-Dinitro-O-Cresol			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
59	2, 4-Dinitrophenol			0	0	-	-	-	-	0	0	-	-	-	-		3.11E+03	8.00E+03	1.60E+03	No
60	4,6-Dinitro-2-methylphenol		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.65E+02	1.79E+03	3.57E+02	No
61	Dioxin (2,3,7,8-TCDD)		YES	0	0	-	-	-	-	0	0	-	-	-	-		2.67E-08	2.88E-07	5.76E-08	No
62	2-Nitrophenol			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
63	4-Nitrophenol			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
64	Pentachlorophenol		YES	0	0	8.723	17.422	3.484	No	0	0	6.693	17.206	3.441	No		1.77E+00	1.91E+01	3.82E+00	No
65	Phenol			0	0	-	-	-	-	0	0	-	-	-	-		5.00E+05	1.29E+06	2.57E+05	No
66	2, 4, 6-Trichlorophenol		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.41E+00	1.53E+01	3.05E+00	No
67	Acenaphthene			0	0	-	-	-	-	0	0	-	-	-	-		5.79E+02	1.49E+03	2.97E+02	No
68	Acenaphthylene			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
69	Anthracene			0	0	-	-	-	-	0	0	-	-	-	-		2.33E+04	6.00E+04	1.20E+04	No
70	Benzidine			0	0	-	-	-	-	0	0	-	-	-	-		1.16E-04	2.98E-04	5.96E-05	No
71	Benzo(A)Anthracene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.07E-02	1.15E-01	2.30E-02	No
72	Benzo(A)Pyrene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.07E-02	1.15E-01	2.30E-02	No
73	Benzo(b)fluoranthene			0	0	-	-	-	-	0	0	-	-	-	-		1.07E-02	2.74E-02	5.48E-03	No
74	Benzo(GHI)Perylene			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
75	Benzo(K)Fluoranthene			0	0	-	-	-	-	0	0	-	-	-	-		1.07E-02	2.74E-02	5.48E-03	No
76	Bis (2-Chloroethoxy) Methane			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
77	Bis (2-Chloroethyl)-Ether		YES	0	0	-	-	-	-	0	0	-	-	-	-		3.07E-01	3.32E+00	6.64E-01	No
78	Bis (2-Chloroiso-Propyl) Ether			0	0	-	-	-	-	0	0	-	-	-	-		3.78E+04	9.71E+04	1.94E+04	No
79	Bis (2-Ethylhexyl) Phthalate		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.28E+00	1.38E+01	2.77E+00	No
80	4-Bromophenyl Phenyl Ether			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
81	Butyl Benzyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-		1.13E+03	2.90E+03	5.80E+02	No
82	2-Chloronaphthalene			0	0	-	-	-	-	0	0	-	-	-	-		9.24E+02	2.38E+03	4.75E+02	No
83	4-Chlorophenyl Phenyl Ether			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
84	Chrysene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.07E-02	1.15E-01	2.30E-02	No
85	Di-N-Butyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-		2.62E+03	6.74E+03	1.35E+03	No
86	Di-N-Octyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
87	Dibenzo(A,H)Anthracene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.07E-02	1.15E-01	2.30E-02	No
88	1, 2-Dichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-		7.55E+02	1.94E+03	3.88E+02	No
89	1, 3-Dichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-		5.62E+02	1.45E+03	2.89E+02	No
90	1, 4-Dichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-		1.12E+02	2.89E+02	5.78E+01	No
91	3, 3-Dichlorobenzidine		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.66E-02	1.79E-01	3.59E-02	No
92	Diethyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-		2.56E+04	6.57E+04	1.31E+04	No
93	Dimethyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-		6.48E+05	1.67E+06	3.33E+05	No
94	2, 4-Dinitrotoluene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.98E+00	2.14E+01	4.28E+00	No
95	2, 6-Dinitrotoluene			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
96	1,2-Diphenylhydrazine			0	0	-	-	-	-	0	0	-	-	-	-		1.17E-01	3.01E-01	6.02E-02	No
97	Endosulfan (alpha)		YES	0	0	0.22	0.439	0.088	No	0	0	0.056	0.144	0.029	No		5.19E+01	5.60E+02	1.12E+02	No
98	Endosulfan (beta)		YES	0	0	0.22	0.439	0.088	No	0	0	0.056	0.144	0.029	No		5.19E+01	5.60E+02	1.12E+02	No
99	Endosulfan sulfate		YES	0	0	-	-	-	-	0	0	-	-	-	-		5.19E+01	5.60E+02	1.12E+02	No
100	Endrin		YES	0	0	0.086	0.172	0.034	No	0	0	0.036	0.093	0.019	No		3.53E-02	3.81E-01	7.61E-02	No
101	Endrin Aldeyhde		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.76E-01	1.90E+00	3.81E-01	No
102	Fluoranthene			0	0	-	-	-	-	0	0	-	-	-	-		8.12E+01	2.09E+02	4.17E+01	No
103	Fluorene			0	0	-	-	-	-	0	0	-	-	-	-		3.11E+03	8.00E+03	1.60E+03	No
104	Heptochlor		YES	0	0	0.52	1.039	0.208	No	0	0	0.0038	0.010	0.002	No		4.63E-05	5.00E-04	9.99E-05	No
105	Heptachlor Epoxide		YES	0	0	0.52	1.039	0.208	No	0	0	0.0038	0.010	0.002	No		2.29E-05	2.47E-04	4.94E-05	No
106	Hexachlorobenzene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.68E-04	1.81E-03	3.62E-04	No
107	Hexachlorobutadiene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.08E+01	1.16E+02	2.32E+01	No
108	Hexachlorocyclohexan (alpha)		YES	0	0	-	-	-	-	0	0	-	-	-	-		2.85E-03	3.07E-02	6.15E-03	No
109	Hexachlorocyclohexan (beta)		YES	0	0	-	-	-	-	0	0	-	-	-	-		9.97E-03	1.08E-01	2.15E-02	No
110	Hexachlorocyclohexan (gamma)		YES	0	0	0.95	1.897	0.379	No	0	0	-	-	-	-		1.08E+00	1.16E+01	2.32E+00	No
111	HexachlorocycloPentadiene			0	0	-	-	-	-	0	0	-	-	-	-		6.45E+02	1.66E+03	3.32E+02	No
112	Hexachloroethane			0	0	-	-	-	-	0	0	-	-	-	-		1.92E+00	4.93E+00	9.86E-01	No
113	Indeno(1, 2, 3-CK)Pyrene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.07E-02	1.15E-01	2.30E-02	No
114	Isophorone			0	0	-	-	-	-	0	0	-	-	-	-		5.61E+02	1.44E+03	2.88E+02	No
115	Naphthalene			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
116	Nitrobenzene			0	0	-	-	-	-	0	0	-	-	-	-		4.04E+02	1.04E+03	2.08E+02	No
117	N-Nitrosodi-N-Propylamine		YES	0	0	-	-	-	-	0	0	-	-	-	-		2.95E-01	3.18E+00	6.37E-01	No
118	N-Nitrosodimethylamine		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.76E+00	1.90E+01	3.80E+00	No
119	N-Nitrosodiphenylamine		YES	0	0	-	-	-	-	0	0	-	-	-	-		3.50E+00	3.78E+01	7.56E+00	No
120	PCB-1016		YES	0	0	-	-	-	-	0	0	0.014	0.036	0.007	No		3.74E-05	4.04E-04	8.07E-05	No
121	PCB-1221		YES	0	0	-	-	-	-	0	0	0.014	0.036	0.007	No		3.74E-05	4.04E-04	8.07E-05	No
122	PCB-1232		YES	0	0	-	-	-	-	0	0	0.014	0.036	0.007	No		3.74E-05	4.04E-04	8.07E-05	No
123	PCB-1242		YES	0	0	-	-	-	-	0	0	0.014	0.036	0.007	No		3.74E-05	4.04E-04	8.07E-05	No
124	PCB-1248		YES	0	0	-	-	-	-	0	0	0.014	0.036	0.007	No		3.74E-05	4.04E-04	8.07E-05	No
125	PCB-1254		YES	0	0	-	-	-	-	0	0	0.014	0.036	0.007	No		3.74E-05	4.04E-04	8.07E-05	No
126	PCB-1260		YES	0	0	-	-	-	-	0	0	0.014	0.036	0.007	No		3.74E-05	4.04E-04	8.07E-05	No
127	Phenanthrene			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
128	Pyrene			0	0	-	-	-	-	0	0	-	-	-	-		2.33E+03	6.00E+03	1.20E+03	No
129	1, 2, 4-Trichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-		4.09E+01	1.05E+02	2.10E+01	No

Facility Name: **TVA Browns Ferry Nuclear Plant DSN01B**

NPDES No.: **AL0022080**

$Q_d*C_d + Q_{d2}*C_{d2} + Q_s*C_s = Q_r*C_r$

ID	Pollutant	Carcinogen "yes"	Type	Background from upstream source (C_{d2}) Daily Max	Background from upstream source (C_{d2}) Monthly Ave	Background Instream (C_s) Daily Max	Background Instream (C_s) Monthly Ave	**Enter** Max Daily Discharge as reported by Applicant (C_d) Max	**Enter** Avg Daily Discharge as reported by Applicant (C_d) Ave	Partition Coefficient (Stream / Lake)
				µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	
1	Antimony		Metals	0	0	0	0	0	0	-
2	**Arsenic*,****	YES	Metals	0	0	0	0	0	0	0.574
3	Berylium		Metals	0	0	0	0	0	0	-
4	Cadmium**		Metals	0	0	0	0	0	0	0.200
5	Chromium / Chromium III**		Metals	0	0	0	0	0	0	0.125
6	Chromium / Chromium VI**		Metals	0	0	0	0	0	0	
7	Copper**		Metals	0	0	0	0	0	0	0.230
8	Lead**		Metals	0	0	0	0	0	0	0.206
9	Mercury**		Metals	0	0	0	0	0	0	0.400
10	Nickel**		Metals	0	0	0	0	0	0	0.235
11	Selenium		Metals	0	0	0	0	0	0	-
12	Silver		Metals	0	0	0	0	0	0	-
13	Thallium		Metals	0	0	0	0	0	0	-
14	Zinc**		Metals	0	0	0	0	0	0	0.152
15	Cyanide		Metals	0	0	0	0	0	0	-
16	Total Phenolic Compounds		Metals	0	0	0	0	0	0	-
17	Hardness (As CaCO3)		Metals	0	0	0	0	0	0	-
18	Acrolein		VOC	0	0	0	0	0	0	-
19	**Acrylonitrile***	YES	VOC	0	0	0	0	0	0	-
20	**Aldrin**	YES	VOC	0	0	0	0	0	0	-
21	**Benzene***	YES	VOC	0	0	0	0	0	0	-
22	**Bromoform***	YES	VOC	0	0	0	0	0	0	-
23	**Carbon Tetrachloride***	YES	VOC	0	0	0	0	0	0	-
24	**Chlordane**	YES	VOC	0	0	0	0	0	0	-
25	Clorobenzene		VOC	0	0	0	0	0	0	-
26	**Chlorodibromo-Methane***	YES	VOC	0	0	0	0	0	0	-
27	Chloroethane		VOC	0	0	0	0	0	0	-
28	2-Chloro-Ethylvinyl Ether		VOC	0	0	0	0	0	0	-
29	**ChloroForm***	YES	VOC	0	0	0	0	0	0	-
30	**4,4'-DDD**	YES	VOC	0	0	0	0	0	0	-
31	**4,4'-DDE**	YES	VOC	0	0	0	0	0	0	-
32	**4.4'-DDT**	YES	VOC	0	0	0	0	0	0	-
33	**Dichlorobromo-Methane***	YES	VOC	0	0	0	0	0	0	-
34	1, 1-Dichloroethane		VOC	0	0	0	0	0	0	-
35	**1, 2-Dichloroethane***	YES	VOC	0	0	0	0	0	0	-
36	Trans-1, 2-Dichloro-Ethylene		VOC	0	0	0	0	0	0	-
37	**1, 1-Dichloroethylene***	YES	VOC	0	0	0	0	0	0	-
38	1, 2-Dichloropropane		VOC	0	0	0	0	0	0	-
39	1, 3-Dichloro-Propylene		VOC	0	0	0	0	0	0	-
40	**Dieldrin**	YES	VOC	0	0	0	0	0	0	-
41	Ethylbenzene		VOC	0	0	0	0	0	0	-
42	Methyl Bromide		VOC	0	0	0	0	0	0	-
43	Methyl Chloride		VOC	0	0	0	0	0	0	-
44	**Methylene Chloride***	YES	VOC	0	0	0	0	0	0	-
45	**1, 1, 2, 2-Tetrachloro-Ethane***	YES	VOC	0	0	0	0	0	0	-
46	**Tetrachloro-Ethylene***	YES	VOC	0	0	0	0	0	0	-
47	Toluene		VOC	0	0	0	0	0	0	-
48	**Toxaphene**	YES	VOC	0	0	0	0	0	0	-
49	**Tributyltine (TBT)**	YES	VOC	0	0	0	0	0	0	-
50	1, 1, 1-Trichloroethane		VOC	0	0	0	0	0	0	-
51	**1, 1, 2-Trichloroethane***	YES	VOC	0	0	0	0	0	0	-
52	**Trichlorethylene***	YES	VOC	0	0	0	0	0	0	-
53	**Vinyl Chloride***	YES	VOC	0	0	0	0	0	0	-
54	P-Chloro-M-Cresol		Acids	0	0	0	0	0	0	-
55	2-Chlorophenol		Acids	0	0	0	0	0	0	-
56	2, 4-Dichlorophenol		Acids	0	0	0	0	0	0	-
57	2, 4-Dimethylphenol		Acids	0	0	0	0	0	0	-
58	4, 6-Dinitro-O-Cresol		Acids	0	0	0	0	0	0	-
59	2, 4-Dinitrophenol		Acids	0	0	0	0	0	0	-
60	**4,6-Dintro-2-methylophenol**	YES	Acids	0	0	0	0	0	0	-
61	**Dioxin (2,3,7,8-TCDD)**	YES	Acids	0	0	0	0	0	0	-
62	2-Nitrophenol		Acids	0	0	0	0	0	0	-
63	4-Nitrophenol		Acids	0	0	0	0	0	0	-
64	**Pentachlorophenol***	YES	Acids	0	0	0	0	0	0	-
65	Phenol		Acids	0	0	0	0	0	0	-
66	**2, 4, 6-Trichlorophenol***	YES	Acids	0	0	0	0	0	0	-
67	Acenaphthene		Bases	0	0	0	0	0	0	-
68	Acenaphthylene		Bases	0	0	0	0	0	0	-
69	Anthracene		Bases	0	0	0	0	0	0	-
70	Benzidine		Bases	0	0	0	0	0	0	-
71	**Benzo(A)Anthracene***	YES	Bases	0	0	0	0	0	0	-
72	**Benzo(A)Pyrene***	YES	Bases	0	0	0	0	0	0	-
73	3, 4 Benzo-Fluoranthene		Bases	0	0	0	0	0	0	-
74	Benzo(GHI)Perylene		Bases	0	0	0	0	0	0	-
75	Benzo(K)Fluoranthene		Bases	0	0	0	0	0	0	-
76	Bis (2-Chloroethoxy) Methane		Bases	0	0	0	0	0	0	-
77	**Bis (2-Chloroethyl)-Ether***	YES	Bases	0	0	0	0	0	0	-
78	Bis (2-Chloroiso-Propyl) Ether		Bases	0	0	0	0	0	0	-
79	**Bis (2-Ethylhexyl) Phthalate***	YES	Bases	0	0	0	0	0	0	-
80	4-Bromophenyl Phenyl Ether		Bases	0	0	0	0	0	0	-
81	Butyl Benzyl Phthalate		Bases	0	0	0	0	0	0	-
82	2-Chloronaphthalene		Bases	0	0	0	0	0	0	-
83	4-Chlorophenyl Phenyl Ether		Bases	0	0	0	0	0	0	-
84	**Chrysene***	YES	Bases	0	0	0	0	0	0	-
85	Di-N-Butyl Phthalate		Bases	0	0	0	0	0	0	-
86	Di-N-Octyl Phthalate		Bases	0	0	0	0	0	0	-
87	**Dibenzo(A,H)Anthracene***	YES	Bases	0	0	0	0	0	0	-
88	1, 2-Dichlorobenzene		Bases	0	0	0	0	0	0	-
89	1, 3-Dichlorobenzene		Bases	0	0	0	0	0	0	-
90	1, 4-Dichlorobenzene		Bases	0	0	0	0	0	0	-
91	**3, 3-Dichlorobenzidine***	YES	Bases	0	0	0	0	0	0	-
92	Diethyl Phthalate		Bases	0	0	0	0	0	0	-
93	Dimethyl Phthalate		Bases	0	0	0	0	0	0	-
94	**2, 4-Dinitrotoluene***	YES	Bases	0	0	0	0	0	0	-
95	2, 6-Dinitrotoluene		Bases	0	0	0	0	0	0	-
96	1,2-Diphenylhydrazine		Bases	0	0	0	0	0	0	-
97	**Endosulfan (alpha)**	YES	Bases	0	0	0	0	0	0	-
98	**Endosulfan (beta)**	YES	Bases	0	0	0	0	0	0	-
99	**Endosulfan sulfate**	YES	Bases	0	0	0	0	0	0	-
100	**Endrin**	YES	Bases	0	0	0	0	0	0	-
101	**Endrin Aldeyhide**	YES	Bases	0	0	0	0	0	0	-
102	Fluoranthene		Bases	0	0	0	0	0	0	-
103	Fluorene		Bases	0	0	0	0	0	0	-
104	Heptochlor	YES	Bases	0	0	0	0	0	0	-
105	Heptachlor Epoxide	YES	Bases	0	0	0	0	0	0	-
106	**Hexachlorobenzene***	YES	Bases	0	0	0	0	0	0	-
107	**Hexachlorobutadiene***	YES	Bases	0	0	0	0	0	0	-
108	**Hexachlorocyclohexan (alpa)**	YES	Bases	0	0	0	0	0	0	-
109	**Hexachlorocyclohexan (beta)**	YES	Bases	0	0	0	0	0	0	-
110	**Hexachlorocyclohexan (gamma)**	YES	Bases	0	0	0	0	0	0	-
111	HexachlorocycloPentadiene		Bases	0	0	0	0	0	0	-
112	Hexachloroethane		Bases	0	0	0	0	0	0	-
113	**Indeno(1, 2, 3-CK)Pyrene***	YES	Bases	0	0	0	0	0	0	-
114	Isophorone		Bases	0	0	0	0	0	0	-
115	Naphthalene		Bases	0	0	0	0	0	0	-
116	Nitrobenzene		Bases	0	0	0	0	0	0	-
117	**N-Nitrosodi-N-Propylamine***	YES	Bases	0	0	0	0	0	0	-
118	**N-Nitrosodi-N-Methylamine***	YES	Bases	0	0	0	0	0	0	-
119	**N-Nitrosodi-N-Phenylamine***	YES	Bases	0	0	0	0	0	0	-
120	**PCB-1016**	YES	Bases	0	0	0	0	0	0	-
121	**PCB-1221**	YES	Bases	0	0	0	0	0	0	-
122	**PCB-1232**	YES	Bases	0	0	0	0	0	0	-
123	**PCB-1242**	YES	Bases	0	0	0	0	0	0	-
124	**PCB-1248**	YES	Bases	0	0	0	0	0	0	-
125	**PCB-1254**	YES	Bases	0	0	0	0	0	0	-
126	**PCB-1260**	YES	Bases	0	0	0	0	0	0	-
127	Phenanthrene		Bases	0	0	0	0	0	0	-
128	Pyrene		Bases	0	0	0	0	0	0	-
129	1, 2, 4-Trichlorobenzene		Bases	0	0	0	0	0	0	-

0.022	**Enter** Q_d = wastewater discharge flow from facility (MGD)
0.03403904	Q_d = wastewater discharge flow (cfs) (this value is caluclated from the MGD)
0	**Enter flow from upstream discharge** Qd2 = background stream flow in MGD above point of discharge
0	Qd2 = background stream flow from upstream source (cfs)
7398.85	**Enter 7Q10,** Q_s = background stream flow in cfs above point of discharge
4696.71	**Enter or estimated, 1Q10,** Q_s = background stream flow in cfs above point of discharge (1Q10 estimated at 75% of 7Q10)
46126.04	**Enter Mean Annual Flow**, Q_s = background stream flow in cfs above point of discharge
11710.51	**Enter 7Q2**, Q_s = background stream flow in cfs above point of discharge (For LWF class streams)
Enter to Left	**Enter** C_s = background in-stream pollutant concentration in µg/l (assuming this is zero "0" unless there is data)
Q_d +Qd2+Q_s	Q_r = resultant in-stream flow, after discharge
Calculated on other	C_r = resultant in-stream pollutant concentration in µg/l in the stream (after complete mixing occurs)
100	**Enter**, Background Hardness above point of discharge (assumed 50 South of Birmingham and 100 North of Birmingham)
7.00 s.u.	**Enter**, Background pH above point of discharge
No	**Enter**, Is discharge to a stream? "YES" Other option would be to a Lake. (This changes the partition coefficients for the metals)

** Using Partition Coefficients

July 9, 2025

Facility Name: **TVA Browns Ferry Nuclear Plant DSN01B**

NPDES No.: **AL0022080**

Freshwater F&W classification.						Freshwater Acute (µg/l) Q_s =1Q10						Freshwater Chronic (µg/l) Q_s = 7Q10					Human Health Consumption Fish only (µg/l) Carcinogen Q_s = Annual Average Non-Carcinogen Q_s = 7Q10			
ID	Pollutant	RP?	Carcinogen yes	Background from upstream source (Cd2) Daily Max	Max Daily Discharge as reported by Applicant (C_{dmax})	Water Quality Criteria (C_T)	Draft Permit Limit (C_{dmax})	20% of Draft Permit Limit	RP?	Background from upstream source (Cd2) Monthly Ave	Avg Daily Discharge as reported by Applicant (C_{davg})	Water Quality Criteria (C_T)	Draft Permit Limit (C_{davg})	20% of Draft Permit Limit	RP?		Water Quality Criteria (C_T)	Draft Permit Limit (C_{davg})	20% of Draft Permit Limit	RP?
1	Antimony			0	0	-	-	-	-	0	0	-	-	-	-		3.73E+02	8.11E+07	1.62E+07	No
2	Arsenic		YES	0	0	592.334	##########	##########	No	0	0	261.324	##########	##########	No		3.03E-01	4.11E+05	8.21E+04	No
3	Beryllium			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
4	Cadmium			0	0	10.069	##########	277856.443	No	0	0	1.230	267354.560	53470.912	No		-	-	-	-
5	Chromium/ Chromium III			0	0	4558.108	##########	##########	No	0	0	592.916	##########	##########	No		-	-	-	-
6	Chromium/ Chromium VI			0	0	16.000	##########	441539.532	No	0	0	11.000	##########	478202.260	No		-	-	-	-
7	Copper			0	0	58.431	##########	1612472.767	No	0	0	38.938	##########	1692751.189	No		-	-	-	-
8	Lead			0	0	313.502	##########	8651466.332	No	0	0	12.217	##########	531096.521	No		-	-	-	-
9	Mercury			0	0	2.400	331154.649	66230.930	No	0	0	0.012	2608.376	521.675	No		0.042	9221.531	1844.306	No
10	Nickel			0	0	1992.493	##########	##########	No	0	0	221.304	##########	9620752.284	No		9.93E+02	2.16E+08	4.32E+07	No
11	Selenium			0	0	20.000	##########	551924.416	No	0	0	5.000	##########	217364.663	No		2.43E+03	5.28E+08	1.06E+08	No
12	Silver			0	0	3.217	443851.718	88770.344	No	0	0	-	-	-	-		-	-	-	-
13	Thallium			0	0	-	-	-	-	0	0	-	-	-	-		2.74E-01	5.95E+04	1.19E+04	No
14	Zinc			0	0	770.924	##########	##########	No	0	0	777.230	##########	##########	No		1.49E+04	3.24E+09	6.47E+08	No
15	Cyanide			0	0	22.000	##########	607116.857	No	0	0	5.200	##########	226059.250	No		9.33E+03	2.03E+09	4.06E+08	No
16	Total Phenolic Compounds			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
17	Hardness (As CaCO3)			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
18	Acrolein			0	0	-	-	-	-	0	0	-	-	-	-		5.43E+00	1.18E+06	2.36E+05	No
19	Acrylonitrile		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.44E-01	1.95E+05	3.90E+04	No
20	Aldrin		YES	0	0	3.000	413943.312	82788.662	No	0	0	-	-	-	-		2.94E-05	3.98E+01	7.97E+00	No
21	Benzene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.55E+01	2.10E+07	4.19E+06	No
22	Bromoform		YES	0	0	-	-	-	-	0	0	-	-	-	-		7.88E+01	1.07E+08	2.13E+07	No
23	Carbon Tetrachloride		YES	0	0	-	-	-	-	0	0	-	-	-	-		9.57E-01	1.30E+06	2.59E+05	No
24	Chlordane		YES	0	0	2.400	331154.649	66230.930	No	0	0	0.0043	934.668	186.934	No		4.73E-04	6.41E+02	1.28E+02	No
25	Clorobenzene			0	0	-	-	-	-	0	0	-	-	-	-		9.06E+02	1.97E+08	3.94E+07	No
26	Chlorodibromo-Methane		YES	0	0	-	-	-	-	0	0	-	-	-	-		7.41E+00	1.00E+07	2.01E+06	No
27	Chloroethane			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
28	2-Chloro-Ethylvinyl Ether			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
29	ChloroForm		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.02E+02	1.38E+08	2.76E+07	No
30	4,4' - DDD		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.81E-04	2.46E+02	4.92E+01	No
31	4,4' - DDE		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.28E-04	1.74E+02	3.47E+01	No
32	4,4' - DDT		YES	0	0	1.100	151779.214	30355.843	No	0	0	0.001	217.365	43.473	No		1.28E-04	1.74E+02	3.47E+01	No
33	Dichlorobromo-Methane		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.00E+01	1.36E+07	2.72E+06	No
34	1, 1-Dichloroethane			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
35	1, 2-Dichloroethane		YES	0	0	-	-	-	-	0	0	-	-	-	-		2.14E+01	2.90E+07	5.79E+06	No
36	Trans-1, 2-Dichloro-Ethylene			0	0	-	-	-	-	0	0	-	-	-	-		5.91E+03	1.28E+09	2.57E+08	No
37	1, 1-Dichloroethylene		YES	0	0	-	-	-	-	0	0	-	-	-	-		4.17E+03	5.65E+09	1.13E+09	No
38	1, 2-Dichloropropane			0	0	-	-	-	-	0	0	-	-	-	-		8.49E+00	1.85E+06	3.69E+05	No
39	1, 3-Dichloro-Propylene			0	0	-	-	-	-	0	0	-	-	-	-		1.23E+01	2.67E+06	5.34E+05	No
40	Dieldrin		YES	0	0	0.240	33115.465	6623.093	No	0	0	0.056	12172.421	2434.484	No		3.12E-05	4.23E+01	8.46E+00	No
41	Ethylbenzene			0	0	-	-	-	-	0	0	-	-	-	-		1.24E+03	2.70E+08	5.41E+07	No
42	Methyl Bromide			0	0	-	-	-	-	0	0	-	-	-	-		8.71E+02	1.89E+08	3.79E+07	No
43	Methyl Chloride			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
44	Methylene Chloride		YES	0	0	-	-	-	-	0	0	-	-	-	-		3.46E+02	4.68E+08	9.37E+07	No
45	1, 1, 2, 2-Tetrachloro-Ethane		YES	0	0	-	-	-	-	0	0	-	-	-	-		2.33E+00	3.16E+06	6.32E+05	No
46	Tetrachloro-Ethylene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.92E+00	2.60E+06	5.20E+05	No
47	Toluene			0	0	-	-	-	-	0	0	-	-	-	-		8.72E+03	1.90E+09	3.79E+08	No
48	Toxaphene		YES	0	0	0.730	100726.206	20145.241	No	0	0	0.0002	43.473	8.695	No		1.62E-04	2.19E+02	4.39E+01	No
49	Tributyltin (TBT)		YES	0	0	0.460	63471.308	12694.262	No	0	0	0.072	15650.256	3130.051	No		-	-	-	-
50	1, 1, 1-Trichloroethane			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
51	1, 1, 2-Trichloroethane		YES	0	0	-	-	-	-	0	0	-	-	-	-		9.10E+00	1.23E+07	2.47E+06	No
52	Trichlorethylene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.75E+01	2.37E+07	4.73E+06	No
53	Vinyl Chloride		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.42E+00	1.93E+06	3.86E+05	No
54	P-Chloro-M-Cresol			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
55	2-Chlorophenol			0	0	-	-	-	-	0	0	-	-	-	-		8.71E+01	1.89E+07	3.78E+06	No
56	2, 4-Dichlorophenol			0	0	-	-	-	-	0	0	-	-	-	-		1.72E+02	3.74E+07	7.48E+06	No
57	2, 4-Dimethylphenol			0	0	-	-	-	-	0	0	-	-	-	-		4.98E+02	1.08E+08	2.16E+07	No
58	4, 6-Dinitro-O-Cresol			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
59	2, 4-Dinitrophenol			0	0	-	-	-	-	0	0	-	-	-	-		3.11E+03	6.76E+08	1.35E+08	No
60	4,6-Dinitro-2-methylphenol		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.65E+02	2.24E+08	4.48E+07	No
61	Dioxin (2,3,7,8-TCDD)		YES	0	0	-	-	-	-	0	0	-	-	-	-		2.67E-08	3.61E-02	7.23E-03	No
62	2-Nitrophenol			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
63	4-Nitrophenol			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
64	Pentachlorophenol		YES	0	0	8.723	##########	240730.689	No	0	0	6.693	##########	290946.240	No		1.77E+00	2.40E+06	4.79E+05	No
65	Phenol			0	0	-	-	-	-	0	0	-	-	-	-		5.00E+05	1.09E+11	2.17E+10	No
66	2, 4, 6-Trichlorophenol		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.41E+00	1.92E+06	3.83E+05	No
67	Acenaphthene			0	0	-	-	-	-	0	0	-	-	-	-		5.79E+02	1.26E+08	2.51E+07	No
68	Acenaphthylene			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
69	Anthracene			0	0	-	-	-	-	0	0	-	-	-	-		2.33E+04	5.07E+09	1.01E+09	No
70	Benzidine			0	0	-	-	-	-	0	0	-	-	-	-		1.16E-04	2.52E+01	5.04E+00	No
71	Benzo(A)Anthracene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.07E-02	1.44E+04	2.89E+03	No
72	Benzo(A)Pyrene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.07E-02	1.44E+04	2.89E+03	No
73	Benzo(b)fluoranthene			0	0	-	-	-	-	0	0	-	-	-	-		1.07E-02	2.32E+03	4.63E+02	No
74	Benzo(GHI)Perylene			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
75	Benzo(K)Fluoranthene			0	0	-	-	-	-	0	0	-	-	-	-		1.07E-02	2.32E+03	4.63E+02	No
76	Bis (2-Chloroethoxy) Methane			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
77	Bis (2-Chloroethyl)-Ether		YES	0	0	-	-	-	-	0	0	-	-	-	-		3.07E-01	4.17E+05	8.33E+04	No
78	Bis (2-Chloroiso-Propyl) Ether			0	0	-	-	-	-	0	0	-	-	-	-		3.78E+04	8.21E+09	1.64E+09	No
79	Bis (2-Ethylhexyl) Phthalate		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.28E+00	1.74E+06	3.47E+05	No
80	4-Bromophenyl Phenyl Ether			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
81	Butyl Benzyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-		1.13E+03	2.45E+08	4.90E+07	No
82	2-Chloronaphthalene			0	0	-	-	-	-	0	0	-	-	-	-		9.24E+02	2.01E+08	4.02E+07	No
83	4-Chlorophenyl Phenyl Ether			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
84	Chrysene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.07E-02	1.44E+04	2.89E+03	No
85	Di-N-Butyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-		2.62E+03	5.70E+08	1.14E+08	No
86	Di-N-Octyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
87	Dibenzo(A,H)Anthracene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.07E-02	1.44E+04	2.89E+03	No
88	1, 2-Dichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-		7.55E+02	1.64E+08	3.28E+07	No
89	1, 3-Dichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-		5.62E+02	1.22E+08	2.44E+07	No
90	1, 4-Dichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-		1.12E+02	2.44E+07	4.89E+06	No
91	3, 3-Dichlorobenzidine		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.66E-02	2.25E+04	4.50E+03	No
92	Diethyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-		2.56E+04	5.56E+09	1.11E+09	No
93	Dimethyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-		6.48E+05	1.41E+11	2.82E+10	No
94	2, 4-Dinitrotoluene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.98E+00	2.68E+06	5.37E+05	No
95	2, 6-Dinitrotoluene			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
96	1,2-Diphenylhydrazine			0	0	-	-	-	-	0	0	-	-	-	-		1.17E-01	2.55E+04	5.09E+03	No
97	Endosulfan (alpha)		YES	0	0	0.22	30355.843	6071.169	No	0	0	0.056	12172.421	2434.484	No		5.19E+01	7.03E+07	1.41E+07	No
98	Endosulfan (beta)		YES	0	0	0.22	30355.843	6071.169	No	0	0	0.056	12172.421	2434.484	No		5.19E+01	7.03E+07	1.41E+07	No
99	Endosulfan sulfate		YES	0	0	-	-	-	-	0	0	-	-	-	-		5.19E+01	7.03E+07	1.41E+07	No
100	Endrin		YES	0	0	0.086	11866.375	2373.275	No	0	0	0.036	7825.128	1565.026	No		3.53E-02	4.78E+04	9.56E+03	No
101	Endrin Aldeyhde		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.76E-01	2.39E+05	4.78E+04	No
102	Fluoranthene			0	0	-	-	-	-	0	0	-	-	-	-		8.12E+01	1.76E+07	3.53E+06	No
103	Fluorene			0	0	-	-	-	-	0	0	-	-	-	-		3.11E+03	6.76E+08	1.35E+08	No
104	Heptochlor		YES	0	0	0.52	71750.174	14350.035	No	0	0	0.0038	825.986	165.197	No		4.63E-05	6.27E+01	1.25E+01	No
105	Heptachlor Epoxide		YES	0	0	0.52	71750.174	14350.035	No	0	0	0.0038	825.986	165.197	No		2.29E-05	3.10E+01	6.20E+00	No
106	Hexachlorobenzene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.68E-04	2.27E+02	4.55E+01	No
107	Hexachlorobutadiene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.08E+01	1.46E+07	2.92E+06	No
108	Hexachlorocyclohexan (alpha)		YES	0	0	-	-	-	-	0	0	-	-	-	-		2.85E-03	3.86E+03	7.72E+02	No
109	Hexachlorocyclohexan (beta)		YES	0	0	-	-	-	-	0	0	-	-	-	-		9.97E-03	1.35E+04	2.70E+03	No
110	Hexachlorocyclohexan (gamma)		YES	0	0	0.95	131082.049	26216.410	No	0	0	-	-	-	-		1.08E+00	1.46E+06	2.92E+05	No
111	HexachlorocycloPentadiene			0	0	-	-	-	-	0	0	-	-	-	-		6.45E+02	1.40E+08	2.80E+07	No
112	Hexachloroethane			0	0	-	-	-	-	0	0	-	-	-	-		1.92E+00	4.17E+05	8.34E+04	No
113	Indeno(1, 2, 3-CK)Pyrene		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.07E-02	1.44E+04	2.89E+03	No
114	Isophorone			0	0	-	-	-	-	0	0	-	-	-	-		5.61E+02	1.22E+08	2.44E+07	No
115	Naphthalene			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
116	Nitrobenzene			0	0	-	-	-	-	0	0	-	-	-	-		4.04E+02	8.77E+07	1.75E+07	No
117	N-Nitrosodi-N-Propylamine		YES	0	0	-	-	-	-	0	0	-	-	-	-		2.95E-01	4.00E+05	7.99E+04	No
118	N-Nitrosodimethylamine		YES	0	0	-	-	-	-	0	0	-	-	-	-		1.76E+00	2.38E+06	4.77E+05	No
119	N-Nitrosodiphenylamine		YES	0	0	-	-	-	-	0	0	-	-	-	-		3.50E+00	4.74E+06	9.49E+05	No
120	PCB-1016		YES	0	0	-	-	-	-	0	0	0.014	3043.105	608.621	No		3.74E-05	5.07E+01	1.01E+01	No
121	PCB-1221		YES	0	0	-	-	-	-	0	0	0.014	3043.105	608.621	No		3.74E-05	5.07E+01	1.01E+01	No
122	PCB-1232		YES	0	0	-	-	-	-	0	0	0.014	3043.105	608.621	No		3.74E-05	5.07E+01	1.01E+01	No
123	PCB-1242		YES	0	0	-	-	-	-	0	0	0.014	3043.105	608.621	No		3.74E-05	5.07E+01	1.01E+01	No
124	PCB-1248		YES	0	0	-	-	-	-	0	0	0.014	3043.105	608.621	No		3.74E-05	5.07E+01	1.01E+01	No
125	PCB-1254		YES	0	0	-	-	-	-	0	0	0.014	3043.105	608.621	No		3.74E-05	5.07E+01	1.01E+01	No
126	PCB-1260		YES	0	0	-	-	-	-	0	0	0.014	3043.105	608.621	No		3.74E-05	5.07E+01	1.01E+01	No
127	Phenanthrene			0	0	-	-	-	-	0	0	-	-	-	-		-	-	-	-
128	Pyrene			0	0	-	-	-	-	0	0	-	-	-	-		2.33E+03	5.07E+08	1.01E+08	No
129	1, 2, 4-Trichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-		4.09E+01	8.90E+06	1.78E+06	No

Facility Name: **TVA Browns Ferry Nuclear Plant DSN0051**

NPDES No.: **AL0022080**

$Q_d*C_d + Q_{d2}*C_{d2} + Q_s*C_s = Q_r*C_r$

ID	Pollutant	Carcinogen "yes"	Type	Background from upstream source (C_{d2}) Daily Max	Background from upstream source (C_{d2}) Monthly Ave	Background Instream (C_s) Daily Max	Background Instream (C_s) Monthly Ave	**Enter** Max Daily Discharge as reported by Applicant (C_d) Max	**Enter** Avg Daily Discharge as reported by Applicant (C_d) Ave	Partition Coefficient (Stream / Lake)
				µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	
1	Antimony		Metals	0	0	0	0	0	0	-
2	**Arsenic*,****	YES	Metals	0	0	0	0	0	0	0.574
3	Berylium		Metals	0	0	0	0	0	0	-
4	Cadmium**		Metals	0	0	0	0	0	0	0.200
5	Chromium / Chromium III**		Metals	0	0	0	0	0	0	0.125
6	Chromium / Chromium VI**		Metals	0	0	0	0	0	0	
7	Copper**		Metals	0	0	0	0	2.85	2.85	0.230
8	Lead**		Metals	0	0	0	0	0	0	0.206
9	Mercury**		Metals	0	0	0	0	0.00188	0.00188	0.400
10	Nickel**		Metals	0	0	0	0	0.901	0.901	0.235
11	Selenium		Metals	0	0	0	0	0	0	-
12	Silver		Metals	0	0	0	0	0	0	-
13	Thallium		Metals	0	0	0	0	0	0	-
14	Zinc**		Metals	0	0	0	0	176	176	0.152
15	Cyanide		Metals	0	0	0	0	0	0	-
16	Total Phenolic Compounds		Metals	0	0	0	0	2.02	2.02	-
17	Hardness (As CaCO3)		Metals	0	0	0	0	0	0	-
18	Acrolein		VOC	0	0	0	0	0	0	-
19	**Acrylonitrile***	YES	VOC	0	0	0	0	0	0	-
20	**Aldrin**	YES	VOC	0	0	0	0	0	0	-
21	**Benzene***	YES	VOC	0	0	0	0	0	0	-
22	**Bromoform***	YES	VOC	0	0	0	0	0	0	-
23	**Carbon Tetrachloride***	YES	VOC	0	0	0	0	0	0	-
24	**Chlordane**	YES	VOC	0	0	0	0	0	0	-
25	Clorobenzene		VOC	0	0	0	0	0	0	-
26	**Chlorodibromo-Methane***	YES	VOC	0	0	0	0	0	0	-
27	Chloroethane		VOC	0	0	0	0	0	0	-
28	2-Chloro-Ethylvinyl Ether		VOC	0	0	0	0	0	0	-
29	**ChloroForm***	YES	VOC	0	0	0	0	0	0	-
30	**4,4'-DDD**	YES	VOC	0	0	0	0	0	0	-
31	**4,4'-DDE**	YES	VOC	0	0	0	0	0	0	-
32	**4.4'-DDT**	YES	VOC	0	0	0	0	0	0	-
33	**Dichlorobromo-Methane***	YES	VOC	0	0	0	0	0	0	-
34	1, 1-Dichloroethane		VOC	0	0	0	0	0	0	-
35	**1, 2-Dichloroethane***	YES	VOC	0	0	0	0	0	0	-
36	Trans-1, 2-Dichloro-Ethylene		VOC	0	0	0	0	0	0	-
37	**1, 1-Dichloroethylene***	YES	VOC	0	0	0	0	0	0	-
38	1, 2-Dichloropropane		VOC	0	0	0	0	0	0	-
39	1, 3-Dichloro-Propylene		VOC	0	0	0	0	0	0	-
40	**Dieldrin**	YES	VOC	0	0	0	0	0	0	-
41	Ethylbenzene		VOC	0	0	0	0	0	0	-
42	Methyl Bromide		VOC	0	0	0	0	0	0	-
43	Methyl Chloride		VOC	0	0	0	0	0	0	-
44	**Methylene Chloride***	YES	VOC	0	0	0	0	0	0	-
45	**1, 1, 2, 2-Tetrachloro-Ethane***	YES	VOC	0	0	0	0	0	0	-
46	**Tetrachloro-Ethylene***	YES	VOC	0	0	0	0	0	0	-
47	Toluene		VOC	0	0	0	0	0	0	-
48	**Toxaphene**	YES	VOC	0	0	0	0	0	0	-
49	**Tributyltine (TBT)**	YES	VOC	0	0	0	0	0	0	-
50	1, 1, 1-Trichloroethane		VOC	0	0	0	0	0	0	-
51	**1, 1, 2-Trichloroethane***	YES	VOC	0	0	0	0	0	0	-
52	**Trichlorethylene***	YES	VOC	0	0	0	0	0	0	-
53	**Vinyl Chloride***	YES	VOC	0	0	0	0	0	0	-
54	P-Chloro-M-Cresol		Acids	0	0	0	0	0	0	-
55	2-Chlorophenol		Acids	0	0	0	0	0	0	-
56	2, 4-Dichlorophenol		Acids	0	0	0	0	0	0	-
57	2, 4-Dimethylphenol		Acids	0	0	0	0	0	0	-
58	4, 6-Dinitro-O-Cresol		Acids	0	0	0	0	0	0	-
59	2, 4-Dinitrophenol		Acids	0	0	0	0	0	0	-
60	**4,6-Dintro-2-methylophenol**	YES	Acids	0	0	0	0	0	0	-
61	**Dioxin (2,3,7,8-TCDD)**	YES	Acids	0	0	0	0	0	0	-
62	2-Nitrophenol		Acids	0	0	0	0	0	0	-
63	4-Nitrophenol		Acids	0	0	0	0	0	0	-
64	**Pentachlorophenol***	YES	Acids	0	0	0	0	0	0	-
65	Phenol		Acids	0	0	0	0	0	0	-
66	**2, 4, 6-Trichlorophenol***	YES	Acids	0	0	0	0	0	0	-
67	Acenaphthene		Bases	0	0	0	0	0	0	-
68	Acenaphthylene		Bases	0	0	0	0	0	0	-
69	Anthracene		Bases	0	0	0	0	0	0	-
70	Benzidine		Bases	0	0	0	0	0	0	-
71	**Benzo(A)Anthracene***	YES	Bases	0	0	0	0	0	0	-
72	**Benzo(A)Pyrene***	YES	Bases	0	0	0	0	0	0	-
73	3, 4 Benzo-Fluoranthene		Bases	0	0	0	0	0	0	-
74	Benzo(GHI)Perylene		Bases	0	0	0	0	0	0	-
75	Benzo(K)Fluoranthene		Bases	0	0	0	0	0	0	-
76	Bis (2-Chloroethoxy) Methane		Bases	0	0	0	0	0	0	-
77	**Bis (2-Chloroethyl)-Ether***	YES	Bases	0	0	0	0	0	0	-
78	Bis (2-Chloroiso-Propyl) Ether		Bases	0	0	0	0	0	0	-
79	**Bis (2-Ethylhexyl) Phthalate***	YES	Bases	0	0	0	0	0	0	-
80	4-Bromophenyl Phenyl Ether		Bases	0	0	0	0	0	0	-
81	Butyl Benzyl Phthalate		Bases	0	0	0	0	0	0	-
82	2-Chloronaphthalene		Bases	0	0	0	0	0	0	-
83	4-Chlorophenyl Phenyl Ether		Bases	0	0	0	0	0	0	-
84	**Chrysene***	YES	Bases	0	0	0	0	0	0	-
85	Di-N-Butyl Phthalate		Bases	0	0	0	0	0	0	-
86	Di-N-Octyl Phthalate		Bases	0	0	0	0	0	0	-
87	**Dibenzo(A,H)Anthracene***	YES	Bases	0	0	0	0	0	0	-
88	1, 2-Dichlorobenzene		Bases	0	0	0	0	0	0	-
89	1, 3-Dichlorobenzene		Bases	0	0	0	0	0	0	-
90	1, 4-Dichlorobenzene		Bases	0	0	0	0	0	0	-
91	**3, 3-Dichlorobenzidine***	YES	Bases	0	0	0	0	0	0	-
92	Diethyl Phthalate		Bases	0	0	0	0	0	0	-
93	Dimethyl Phthalate		Bases	0	0	0	0	0	0	-
94	**2, 4-Dinitrotoluene***	YES	Bases	0	0	0	0	0	0	-
95	2, 6-Dinitrotoluene		Bases	0	0	0	0	0	0	-
96	1,2-Diphenylhydrazine		Bases	0	0	0	0	0	0	-
97	**Endosulfan (alpha)**	YES	Bases	0	0	0	0	0	0	-
98	**Endosulfan (beta)**	YES	Bases	0	0	0	0	0	0	-
99	**Endosulfan sulfate**	YES	Bases	0	0	0	0	0	0	-
100	**Endrin**	YES	Bases	0	0	0	0	0	0	-
101	**Endrin Aldeyhide**	YES	Bases	0	0	0	0	0	0	-
102	Fluoranthene		Bases	0	0	0	0	0	0	-
103	Fluorene		Bases	0	0	0	0	0	0	-
104	Heptochlor	YES	Bases	0	0	0	0	0	0	-
105	Heptachlor Epoxide	YES	Bases	0	0	0	0	0	0	-
106	**Hexachlorobenzene***	YES	Bases	0	0	0	0	0	0	-
107	**Hexachlorobutadiene***	YES	Bases	0	0	0	0	0	0	-
108	**Hexachlorocyclohexan (alpa)**	YES	Bases	0	0	0	0	0	0	-
109	**Hexachlorocyclohexan (beta)**	YES	Bases	0	0	0	0	0	0	-
110	**Hexachlorocyclohexan (gamma)**	YES	Bases	0	0	0	0	0	0	-
111	HexachlorocycloPentadiene		Bases	0	0	0	0	0	0	-
112	Hexachloroethane		Bases	0	0	0	0	0	0	-
113	**Indeno(1, 2, 3-CK)Pyrene***	YES	Bases	0	0	0	0	0	0	-
114	Isophorone		Bases	0	0	0	0	0	0	-
115	Naphthalene		Bases	0	0	0	0	0	0	-
116	Nitrobenzene		Bases	0	0	0	0	0	0	-
117	**N-Nitrosodi-N-Propylamine***	YES	Bases	0	0	0	0	0	0	-
118	**N-Nitrosodi-N-Methylamine***	YES	Bases	0	0	0	0	0	0	-
119	**N-Nitrosodi-N-Phenylamine***	YES	Bases	0	0	0	0	0	0	-
120	**PCB-1016**	YES	Bases	0	0	0	0	0	0	-
121	**PCB-1221**	YES	Bases	0	0	0	0	0	0	-
122	**PCB-1232**	YES	Bases	0	0	0	0	0	0	-
123	**PCB-1242**	YES	Bases	0	0	0	0	0	0	-
124	**PCB-1248**	YES	Bases	0	0	0	0	0	0	-
125	**PCB-1254**	YES	Bases	0	0	0	0	0	0	-
126	**PCB-1260**	YES	Bases	0	0	0	0	0	0	-
127	Phenanthrene		Bases	0	0	0	0	0	0	-
128	Pyrene		Bases	0	0	0	0	0	0	-
129	1, 2, 4-Trichlorobenzene		Bases	0	0	0	0	0	0	-

0.144	**Enter** Q_d = wastewater discharge flow from facility (MGD)
0.22280098	Q_d = wastewater discharge flow (cfs) (this value is caluclated from the MGD)
0	**Enter flow from upstream discharge** Qd2 = background stream flow in MGD above point of discharge
0	Qd2 = background stream flow from upstream source (cfs)
7398.85	**Enter 7Q10,** Q_s = background stream flow in cfs above point of discharge
4696.71	**Enter or estimated, 1Q10,** Q_s = background stream flow in cfs above point of discharge (1Q10 estimated at 75% of 7Q10)
46126.04	**Enter Mean Annual Flow**, Q_s = background stream flow in cfs above point of discharge
11710.51	**Enter 7Q2**, Q_s = background stream flow in cfs above point of discharge (For LWF class streams)
Enter to Left	**Enter C_s** = background in-stream pollutant concentration in µg/l (assuming this is zero "0" unless there is data)
Q_d +Qd2+Q_s	Q_r = resultant in-stream flow, after discharge
Calculated on other	C_r = resultant in-stream pollutant concentration in µg/l in the stream (after complete mixing occurs)
100	**Enter**, Background Hardness above point of discharge (assumed 50 South of Birmingham and 100 North of Birmingham)
7.00 s.u.	**Enter**, Background pH above point of discharge
No	**Enter**, Is discharge to a stream? "YES" Other option would be to a Lake. (This changes the partition coefficients for the metals)

** Using Partition Coefficients

July 9, 2025

Facility Name: **TVA Browns Ferry Nuclear Plant DSN0051**

NPDES No.: **AL0022080**

Freshwater F&W classification.						Freshwater Acute (µg/l) Q_s =1Q10					Avg Daily Discharge as reported by Applicant (C_{davg})	Freshwater Chronic (µg/l) Q_s = 7Q10				Human Health Consumption Fish only (µg/l) Carcinogen Q_s = Annual Average Non-Carcinogen Q_s = 7Q10			
ID	Pollutant	RP?	Carcinogen yes	Background from upstream source (Cd2) Daily Max	Max Daily Discharge as reported by Applicant (C_{dmax})	Water Quality Criteria (C_T)	Draft Permit Limit (C_{dmax})	20% of Draft Permit Limit	RP?	Background from upstream source (Cd2) Monthly Ave		Water Quality Criteria (C_T)	Draft Permit Limit (C_{davg})	20% of Draft Permit Limit	RP?	Water Quality Criteria (C_T)	Draft Permit Limit (C_{davg})	20% of Draft Permit Limit	RP?
1	Antimony			0	0	-	-	-	-	0	0	-	-	-	-	3.73E+02	1.24E+07	2.48E+06	No
2	Arsenic		YES	0	0	592.334	##########	2497435.485	No	0	0	261.324	##########	1735679.659	No	3.03E-01	6.27E+04	1.25E+04	No
3	Beryllium			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
4	Cadmium			0	0	10.069	212259.980	42451.996	No	0	0	1.230	40846.878	8169.376	No	-	-	-	-
5	Chromium/ Chromium III			0	0	4558.108	##########	##########	No	0	0	592.916	##########	3938070.680	No	-	-	-	-
6	Chromium/ Chromium VI			0	0	16.000	337300.698	67460.140	No	0	0	11.000	365302.712	73060.542	No	-	-	-	-
7	Copper			0	2.85	58.431	##########	246359.907	No	0	2.85	38.938	##########	258621.363	No	-	-	-	-
8	Lead			0	0	313.502	##########	1321804.922	No	0	0	12.217	405709.081	81141.816	No	-	-	-	-
9	Mercury			0	0.00188	2.400	50595.105	10119.021	No	0	0.00188	0.012	398.512	79.702	No	0.042	1408.881	281.776	No
10	Nickel			0	0.901	1992.493	##########	8400864.679	No	0	0.901	221.304	##########	1469874.653	No	9.93E+02	3.30E+07	6.59E+06	No
11	Selenium			0	0	20.000	421625.873	84325.175	No	0	0	5.000	166046.687	33209.337	No	2.43E+03	8.07E+07	1.61E+07	No
12	Silver			0	0	3.217	67813.404	13562.681	No	0	0	-	-	-	-	-	-	-	-
13	Thallium			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
14	Zinc			0	176	770.924	##########	3250415.216	No	0	176	777.230	##########	5162259.785	No	1.49E+04	4.95E+08	9.89E+07	No
15	Cyanide			0	0	22.000	463788.460	92757.692	No	0	0	5.200	172688.555	34537.711	No	9.33E+03	3.10E+08	6.20E+07	No
16	Total Phenolic Compounds			0	2.02	-	-	-	-	0	2.02	-	-	-	-	-	-	-	-
17	Hardness (As CaCO3)			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
18	Acrolein			0	0	-	-	-	-	0	0	-	-	-	-	5.43E+00	1.80E+05	3.60E+04	No
19	Acrylonitrile		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.44E-01	2.98E+04	5.96E+03	No
20	Aldrin		YES	0	0	3.000	63243.881	12648.776	No	0	0	-	-	-	-	2.94E-05	6.08E+00	1.22E+00	No
21	Benzene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.55E+01	3.20E+06	6.41E+05	No
22	Bromoform		YES	0	0	-	-	-	-	0	0	-	-	-	-	7.88E+01	1.63E+07	3.26E+06	No
23	Carbon Tetrachloride		YES	0	0	-	-	-	-	0	0	-	-	-	-	9.57E-01	1.98E+05	3.96E+04	No
24	Chlordane		YES	0	0	2.400	50595.105	10119.021	No	0	0	0.0043	142.800	28.560	No	4.73E-04	9.79E+01	1.96E+01	No
25	Clorobenzene			0	0	-	-	-	-	0	0	-	-	-	-	9.06E+02	3.01E+07	6.02E+06	No
26	Chlorodibromo-Methane		YES	0	0	-	-	-	-	0	0	-	-	-	-	7.41E+00	1.53E+06	3.07E+05	No
27	Chloroethane			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
28	2-Chloro-Ethylvinyl Ether			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
29	ChloroForm		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.02E+02	2.11E+07	4.22E+06	No
30	4,4' - DDD		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.81E-04	3.76E+01	7.51E+00	No
31	4,4' - DDE		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.28E-04	2.65E+01	5.30E+00	No
32	4,4' - DDT		YES	0	0	1.100	23189.423	4637.885	No	0	0	0.001	33.209	6.642	No	1.28E-04	2.65E+01	5.30E+00	No
33	Dichlorobromo-Methane		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.00E+01	2.08E+06	4.16E+05	No
34	1, 1-Dichloroethane			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
35	1, 2-Dichloroethane		YES	0	0	-	-	-	-	0	0	-	-	-	-	2.14E+01	4.42E+06	8.85E+05	No
36	Trans-1, 2-Dichloro-Ethylene			0	0	-	-	-	-	0	0	-	-	-	-	5.91E+03	1.96E+08	3.92E+07	No
37	1, 1-Dichloroethylene		YES	0	0	-	-	-	-	0	0	-	-	-	-	4.17E+03	8.63E+08	1.73E+08	No
38	1, 2-Dichloropropane			0	0	-	-	-	-	0	0	-	-	-	-	8.49E+00	2.82E+05	5.64E+04	No
39	1, 3-Dichloro-Propylene			0	0	-	-	-	-	0	0	-	-	-	-	1.23E+01	4.08E+05	8.16E+04	No
40	Dieldrin		YES	0	0	0.240	5059.510	1011.902	No	0	0	0.056	1859.723	371.945	No	3.12E-05	6.47E+00	1.29E+00	No
41	Ethylbenzene			0	0	-	-	-	-	0	0	-	-	-	-	1.24E+03	4.13E+07	8.27E+06	No
42	Methyl Bromide			0	0	-	-	-	-	0	0	-	-	-	-	8.71E+02	2.89E+07	5.79E+06	No
43	Methyl Chloride			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
44	Methylene Chloride		YES	0	0	-	-	-	-	0	0	-	-	-	-	3.46E+02	7.16E+07	1.43E+07	No
45	1, 1, 2, 2-Tetrachloro-Ethane		YES	0	0	-	-	-	-	0	0	-	-	-	-	2.33E+00	4.83E+05	9.66E+04	No
46	Tetrachloro-Ethylene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.92E+00	3.97E+05	7.94E+04	No
47	Toluene			0	0	-	-	-	-	0	0	-	-	-	-	8.72E+03	2.90E+08	5.79E+07	No
48	Toxaphene		YES	0	0	0.730	15389.344	3077.869	No	0	0	0.0002	6.642	1.328	No	1.62E-04	3.35E+01	6.70E+00	No
49	Tributyltin (TBT)		YES	0	0	0.460	9697.395	1939.479	No	0	0	0.072	2391.072	478.214	No	-	-	-	-
50	1, 1, 1-Trichloroethane			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
51	1, 1, 2-Trichloroethane		YES	0	0	-	-	-	-	0	0	-	-	-	-	9.10E+00	1.88E+06	3.77E+05	No
52	Trichlorethylene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.75E+01	3.62E+06	7.23E+05	No
53	Vinyl Chloride		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.42E+00	2.95E+05	5.90E+04	No
54	P-Chloro-M-Cresol			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
55	2-Chlorophenol			0	0	-	-	-	-	0	0	-	-	-	-	8.71E+01	2.89E+06	5.78E+05	No
56	2, 4-Dichlorophenol			0	0	-	-	-	-	0	0	-	-	-	-	1.72E+02	5.71E+06	1.14E+06	No
57	2, 4-Dimethylphenol			0	0	-	-	-	-	0	0	-	-	-	-	4.98E+02	1.65E+07	3.30E+06	No
58	4, 6-Dinitro-O-Cresol			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
59	2, 4-Dinitrophenol			0	0	-	-	-	-	0	0	-	-	-	-	3.11E+03	1.03E+08	2.07E+07	No
60	4,6-Dinitro-2-methylphenol		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.65E+02	3.43E+07	6.85E+06	No
61	Dioxin (2,3,7,8-TCDD)		YES	0	0	-	-	-	-	0	0	-	-	-	-	2.67E-08	5.52E-03	1.10E-03	No
62	2-Nitrophenol			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
63	4-Nitrophenol			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
64	Pentachlorophenol		YES	0	0	8.723	183898.889	36779.778	No	0	0	6.693	222256.270	44451.254	No	1.77E+00	3.66E+05	7.32E+04	No
65	Phenol			0	0	-	-	-	-	0	0	-	-	-	-	5.00E+05	1.66E+10	3.32E+09	No
66	2, 4, 6-Trichlorophenol		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.41E+00	2.93E+05	5.86E+04	No
67	Acenaphthene			0	0	-	-	-	-	0	0	-	-	-	-	5.79E+02	1.92E+07	3.84E+06	No
68	Acenaphthylene			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
69	Anthracene			0	0	-	-	-	-	0	0	-	-	-	-	2.33E+04	7.75E+08	1.55E+08	No
70	Benzidine			0	0	-	-	-	-	0	0	-	-	-	-	1.16E-04	3.85E+00	7.70E-01	No
71	Benzo(A)Anthracene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.07E-02	2.21E+03	4.41E+02	No
72	Benzo(A)Pyrene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.07E-02	2.21E+03	4.41E+02	No
73	Benzo(b)fluoranthene			0	0	-	-	-	-	0	0	-	-	-	-	1.07E-02	3.54E+02	7.08E+01	No
74	Benzo(GHI)Perylene			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
75	Benzo(K)Fluoranthene			0	0	-	-	-	-	0	0	-	-	-	-	1.07E-02	3.54E+02	7.08E+01	No
76	Bis (2-Chloroethoxy) Methane			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
77	Bis (2-Chloroethyl)-Ether		YES	0	0	-	-	-	-	0	0	-	-	-	-	3.07E-01	6.36E+04	1.27E+04	No
78	Bis (2-Chloroiso-Propyl) Ether			0	0	-	-	-	-	0	0	-	-	-	-	3.78E+04	1.25E+09	2.51E+08	No
79	Bis (2-Ethylhexyl) Phthalate		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.28E+00	2.65E+05	5.31E+04	No
80	4-Bromophenyl Phenyl Ether			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
81	Butyl Benzyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-	1.13E+03	3.74E+07	7.49E+06	No
82	2-Chloronaphthalene			0	0	-	-	-	-	0	0	-	-	-	-	9.24E+02	3.07E+07	6.14E+06	No
83	4-Chlorophenyl Phenyl Ether			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
84	Chrysene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.07E-02	2.21E+03	4.41E+02	No
85	Di-N-Butyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-	2.62E+03	8.71E+07	1.74E+07	No
86	Di-N-Octyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
87	Dibenzo(A,H)Anthracene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.07E-02	2.21E+03	4.41E+02	No
88	1, 2-Dichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-	7.55E+02	2.51E+07	5.02E+06	No
89	1, 3-Dichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-	5.62E+02	1.87E+07	3.74E+06	No
90	1, 4-Dichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-	1.12E+02	3.74E+06	7.47E+05	No
91	3, 3-Dichlorobenzidine		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.66E-02	3.44E+03	6.88E+02	No
92	Diethyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-	2.56E+04	8.49E+08	1.70E+08	No
93	Dimethyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-	6.48E+05	2.15E+10	4.30E+09	No
94	2, 4-Dinitrotoluene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.98E+00	4.10E+05	8.20E+04	No
95	2, 6-Dinitrotoluene			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
96	1,2-Diphenylhydrazine			0	0	-	-	-	-	0	0	-	-	-	-	1.17E-01	3.89E+03	7.78E+02	No
97	Endosulfan (alpha)		YES	0	0	0.22	4637.885	927.577	No	0	0	0.056	1859.723	371.945	No	5.19E+01	1.07E+07	2.15E+06	No
98	Endosulfan (beta)		YES	0	0	0.22	4637.885	927.577	No	0	0	0.056	1859.723	371.945	No	5.19E+01	1.07E+07	2.15E+06	No
99	Endosulfan sulfate		YES	0	0	-	-	-	-	0	0	-	-	-	-	5.19E+01	1.07E+07	2.15E+06	No
100	Endrin		YES	0	0	0.086	1812.991	362.598	No	0	0	0.036	1195.536	239.107	No	3.53E-02	7.30E+03	1.46E+03	No
101	Endrin Aldeyhde		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.76E-01	3.65E+04	7.30E+03	No
102	Fluoranthene			0	0	-	-	-	-	0	0	-	-	-	-	8.12E+01	2.70E+06	5.39E+05	No
103	Fluorene			0	0	-	-	-	-	0	0	-	-	-	-	3.11E+03	1.03E+08	2.07E+07	No
104	Heptochlor		YES	0	0	0.52	10962.273	2192.455	No	0	0	0.0038	126.195	25.239	No	4.63E-05	9.58E+00	1.92E+00	No
105	Heptachlor Epoxide		YES	0	0	0.52	10962.273	2192.455	No	0	0	0.0038	126.195	25.239	No	2.29E-05	4.74E+00	9.48E-01	No
106	Hexachlorobenzene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.68E-04	3.47E+01	6.95E+00	No
107	Hexachlorobutadiene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.08E+01	2.23E+06	4.46E+05	No
108	Hexachlorocyclohexan (alpha)		YES	0	0	-	-	-	-	0	0	-	-	-	-	2.85E-03	5.90E+02	1.18E+02	No
109	Hexachlorocyclohexan (beta)		YES	0	0	-	-	-	-	0	0	-	-	-	-	9.97E-03	2.06E+03	4.13E+02	No
110	Hexachlorocyclohexan (gamma)		YES	0	0	0.95	20027.229	4005.446	No	0	0	-	-	-	-	1.08E+00	2.23E+05	4.46E+04	No
111	HexachlorocycloPentadiene			0	0	-	-	-	-	0	0	-	-	-	-	6.45E+02	2.14E+07	4.29E+06	No
112	Hexachloroethane			0	0	-	-	-	-	0	0	-	-	-	-	1.92E+00	6.37E+04	1.27E+04	No
113	Indeno(1, 2, 3-CK)Pyrene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.07E-02	2.21E+03	4.41E+02	No
114	Isophorone			0	0	-	-	-	-	0	0	-	-	-	-	5.61E+02	1.86E+07	3.72E+06	No
115	Naphthalene			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
116	Nitrobenzene			0	0	-	-	-	-	0	0	-	-	-	-	4.04E+02	1.34E+07	2.68E+06	No
117	N-Nitrosodi-N-Propylamine		YES	0	0	-	-	-	-	0	0	-	-	-	-	2.95E-01	6.11E+04	1.22E+04	No
118	N-Nitrosodimethylamine		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.76E+00	3.64E+05	7.29E+04	No
119	N-Nitrosodiphenylamine		YES	0	0	-	-	-	-	0	0	-	-	-	-	3.50E+00	7.25E+05	1.45E+05	No
120	PCB-1016		YES	0	0	-	-	-	-	0	0	0.014	464.931	92.986	No	3.74E-05	7.74E+00	1.55E+00	No
121	PCB-1221		YES	0	0	-	-	-	-	0	0	0.014	464.931	92.986	No	3.74E-05	7.74E+00	1.55E+00	No
122	PCB-1232		YES	0	0	-	-	-	-	0	0	0.014	464.931	92.986	No	3.74E-05	7.74E+00	1.55E+00	No
123	PCB-1242		YES	0	0	-	-	-	-	0	0	0.014	464.931	92.986	No	3.74E-05	7.74E+00	1.55E+00	No
124	PCB-1248		YES	0	0	-	-	-	-	0	0	0.014	464.931	92.986	No	3.74E-05	7.74E+00	1.55E+00	No
125	PCB-1254		YES	0	0	-	-	-	-	0	0	0.014	464.931	92.986	No	3.74E-05	7.74E+00	1.55E+00	No
126	PCB-1260		YES	0	0	-	-	-	-	0	0	0.014	464.931	92.986	No	3.74E-05	7.74E+00	1.55E+00	No
127	Phenanthrene			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
128	Pyrene			0	0	-	-	-	-	0	0	-	-	-	-	2.33E+03	7.75E+07	1.55E+07	No
129	1, 2, 4-Trichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-	4.09E+01	1.36E+06	2.72E+05	No

Facility Name: **TVA Browns Ferry Nuclear Plant DSN13B1**

NPDES No.: **AL0022080**

$Q_d*C_d + Q_{d2}*C_{d2} + Q_s*C_s = Q_r*C_r$

ID	Pollutant	Carcinogen "yes"	Type	Background from upstream source (C_{d2}) Daily Max	Background from upstream source (C_{d2}) Monthly Ave	Background Instream (C_s) Daily Max	Background Instream (C_s) Monthly Ave	**Enter** Max Daily Discharge as reported by Applicant (C_d) Max	**Enter** Avg Daily Discharge as reported by Applicant (C_d) Ave	Partition Coefficient (Stream / Lake)
				µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	
1	Antimony		Metals	0	0	0	0	0	0	-
2	**Arsenic*,****	YES	Metals	0	0	0	0	0	0	0.574
3	Beryllium		Metals	0	0	0	0	0	0	-
4	Cadmium**		Metals	0	0	0	0	0	0	0.200
5	Chromium / Chromium III**		Metals	0	0	0	0	0	0	0.125
6	Chromium / Chromium VI**		Metals	0	0	0	0	0	0	
7	Copper**		Metals	0	0	0	0	0.963	0.963	0.230
8	Lead**		Metals	0	0	0	0	0	0	0.206
9	Mercury**		Metals	0	0	0	0	0	0	0.400
10	Nickel**		Metals	0	0	0	0	0	0	0.235
11	Selenium		Metals	0	0	0	0	0	0	-
12	Silver		Metals	0	0	0	0	0	0	-
13	Thallium		Metals	0	0	0	0	0	0	-
14	Zinc**		Metals	0	0	0	0	0	0	0.152
15	Cyanide		Metals	0	0	0	0	0	0	-
16	Total Phenolic Compounds		Metals	0	0	0	0	0	0	-
17	Hardness (As CaCO3)		Metals	0	0	0	0	0	0	-
18	Acrolein		VOC	0	0	0	0	0	0	-
19	**Acrylonitrile***	YES	VOC	0	0	0	0	0	0	-
20	**Aldrin**	YES	VOC	0	0	0	0	0	0	-
21	**Benzene***	YES	VOC	0	0	0	0	0	0	-
22	**Bromoform***	YES	VOC	0	0	0	0	0	0	-
23	**Carbon Tetrachloride***	YES	VOC	0	0	0	0	0	0	-
24	**Chlordane**	YES	VOC	0	0	0	0	0	0	-
25	Clorobenzene		VOC	0	0	0	0	0	0	-
26	**Chlorodibromo-Methane***	YES	VOC	0	0	0	0	0	0	-
27	Chloroethane		VOC	0	0	0	0	0	0	-
28	2-Chloro-Ethylvinyl Ether		VOC	0	0	0	0	0	0	-
29	**ChloroForm***	YES	VOC	0	0	0	0	0	0	-
30	**4,4'-DDD**	YES	VOC	0	0	0	0	0	0	-
31	**4,4'-DDE**	YES	VOC	0	0	0	0	0	0	-
32	**4.4'-DDT**	YES	VOC	0	0	0	0	0	0	-
33	**Dichlorobromo-Methane***	YES	VOC	0	0	0	0	0	0	-
34	1, 1-Dichloroethane		VOC	0	0	0	0	0	0	-
35	**1, 2-Dichloroethane***	YES	VOC	0	0	0	0	0	0	-
36	Trans-1, 2-Dichloro-Ethylene		VOC	0	0	0	0	0	0	-
37	**1, 1-Dichloroethylene***	YES	VOC	0	0	0	0	0	0	-
38	1, 2-Dichloropropane		VOC	0	0	0	0	0	0	-
39	1, 3-Dichloro-Propylene		VOC	0	0	0	0	0	0	-
40	**Dieldrin**	YES	VOC	0	0	0	0	0	0	-
41	Ethylbenzene		VOC	0	0	0	0	0	0	-
42	Methyl Bromide		VOC	0	0	0	0	0	0	-
43	Methyl Chloride		VOC	0	0	0	0	0	0	-
44	**Methylene Chloride***	YES	VOC	0	0	0	0	0	0	-
45	**1, 1, 2, 2-Tetrachloro-Ethane***	YES	VOC	0	0	0	0	0	0	-
46	**Tetrachloro-Ethylene***	YES	VOC	0	0	0	0	0	0	-
47	Toluene		VOC	0	0	0	0	0	0	-
48	**Toxaphene**	YES	VOC	0	0	0	0	0	0	-
49	**Tributyltine (TBT)**	YES	VOC	0	0	0	0	0	0	-
50	1, 1, 1-Trichloroethane		VOC	0	0	0	0	0	0	-
51	**1, 1, 2-Trichloroethane***	YES	VOC	0	0	0	0	0	0	-
52	**Trichlorethylene***	YES	VOC	0	0	0	0	0	0	-
53	**Vinyl Chloride***	YES	VOC	0	0	0	0	0	0	-
54	P-Chloro-M-Cresol		Acids	0	0	0	0	0	0	-
55	2-Chlorophenol		Acids	0	0	0	0	0	0	-
56	2, 4-Dichlorophenol		Acids	0	0	0	0	0	0	-
57	2, 4-Dimethylphenol		Acids	0	0	0	0	0	0	-
58	4, 6-Dinitro-O-Cresol		Acids	0	0	0	0	0	0	-
59	2, 4-Dinitrophenol		Acids	0	0	0	0	0	0	-
60	**4,6-Dintro-2-methylophenol**	YES	Acids	0	0	0	0	0	0	-
61	**Dioxin (2,3,7,8-TCDD)**	YES	Acids	0	0	0	0	0	0	-
62	2-Nitrophenol		Acids	0	0	0	0	0	0	-
63	4-Nitrophenol		Acids	0	0	0	0	0	0	-
64	**Pentachlorophenol***	YES	Acids	0	0	0	0	0	0	-
65	Phenol		Acids	0	0	0	0	0	0	-
66	**2, 4, 6-Trichlorophenol***	YES	Acids	0	0	0	0	0	0	-
67	Acenaphthene		Bases	0	0	0	0	0	0	-
68	Acenaphthylene		Bases	0	0	0	0	0	0	-
69	Anthracene		Bases	0	0	0	0	0	0	-
70	Benzidine		Bases	0	0	0	0	0	0	-
71	**Benzo(A)Anthracene***	YES	Bases	0	0	0	0	0	0	-
72	**Benzo(A)Pyrene***	YES	Bases	0	0	0	0	0	0	-
73	3, 4 Benzo-Fluoranthene		Bases	0	0	0	0	0	0	-
74	Benzo(GHI)Perylene		Bases	0	0	0	0	0	0	-
75	Benzo(K)Fluoranthene		Bases	0	0	0	0	0	0	-
76	Bis (2-Chloroethoxy) Methane		Bases	0	0	0	0	0	0	-
77	**Bis (2-Chloroethyl)-Ether***	YES	Bases	0	0	0	0	0	0	-
78	Bis (2-Chloroiso-Propyl) Ether		Bases	0	0	0	0	0	0	-
79	**Bis (2-Ethylhexyl) Phthalate***	YES	Bases	0	0	0	0	0	0	-
80	4-Bromophenyl Phenyl Ether		Bases	0	0	0	0	0	0	-
81	Butyl Benzyl Phthalate		Bases	0	0	0	0	0	0	-
82	2-Chloronaphthalene		Bases	0	0	0	0	0	0	-
83	4-Chlorophenyl Phenyl Ether		Bases	0	0	0	0	0	0	-
84	**Chrysene***	YES	Bases	0	0	0	0	0	0	-
85	Di-N-Butyl Phthalate		Bases	0	0	0	0	0	0	-
86	Di-N-Octyl Phthalate		Bases	0	0	0	0	0	0	-
87	**Dibenzo(A,H)Anthracene***	YES	Bases	0	0	0	0	0	0	-
88	1, 2-Dichlorobenzene		Bases	0	0	0	0	0	0	-
89	1, 3-Dichlorobenzene		Bases	0	0	0	0	0	0	-
90	1, 4-Dichlorobenzene		Bases	0	0	0	0	0	0	-
91	**3, 3-Dichlorobenzidine***	YES	Bases	0	0	0	0	0	0	-
92	Diethyl Phthalate		Bases	0	0	0	0	0	0	-
93	Dimethyl Phthalate		Bases	0	0	0	0	0	0	-
94	**2, 4-Dinitrotoluene***	YES	Bases	0	0	0	0	0	0	-
95	2, 6-Dinitrotoluene		Bases	0	0	0	0	0	0	-
96	1,2-Diphenylhydrazine		Bases	0	0	0	0	0	0	-
97	**Endosulfan (alpha)**	YES	Bases	0	0	0	0	0	0	-
98	**Endosulfan (beta)**	YES	Bases	0	0	0	0	0	0	-
99	**Endosulfan sulfate**	YES	Bases	0	0	0	0	0	0	-
100	**Endrin**	YES	Bases	0	0	0	0	0	0	-
101	**Endrin Aldeyhide**	YES	Bases	0	0	0	0	0	0	-
102	Fluoranthene		Bases	0	0	0	0	0	0	-
103	Fluorene		Bases	0	0	0	0	0	0	-
104	Heptochlor	YES	Bases	0	0	0	0	0	0	-
105	Heptachlor Epoxide	YES	Bases	0	0	0	0	0	0	-
106	**Hexachlorobenzene***	YES	Bases	0	0	0	0	0	0	-
107	**Hexachlorobutadiene***	YES	Bases	0	0	0	0	0	0	-
108	**Hexachlorocyclohexan (alpa)**	YES	Bases	0	0	0	0	0	0	-
109	**Hexachlorocyclohexan (beta)**	YES	Bases	0	0	0	0	0	0	-
110	**Hexachlorocyclohexan (gamma)**	YES	Bases	0	0	0	0	0	0	-
111	HexachlorocycloPentadiene		Bases	0	0	0	0	0	0	-
112	Hexachloroethane		Bases	0	0	0	0	0	0	-
113	**Indeno(1, 2, 3-CK)Pyrene***	YES	Bases	0	0	0	0	0	0	-
114	Isophorone		Bases	0	0	0	0	0	0	-
115	Naphthalene		Bases	0	0	0	0	0	0	-
116	Nitrobenzene		Bases	0	0	0	0	0	0	-
117	**N-Nitrosodi-N-Propylamine***	YES	Bases	0	0	0	0	0	0	-
118	**N-Nitrosodi-N-Methylamine***	YES	Bases	0	0	0	0	0	0	-
119	**N-Nitrosodi-N-Phenylamine***	YES	Bases	0	0	0	0	0	0	-
120	**PCB-1016**	YES	Bases	0	0	0	0	0	0	-
121	**PCB-1221**	YES	Bases	0	0	0	0	0	0	-
122	**PCB-1232**	YES	Bases	0	0	0	0	0	0	-
123	**PCB-1242**	YES	Bases	0	0	0	0	0	0	-
124	**PCB-1248**	YES	Bases	0	0	0	0	0	0	-
125	**PCB-1254**	YES	Bases	0	0	0	0	0	0	-
126	**PCB-1260**	YES	Bases	0	0	0	0	0	0	-
127	Phenanthrene		Bases	0	0	0	0	0	0	-
128	Pyrene		Bases	0	0	0	0	0	0	-
129	1, 2, 4-Trichlorobenzene		Bases	0	0	0	0	0	0	-

0.504	**Enter** Q_d = wastewater discharge flow from facility (MGD)
0.77980342	Q_d = wastewater discharge flow (cfs) (this value is caluclated from the MGD)
0	**Enter flow from upstream discharge** Qd2 = background stream flow in MGD above point of discharge
0	Qd2 = background stream flow from upstream source (cfs)
7398.85	**Enter 7Q10,** Q_s = background stream flow in cfs above point of discharge
4696.71	**Enter or estimated, 1Q10,** Q_s = background stream flow in cfs above point of discharge (1Q10 estimated at 75% of 7Q10)
46126.04	**Enter Mean Annual Flow**, Q_s = background stream flow in cfs above point of discharge
11710.51	**Enter 7Q2**, Q_s = background stream flow in cfs above point of discharge (For LWF class streams)
Enter to Left	**Enter C_s** = background in-stream pollutant concentration in µg/l (assuming this is zero "0" unless there is data)
Q_d +Qd2+Q_s	Q_r = resultant in-stream flow, after discharge
Calculated on other	C_r = resultant in-stream pollutant concentration in µg/l in the stream (after complete mixing occurs)
100	**Enter**, Background Hardness above point of discharge (assumed 50 South of Birmingham and 100 North of Birmingham)
7.00 s.u.	**Enter**, Background pH above point of discharge
No	**Enter**, Is discharge to a stream? "YES" Other option would be to a Lake. (This changes the partition coefficients for the metals)

** Using Partition Coefficients

July 9, 2025

Facility Name: **TVA Browns Ferry Nuclear Plant DSN13B1**

NPDES No.: **AL0022080**

Freshwater F&W classification.						Freshwater Acute (µg/l) Q_s =1Q10					Avg Daily Discharge as reported by Applicant (C_{davg})	Freshwater Chronic (µg/l) Q_s = 7Q10				Human Health Consumption Fish only (µg/l) Carcinogen Q_s = Annual Average Non-Carcinogen Q_s = 7Q10			
ID	Pollutant	RP?	Carcinogen yes	Background from upstream source (Cd2) Daily Max	Max Daily Discharge as reported by Applicant (C_{dmax})	Water Quality Criteria (C_T)	Draft Permit Limit (C_{dmax})	20% of Draft Permit Limit	RP?	Background from upstream source (Cd2) Monthly Ave		Water Quality Criteria (C_T)	Draft Permit Limit (C_{davg})	20% of Draft Permit Limit	RP?	Water Quality Criteria (C_T)	Draft Permit Limit (C_{davg})	20% of Draft Permit Limit	RP?
1	Antimony			0	0	-	-	-	-	0	0	-	-	-	-	3.73E+02	3.54E+06	7.09E+05	No
2	Arsenic		YES	0	0	592.334	##########	713637.615	No	0	0	261.324	##########	495945.806	No	3.03E-01	1.79E+04	3.58E+03	No
3	Beryllium			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
4	Cadmium			0	0	10.069	60652.900	12130.580	No	0	0	1.230	11671.415	2334.283	No	-	-	-	-
5	Chromium/ Chromium III			0	0	4558.108	##########	5491554.522	No	0	0	592.916	##########	1125247.754	No	-	-	-	-
6	Chromium/ Chromium VI			0	0	16.000	96383.057	19276.611	No	0	0	11.000	104380.061	20876.012	No	-	-	-	-
7	Copper			0	0.963	58.431	351984.460	70396.892	No	0	0.963	38.938	369486.903	73897.381	No	-	-	-	-
8	Lead			0	0	313.502	##########	377703.335	No	0	0	12.217	115925.607	23185.121	No	-	-	-	-
9	Mercury			0	0	2.400	14457.459	2891.492	No	0	0	0.012	113.869	22.774	No	0.042	402.568	80.514	No
10	Nickel			0	0	1992.493	##########	2400531.693	No	0	0	221.304	##########	419995.802	No	9.93E+02	9.42E+06	1.88E+06	No
11	Selenium			0	0	20.000	120478.821	24095.764	No	0	0	5.000	47445.482	9489.096	No	2.43E+03	2.31E+07	4.61E+06	No
12	Silver			0	0	3.217	19377.556	3875.511	No	0	0	-	-	-	-	-	-	-	-
13	Thallium			0	0	-	-	-	-	0	0	-	-	-	-	2.74E-01	2.60E+03	5.19E+02	No
14	Zinc			0	0	770.924	##########	928800.194	No	0	0	777.230	##########	1475042.400	No	1.49E+04	1.41E+08	2.83E+07	No
15	Cyanide			0	0	22.000	132526.703	26505.341	No	0	0	5.200	49343.301	9868.660	No	9.33E+03	8.86E+07	1.77E+07	No
16	Total Phenolic Compounds			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
17	Hardness (As CaCO3)			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
18	Acrolein			0	0	-	-	-	-	0	0	-	-	-	-	5.43E+00	5.15E+04	1.03E+04	No
19	Acrylonitrile		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.44E-01	8.52E+03	1.70E+03	No
20	Aldrin		YES	0	0	3.000	18071.823	3614.365	No	0	0	-	-	-	-	2.94E-05	1.74E+00	3.48E-01	No
21	Benzene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.55E+01	9.15E+05	1.83E+05	No
22	Bromoform		YES	0	0	-	-	-	-	0	0	-	-	-	-	7.88E+01	4.66E+06	9.32E+05	No
23	Carbon Tetrachloride		YES	0	0	-	-	-	-	0	0	-	-	-	-	9.57E-01	5.66E+04	1.13E+04	No
24	Chlordane		YES	0	0	2.400	14457.459	2891.492	No	0	0	0.0043	40.803	8.161	No	4.73E-04	2.80E+01	5.59E+00	No
25	Clorobenzene			0	0	-	-	-	-	0	0	-	-	-	-	9.06E+02	8.60E+06	1.72E+06	No
26	Chlorodibromo-Methane		YES	0	0	-	-	-	-	0	0	-	-	-	-	7.41E+00	4.38E+05	8.76E+04	No
27	Chloroethane			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
28	2-Chloro-Ethylvinyl Ether			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
29	ChloroForm		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.02E+02	6.03E+06	1.21E+06	No
30	4,4' - DDD		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.81E-04	1.07E+01	2.15E+00	No
31	4,4' - DDE		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.28E-04	7.57E+00	1.51E+00	No
32	4,4' - DDT		YES	0	0	1.100	6626.335	1325.267	No	0	0	0.001	9.489	1.898	No	1.28E-04	7.57E+00	1.51E+00	No
33	Dichlorobromo-Methane		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.00E+01	5.94E+05	1.19E+05	No
34	1, 1-Dichloroethane			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
35	1, 2-Dichloroethane		YES	0	0	-	-	-	-	0	0	-	-	-	-	2.14E+01	1.26E+06	2.53E+05	No
36	Trans-1, 2-Dichloro-Ethylene			0	0	-	-	-	-	0	0	-	-	-	-	5.91E+03	5.61E+07	1.12E+07	No
37	1, 1-Dichloroethylene		YES	0	0	-	-	-	-	0	0	-	-	-	-	4.17E+03	2.46E+08	4.93E+07	No
38	1, 2-Dichloropropane			0	0	-	-	-	-	0	0	-	-	-	-	8.49E+00	8.06E+04	1.61E+04	No
39	1, 3-Dichloro-Propylene			0	0	-	-	-	-	0	0	-	-	-	-	1.23E+01	1.17E+05	2.33E+04	No
40	Dieldrin		YES	0	0	0.240	1445.746	289.149	No	0	0	0.056	531.389	106.278	No	3.12E-05	1.85E+00	3.69E-01	No
41	Ethylbenzene			0	0	-	-	-	-	0	0	-	-	-	-	1.24E+03	1.18E+07	2.36E+06	No
42	Methyl Bromide			0	0	-	-	-	-	0	0	-	-	-	-	8.71E+02	8.27E+06	1.65E+06	No
43	Methyl Chloride			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
44	Methylene Chloride		YES	0	0	-	-	-	-	0	0	-	-	-	-	3.46E+02	2.04E+07	4.09E+06	No
45	1, 1, 2, 2-Tetrachloro-Ethane		YES	0	0	-	-	-	-	0	0	-	-	-	-	2.33E+00	1.38E+05	2.76E+04	No
46	Tetrachloro-Ethylene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.92E+00	1.13E+05	2.27E+04	No
47	Toluene			0	0	-	-	-	-	0	0	-	-	-	-	8.72E+03	8.28E+07	1.66E+07	No
48	Toxaphene		YES	0	0	0.730	4397.477	879.495	No	0	0	0.0002	1.898	0.380	No	1.62E-04	9.58E+00	1.92E+00	No
49	Tributyltin (TBT)		YES	0	0	0.460	2771.013	554.203	No	0	0	0.072	683.215	136.643	No	-	-	-	-
50	1, 1, 1-Trichloroethane			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
51	1, 1, 2-Trichloroethane		YES	0	0	-	-	-	-	0	0	-	-	-	-	9.10E+00	5.38E+05	1.08E+05	No
52	Trichlorethylene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.75E+01	1.03E+06	2.07E+05	No
53	Vinyl Chloride		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.42E+00	8.43E+04	1.69E+04	No
54	P-Chloro-M-Cresol			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
55	2-Chlorophenol			0	0	-	-	-	-	0	0	-	-	-	-	8.71E+01	8.26E+05	1.65E+05	No
56	2, 4-Dichlorophenol			0	0	-	-	-	-	0	0	-	-	-	-	1.72E+02	1.63E+06	3.26E+05	No
57	2, 4-Dimethylphenol			0	0	-	-	-	-	0	0	-	-	-	-	4.98E+02	4.72E+06	9.44E+05	No
58	4, 6-Dinitro-O-Cresol			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
59	2, 4-Dinitrophenol			0	0	-	-	-	-	0	0	-	-	-	-	3.11E+03	2.95E+07	5.90E+06	No
60	4,6-Dinitro-2-methylphenol		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.65E+02	9.79E+06	1.96E+06	No
61	Dioxin (2,3,7,8-TCDD)		YES	0	0	-	-	-	-	0	0	-	-	-	-	2.67E-08	1.58E-03	3.15E-04	No
62	2-Nitrophenol			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
63	4-Nitrophenol			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
64	Pentachlorophenol		YES	0	0	8.723	52548.771	10509.754	No	0	0	6.693	63506.572	12701.314	No	1.77E+00	1.05E+05	2.09E+04	No
65	Phenol			0	0	-	-	-	-	0	0	-	-	-	-	5.00E+05	4.74E+09	9.49E+08	No
66	2, 4, 6-Trichlorophenol		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.41E+00	8.36E+04	1.67E+04	No
67	Acenaphthene			0	0	-	-	-	-	0	0	-	-	-	-	5.79E+02	5.49E+06	1.10E+06	No
68	Acenaphthylene			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
69	Anthracene			0	0	-	-	-	-	0	0	-	-	-	-	2.33E+04	2.21E+08	4.43E+07	No
70	Benzidine			0	0	-	-	-	-	0	0	-	-	-	-	1.16E-04	1.10E+00	2.20E-01	No
71	Benzo(A)Anthracene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.07E-02	6.30E+02	1.26E+02	No
72	Benzo(A)Pyrene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.07E-02	6.30E+02	1.26E+02	No
73	Benzo(b)fluoranthene			0	0	-	-	-	-	0	0	-	-	-	-	1.07E-02	1.01E+02	2.02E+01	No
74	Benzo(GHI)Perylene			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
75	Benzo(K)Fluoranthene			0	0	-	-	-	-	0	0	-	-	-	-	1.07E-02	1.01E+02	2.02E+01	No
76	Bis (2-Chloroethoxy) Methane			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
77	Bis (2-Chloroethyl)-Ether		YES	0	0	-	-	-	-	0	0	-	-	-	-	3.07E-01	1.82E+04	3.64E+03	No
78	Bis (2-Chloroiso-Propyl) Ether			0	0	-	-	-	-	0	0	-	-	-	-	3.78E+04	3.59E+08	7.17E+07	No
79	Bis (2-Ethylhexyl) Phthalate		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.28E+00	7.58E+04	1.52E+04	No
80	4-Bromophenyl Phenyl Ether			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
81	Butyl Benzyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-	1.13E+03	1.07E+07	2.14E+06	No
82	2-Chloronaphthalene			0	0	-	-	-	-	0	0	-	-	-	-	9.24E+02	8.77E+06	1.75E+06	No
83	4-Chlorophenyl Phenyl Ether			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
84	Chrysene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.07E-02	6.30E+02	1.26E+02	No
85	Di-N-Butyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-	2.62E+03	2.49E+07	4.98E+06	No
86	Di-N-Octyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
87	Dibenzo(A,H)Anthracene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.07E-02	6.30E+02	1.26E+02	No
88	1, 2-Dichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-	7.55E+02	7.17E+06	1.43E+06	No
89	1, 3-Dichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-	5.62E+02	5.34E+06	1.07E+06	No
90	1, 4-Dichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-	1.12E+02	1.07E+06	2.13E+05	No
91	3, 3-Dichlorobenzidine		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.66E-02	9.83E+02	1.97E+02	No
92	Diethyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-	2.56E+04	2.43E+08	4.85E+07	No
93	Dimethyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-	6.48E+05	6.15E+09	1.23E+09	No
94	2, 4-Dinitrotoluene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.98E+00	1.17E+05	2.34E+04	No
95	2, 6-Dinitrotoluene			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
96	1,2-Diphenylhydrazine			0	0	-	-	-	-	0	0	-	-	-	-	1.17E-01	1.11E+03	2.22E+02	No
97	Endosulfan (alpha)		YES	0	0	0.22	1325.267	265.053	No	0	0	0.056	531.389	106.278	No	5.19E+01	3.07E+06	6.13E+05	No
98	Endosulfan (beta)		YES	0	0	0.22	1325.267	265.053	No	0	0	0.056	531.389	106.278	No	5.19E+01	3.07E+06	6.13E+05	No
99	Endosulfan sulfate		YES	0	0	-	-	-	-	0	0	-	-	-	-	5.19E+01	3.07E+06	6.13E+05	No
100	Endrin		YES	0	0	0.086	518.059	103.612	No	0	0	0.036	341.607	68.321	No	3.53E-02	2.09E+03	4.17E+02	No
101	Endrin Aldeyhde		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.76E-01	1.04E+04	2.09E+03	No
102	Fluoranthene			0	0	-	-	-	-	0	0	-	-	-	-	8.12E+01	7.70E+05	1.54E+05	No
103	Fluorene			0	0	-	-	-	-	0	0	-	-	-	-	3.11E+03	2.95E+07	5.90E+06	No
104	Heptochlor		YES	0	0	0.52	3132.449	626.490	No	0	0	0.0038	36.059	7.212	No	4.63E-05	2.74E+00	5.48E-01	No
105	Heptachlor Epoxide		YES	0	0	0.52	3132.449	626.490	No	0	0	0.0038	36.059	7.212	No	2.29E-05	1.35E+00	2.71E-01	No
106	Hexachlorobenzene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.68E-04	9.93E+00	1.99E+00	No
107	Hexachlorobutadiene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.08E+01	6.37E+05	1.27E+05	No
108	Hexachlorocyclohexan (alpha)		YES	0	0	-	-	-	-	0	0	-	-	-	-	2.85E-03	1.69E+02	3.37E+01	No
109	Hexachlorocyclohexan (beta)		YES	0	0	-	-	-	-	0	0	-	-	-	-	9.97E-03	5.90E+02	1.18E+02	No
110	Hexachlorocyclohexan (gamma)		YES	0	0	0.95	5722.744	1144.549	No	0	0	-	-	-	-	1.08E+00	6.37E+04	1.27E+04	No
111	HexachlorocycloPentadiene			0	0	-	-	-	-	0	0	-	-	-	-	6.45E+02	6.12E+06	1.22E+06	No
112	Hexachloroethane			0	0	-	-	-	-	0	0	-	-	-	-	1.92E+00	1.82E+04	3.64E+03	No
113	Indeno(1, 2, 3-CK)Pyrene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.07E-02	6.30E+02	1.26E+02	No
114	Isophorone			0	0	-	-	-	-	0	0	-	-	-	-	5.61E+02	5.32E+06	1.06E+06	No
115	Naphthalene			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
116	Nitrobenzene			0	0	-	-	-	-	0	0	-	-	-	-	4.04E+02	3.83E+06	7.66E+05	No
117	N-Nitrosodi-N-Propylamine		YES	0	0	-	-	-	-	0	0	-	-	-	-	2.95E-01	1.74E+04	3.49E+03	No
118	N-Nitrosodimethylamine		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.76E+00	1.04E+05	2.08E+04	No
119	N-Nitrosodiphenylamine		YES	0	0	-	-	-	-	0	0	-	-	-	-	3.50E+00	2.07E+05	4.14E+04	No
120	PCB-1016		YES	0	0	-	-	-	-	0	0	0.014	132.847	26.569	No	3.74E-05	2.21E+00	4.42E-01	No
121	PCB-1221		YES	0	0	-	-	-	-	0	0	0.014	132.847	26.569	No	3.74E-05	2.21E+00	4.42E-01	No
122	PCB-1232		YES	0	0	-	-	-	-	0	0	0.014	132.847	26.569	No	3.74E-05	2.21E+00	4.42E-01	No
123	PCB-1242		YES	0	0	-	-	-	-	0	0	0.014	132.847	26.569	No	3.74E-05	2.21E+00	4.42E-01	No
124	PCB-1248		YES	0	0	-	-	-	-	0	0	0.014	132.847	26.569	No	3.74E-05	2.21E+00	4.42E-01	No
125	PCB-1254		YES	0	0	-	-	-	-	0	0	0.014	132.847	26.569	No	3.74E-05	2.21E+00	4.42E-01	No
126	PCB-1260		YES	0	0	-	-	-	-	0	0	0.014	132.847	26.569	No	3.74E-05	2.21E+00	4.42E-01	No
127	Phenanthrene			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
128	Pyrene			0	0	-	-	-	-	0	0	-	-	-	-	2.33E+03	2.21E+07	4.43E+06	No
129	1, 2, 4-Trichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-	4.09E+01	3.88E+05	7.77E+04	No

Facility Name: **TVA Browns Ferry Nuclear Plant DSN13C1**

NPDES No.: **AL0022080**

$Q_d*C_d + Q_{d2}*C_{d2} + Q_s*C_s = Q_r*C_r$

ID	Pollutant	Carcinogen "yes"	Type	Background from upstream source (C_{d2}) Daily Max	Background from upstream source (C_{d2}) Monthly Ave	Background Instream (C_s) Daily Max	Background Instream (C_s) Monthly Ave	**Enter** Max Daily Discharge as reported by Applicant (C_d) Max	**Enter** Avg Daily Discharge as reported by Applicant (C_d) Ave	Partition Coefficient (Stream / Lake)
				µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	
1	Antimony		Metals	0	0	0	0	0	0	-
2	**Arsenic*,****	YES	Metals	0	0	0	0	0	0	0.574
3	Beryllium		Metals	0	0	0	0	0	0	-
4	Cadmium**		Metals	0	0	0	0	0	0	0.200
5	Chromium / Chromium III**		Metals	0	0	0	0	0	0	0.125
6	Chromium / Chromium VI**		Metals	0	0	0	0	0	0	
7	Copper**		Metals	0	0	0	0	0.721	0.721	0.230
8	Lead**		Metals	0	0	0	0	0	0	0.206
9	Mercury**		Metals	0	0	0	0	0.00142	0.00142	0.400
10	Nickel**		Metals	0	0	0	0	0.615	0.615	0.235
11	Selenium		Metals	0	0	0	0	0	0	-
12	Silver		Metals	0	0	0	0	0	0	-
13	Thallium		Metals	0	0	0	0	0	0	-
14	Zinc**		Metals	0	0	0	0	3.98	3.98	0.152
15	Cyanide		Metals	0	0	0	0	0	0	-
16	Total Phenolic Compounds		Metals	0	0	0	0	0	0	-
17	Hardness (As CaCO3)		Metals	0	0	0	0	0	0	-
18	Acrolein		VOC	0	0	0	0	0	0	-
19	**Acrylonitrile***	YES	VOC	0	0	0	0	0	0	-
20	**Aldrin**	YES	VOC	0	0	0	0	0	0	-
21	**Benzene***	YES	VOC	0	0	0	0	0	0	-
22	**Bromoform***	YES	VOC	0	0	0	0	0	0	-
23	**Carbon Tetrachloride***	YES	VOC	0	0	0	0	0	0	-
24	**Chlordane**	YES	VOC	0	0	0	0	0	0	-
25	Clorobenzene		VOC	0	0	0	0	0	0	-
26	**Chlorodibromo-Methane***	YES	VOC	0	0	0	0	0.64	0.64	-
27	Chloroethane		VOC	0	0	0	0	0	0	-
28	2-Chloro-Ethylvinyl Ether		VOC	0	0	0	0	0	0	-
29	**ChloroForm***	YES	VOC	0	0	0	0	13.4	13.4	-
30	**4,4'-DDD**	YES	VOC	0	0	0	0	0	0	-
31	**4,4'-DDE**	YES	VOC	0	0	0	0	0	0	-
32	**4,4'-DDT**	YES	VOC	0	0	0	0	0	0	-
33	**Dichlorobromo-Methane***	YES	VOC	0	0	0	0	0	0	-
34	1, 1-Dichloroethane		VOC	0	0	0	0	0	0	-
35	**1, 2-Dichloroethane***	YES	VOC	0	0	0	0	0	0	-
36	Trans-1, 2-Dichloro-Ethylene		VOC	0	0	0	0	0	0	-
37	**1, 1-Dichloroethylene***	YES	VOC	0	0	0	0	0	0	-
38	1, 2-Dichloropropane		VOC	0	0	0	0	0	0	-
39	1, 3-Dichloro-Propylene		VOC	0	0	0	0	0	0	-
40	**Dieldrin**	YES	VOC	0	0	0	0	0	0	-
41	Ethylbenzene		VOC	0	0	0	0	0	0	-
42	Methyl Bromide		VOC	0	0	0	0	0	0	-
43	Methyl Chloride		VOC	0	0	0	0	0	0	-
44	**Methylene Chloride***	YES	VOC	0	0	0	0	0	0	-
45	**1, 1, 2, 2-Tetrachloro-Ethane***	YES	VOC	0	0	0	0	0	0	-
46	**Tetrachloro-Ethylene***	YES	VOC	0	0	0	0	0	0	-
47	Toluene		VOC	0	0	0	0	0	0	-
48	**Toxaphene**	YES	VOC	0	0	0	0	0	0	-
49	**Tributyltine (TBT)**	YES	VOC	0	0	0	0	0	0	-
50	1, 1, 1-Trichloroethane		VOC	0	0	0	0	0	0	-
51	**1, 1, 2-Trichloroethane***	YES	VOC	0	0	0	0	0	0	-
52	**Trichlorethylene***	YES	VOC	0	0	0	0	0	0	-
53	**Vinyl Chloride***	YES	VOC	0	0	0	0	0	0	-
54	P-Chloro-M-Cresol		Acids	0	0	0	0	0	0	-
55	2-Chlorophenol		Acids	0	0	0	0	0	0	-
56	2, 4-Dichlorophenol		Acids	0	0	0	0	0	0	-
57	2, 4-Dimethylphenol		Acids	0	0	0	0	0	0	-
58	4, 6-Dinitro-O-Cresol		Acids	0	0	0	0	0	0	-
59	2, 4-Dinitrophenol		Acids	0	0	0	0	0	0	-
60	**4,6-Dintro-2-methylophenol**	YES	Acids	0	0	0	0	0	0	-
61	**Dioxin (2,3,7,8-TCDD)**	YES	Acids	0	0	0	0	0	0	-
62	2-Nitrophenol		Acids	0	0	0	0	0	0	-
63	4-Nitrophenol		Acids	0	0	0	0	0	0	-
64	**Pentachlorophenol***	YES	Acids	0	0	0	0	0	0	-
65	Phenol		Acids	0	0	0	0	0	0	-
66	**2, 4, 6-Trichlorophenol***	YES	Acids	0	0	0	0	0	0	-
67	Acenaphthene		Bases	0	0	0	0	0	0	-
68	Acenaphthylene		Bases	0	0	0	0	0	0	-
69	Anthracene		Bases	0	0	0	0	0	0	-
70	Benzidine		Bases	0	0	0	0	0	0	-
71	**Benzo(A)Anthracene***	YES	Bases	0	0	0	0	0	0	-
72	**Benzo(A)Pyrene***	YES	Bases	0	0	0	0	0	0	-
73	3, 4 Benzo-Fluoranthene		Bases	0	0	0	0	0	0	-
74	Benzo(GHI)Perylene		Bases	0	0	0	0	0	0	-
75	Benzo(K)Fluoranthene		Bases	0	0	0	0	0	0	-
76	Bis (2-Chloroethoxy) Methane		Bases	0	0	0	0	0	0	-
77	**Bis (2-Chloroethyl)-Ether***	YES	Bases	0	0	0	0	0	0	-
78	Bis (2-Chloroiso-Propyl) Ether		Bases	0	0	0	0	0	0	-
79	**Bis (2-Ethylhexyl) Phthalate***	YES	Bases	0	0	0	0	0	0	-
80	4-Bromophenyl Phenyl Ether		Bases	0	0	0	0	0	0	-
81	Butyl Benzyl Phthalate		Bases	0	0	0	0	0	0	-
82	2-Chloronaphthalene		Bases	0	0	0	0	0	0	-
83	4-Chlorophenyl Phenyl Ether		Bases	0	0	0	0	0	0	-
84	**Chrysene***	YES	Bases	0	0	0	0	0	0	-
85	Di-N-Butyl Phthalate		Bases	0	0	0	0	0	0	-
86	Di-N-Octyl Phthalate		Bases	0	0	0	0	0	0	-
87	**Dibenzo(A,H)Anthracene***	YES	Bases	0	0	0	0	0	0	-
88	1, 2-Dichlorobenzene		Bases	0	0	0	0	0	0	-
89	1, 3-Dichlorobenzene		Bases	0	0	0	0	0	0	-
90	1, 4-Dichlorobenzene		Bases	0	0	0	0	0	0	-
91	**3, 3-Dichlorobenzidine***	YES	Bases	0	0	0	0	0	0	-
92	Diethyl Phthalate		Bases	0	0	0	0	0	0	-
93	Dimethyl Phthalate		Bases	0	0	0	0	0	0	-
94	**2, 4-Dinitrotoluene***	YES	Bases	0	0	0	0	0	0	-
95	2, 6-Dinitrotoluene		Bases	0	0	0	0	0	0	-
96	1,2-Diphenylhydrazine		Bases	0	0	0	0	0	0	-
97	**Endosulfan (alpha)**	YES	Bases	0	0	0	0	0	0	-
98	**Endosulfan (beta)**	YES	Bases	0	0	0	0	0	0	-
99	**Endosulfan sulfate**	YES	Bases	0	0	0	0	0	0	-
100	**Endrin**	YES	Bases	0	0	0	0	0	0	-
101	**Endrin Aldeyhide**	YES	Bases	0	0	0	0	0	0	-
102	Fluoranthene		Bases	0	0	0	0	0	0	-
103	Fluorene		Bases	0	0	0	0	0	0	-
104	Heptochlor	YES	Bases	0	0	0	0	0	0	-
105	Heptachlor Epoxide	YES	Bases	0	0	0	0	0	0	-
106	**Hexachlorobenzene***	YES	Bases	0	0	0	0	0	0	-
107	**Hexachlorobutadiene***	YES	Bases	0	0	0	0	0	0	-
108	**Hexachlorocyclohexan (alpa)**	YES	Bases	0	0	0	0	0	0	-
109	**Hexachlorocyclohexan (beta)**	YES	Bases	0	0	0	0	0	0	-
110	**Hexachlorocyclohexan (gamma)**	YES	Bases	0	0	0	0	0	0	-
111	HexachlorocycloPentadiene		Bases	0	0	0	0	0	0	-
112	Hexachloroethane		Bases	0	0	0	0	0	0	-
113	**Indeno(1, 2, 3-CK)Pyrene***	YES	Bases	0	0	0	0	0	0	-
114	Isophorone		Bases	0	0	0	0	0	0	-
115	Naphthalene		Bases	0	0	0	0	0	0	-
116	Nitrobenzene		Bases	0	0	0	0	0	0	-
117	**N-Nitrosodi-N-Propylamine***	YES	Bases	0	0	0	0	0	0	-
118	**N-Nitrosodi-N-Methylamine***	YES	Bases	0	0	0	0	0	0	-
119	**N-Nitrosodi-N-Phenylamine***	YES	Bases	0	0	0	0	0	0	-
120	**PCB-1016**	YES	Bases	0	0	0	0	0	0	-
121	**PCB-1221**	YES	Bases	0	0	0	0	0	0	-
122	**PCB-1232**	YES	Bases	0	0	0	0	0	0	-
123	**PCB-1242**	YES	Bases	0	0	0	0	0	0	-
124	**PCB-1248**	YES	Bases	0	0	0	0	0	0	-
125	**PCB-1254**	YES	Bases	0	0	0	0	0	0	-
126	**PCB-1260**	YES	Bases	0	0	0	0	0	0	-
127	Phenanthrene		Bases	0	0	0	0	0	0	-
128	Pyrene		Bases	0	0	0	0	0	0	-
129	1, 2, 4-Trichlorobenzene		Bases	0	0	0	0	0	0	-

0.492	**Enter** Q_d = wastewater discharge flow from facility (MGD)
0.76123667	Q_d = wastewater discharge flow (cfs) (this value is caluclated from the MGD)
0	**Enter flow from upstream discharge** Qd2 = background stream flow in MGD above point of discharge
0	Qd2 = background stream flow from upstream source (cfs)
7398.85	**Enter 7Q10,** Q_s = background stream flow in cfs above point of discharge
4696.71	**Enter or estimated, 1Q10,** Q_s = background stream flow in cfs above point of discharge (1Q10 estimated at 75% of 7Q10)
46126.04	**Enter Mean Annual Flow**, Q_s = background stream flow in cfs above point of discharge
11710.51	**Enter 7Q2**, Q_s = background stream flow in cfs above point of discharge (For LWF class streams)
Enter to Left	**Enter C_s** = background in-stream pollutant concentration in µg/l (assuming this is zero "0" unless there is data)
Q_d +Qd2+Q_s	Q_r = resultant in-stream flow, after discharge
Calculated on other	C_r = resultant in-stream pollutant concentration in µg/l in the stream (after complete mixing occurs)
100	**Enter**, Background Hardness above point of discharge (assumed 50 South of Birmingham and 100 North of Birmingham)
7.00 s.u.	**Enter**, Background pH above point of discharge
No	**Enter**, Is discharge to a stream? "YES" Other option would be to a Lake. (This changes the partition coefficients for the metals)

** Using Partition Coefficients

July 9, 2025

Facility Name: **TVA Browns Ferry Nuclear Plant DSN13C1**

NPDES No.: **AL0022080**

Freshwater F&W classification.						Freshwater Acute (µg/l) Q_s =1Q10					Freshwater Chronic (µg/l) Q_s = 7Q10				Human Health Consumption Fish only (µg/l) Carcinogen Q_s = Annual Average Non-Carcinogen Q_s = 7Q10			
ID	Pollutant	RP?	Carcinogen yes	Background from upstream source (Cd2) Daily Max	Max Daily Discharge as reported by Applicant (C_{dmax})	Water Quality Criteria (C_i)	Draft Permit Limit (C_{dmax})	20% of Draft Permit Limit	RP?	Background from upstream source (Cd2) Monthly Ave	Avg Daily Discharge as reported by Applicant (C_{davg})	Water Quality Criteria (C_i)	Draft Permit Limit (C_{davg})	20% of Draft Permit Limit	RP?	Water Quality Criteria (C_i)	Draft Permit Limit (C_{davg})	20% of Draft Permit Limit	RP?
1	Antimony			0	0	-	-	-	-	0	0	-	-	-	-	373.333	3628991.672	725798.334	No
2	Arsenic		YES	0	0	592.334	3655202.605	731040.521	No	0	0	261.324	2540203.852	508040.770	No	0.303	18361.988	3672.398	No
3	Berylium			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
4	Cadmium			0	0	10.069	62131.994	12426.399	No	0	0	1.230	11956.054	2391.211	No	-	-	-	-
5	Chromium/ Chromium III			0	0	4558.108	28127363.209	5625472.642	No	0	0	592.916	5763449.644	1152689.929	No	-	-	-	-
6	Chromium/ Chromium VI			0	0	16.000	98733.473	19746.695	No	0	0	11.000	106925.647	21385.129	No	-	-	-	-
7	Copper			0	0.721	58.431	360568.022	72113.604	No	0	0.721	38.938	378497.829	75699.566	No	-	-	-	-
8	Lead			0	0	313.502	1934570.411	386914.082	No	0	0	12.217	118752.762	23750.552	No	-	-	-	-
9	Mercury			0	0.00142	2.400	14810.021	2962.004	No	0	0.00142	0.012	116.646	23.329	No	0.042	412.385	82.477	No
10	Nickel			0	0.615	1992.493	12295357.635	2459071.527	No	0	0.615	221.304	2151192.610	430238.522	No	992.908	9651573.595	1930314.719	No
11	Selenium			0	0	20.000	123416.841	24683.368	No	0	0	5.000	48602.567	9720.513	No	2430.556	23626247.863	4725249.573	No
12	Silver			0	0	3.217	19850.101	3970.020	No	0	0	-	-	-	-	-	-	-	-
13	Thallium			0	0	-	-	-	-	0	0	-	-	-	-	0.274	2659.175	531.835	No
14	Zinc			0	3.98	770.924	4757250.481	951450.096	No	0	3.98	777.230	7555076.263	1511015.253	No	14893.617	144773603.924	28954720.785	No
15	Cyanide			0	0	22.000	135758.525	27151.705	No	0	0	5.200	50546.670	10109.334	No	9333.333	90724791.792	18144958.358	No
16	Total Phenolic Compounds			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
17	Hardness (As CaCO3)			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
18	Acrolein			0	0	-	-	-	-	0	0	-	-	-	-	5.426	52746.972	10549.394	No
19	Acrylonitrile		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.144	8727.612	1745.522	No
20	Aldrin		YES	0	0	3.000	18512.526	3702.505	No	0	0	-	-	-	-	0.000	1.781	0.356	No
21	Benzene		YES	0	0	-	-	-	-	0	0	-	-	-	-	15.473	937581.615	187516.323	No
22	Bromoform		YES	0	0	-	-	-	-	0	0	-	-	-	-	78.762	4772567.343	954513.469	No
23	Carbon Tetrachloride		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.957	58005.049	11601.010	No
24	Chlordane		YES	0	0	2.400	14810.021	2962.004	No	0	0	0.0043	41.798	8.360	No	0.000	28.650	5.730	No
25	Clorobenzene			0	0	-	-	-	-	0	0	-	-	-	-	906.149	8808232.213	1761646.443	No
26	Chlorodibromo-Methane		YES	0	0.64	-	-	-	-	0	0.64	-	-	-	-	7.407	448848.595	89769.719	No
27	Chloroethane			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
28	2-Chloro-Ethylvinyl Ether			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
29	ChloroForm		YES	0	13.4	-	-	-	-	0	13.4	-	-	-	-	102.004	6180865.903	1236173.181	No
30	4,4' - DDD		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.000	10.991	2.198	No
31	4,4' - DDE		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.000	7.758	1.552	No
32	4,4' - DDT		YES	0	0	1.100	6787.926	1357.585	No	0	0	0.001	9.721	1.944	No	0.000	7.758	1.552	No
33	Dichlorobromo-Methane		YES	0	0	-	-	-	-	0	0	-	-	-	-	10.036	608117.452	121623.490	No
34	1, 1-Dichloroethane			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
35	1, 2-Dichloroethane		YES	0	0	-	-	-	-	0	0	-	-	-	-	21.368	1294755.564	258951.113	No
36	Trans-1, 2-Dichloro-Ethylene			0	0	-	-	-	-	0	0	-	-	-	-	5907.173	57420754.299	11484150.860	No
37	1, 1-Dichloroethylene		YES	0	0	-	-	-	-	0	0	-	-	-	-	4166.667	252477334.884	50495466.977	No
38	1, 2-Dichloropropane			0	0	-	-	-	-	0	0	-	-	-	-	8.494	82567.157	16513.431	No
39	1, 3-Dichloro-Propylene			0	0	-	-	-	-	0	0	-	-	-	-	12.281	119374.726	23874.945	No
40	Dieldrin		YES	0	0	0.240	1481.002	296.200	No	0	0	0.056	544.349	108.870	No	0.000	1.892	0.378	No
41	Ethylbenzene			0	0	-	-	-	-	0	0	-	-	-	-	1244.444	12096638.906	2419327.781	No
42	Methyl Bromide			0	0	-	-	-	-	0	0	-	-	-	-	871.111	8467647.234	1693529.447	No
43	Methyl Chloride			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
44	Methylene Chloride		YES	0	0	-	-	-	-	0	0	-	-	-	-	345.679	20946267.783	4189253.557	No
45	1, 1, 2, 2-Tetrachloro-Ethane		YES	0	0	-	-	-	-	0	0	-	-	-	-	2.333	141387.308	28277.462	No
46	Tetrachloro-Ethylene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.917	116163.019	23232.604	No
47	Toluene			0	0	-	-	-	-	0	0	-	-	-	-	8722.741	84789525.039	16957905.008	No
48	Toxaphene		YES	0	0	0.730	4504.715	900.943	No	0	0	0.0002	1.944	0.389	No	0.000	9.812	1.962	No
49	Tributyltin (TBT)		YES	0	0	0.460	2838.587	567.717	No	0	0	0.072	699.877	139.975	No	-	-	-	-
50	1, 1, 1-Trichloroethane			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
51	1, 1, 2-Trichloroethane		YES	0	0	-	-	-	-	0	0	-	-	-	-	9.097	551217.573	110243.515	No
52	Trichlorethylene		YES	0	0	-	-	-	-	0	0	-	-	-	-	17.470	1058605.178	211721.036	No
53	Vinyl Chloride		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.425	86317.038	17263.408	No
54	P-Chloro-M-Cresol			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
55	2-Chlorophenol			0	0	-	-	-	-	0	0	-	-	-	-	87.065	846313.356	169262.671	No
56	2, 4-Dichlorophenol			0	0	-	-	-	-	0	0	-	-	-	-	171.990	1671832.773	334366.555	No
57	2, 4-Dimethylphenol			0	0	-	-	-	-	0	0	-	-	-	-	497.512	4836076.322	967215.264	No
58	4, 6-Dinitro-O-Cresol			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
59	2, 4-Dinitrophenol			0	0	-	-	-	-	0	0	-	-	-	-	3111.111	30241597.264	6048319.453	No
60	4,6-Dinitro-2-methylphenol		YES	0	0	-	-	-	-	0	0	-	-	-	-	165.455	10025645.443	2005129.089	No
61	Dioxin (2,3,7,8-TCDD)		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.000	0.002	0.000	No
62	2-Nitrophenol			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
63	4-Nitrophenol			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
64	Pentachlorophenol		YES	0	0	8.723	53830.235	10766.047	No	0	0	6.693	65055.349	13011.070	No	1.768	107111.597	21422.319	No
65	Phenol			0	0	-	-	-	-	0	0	-	-	-	-	500000.000	4860256703.155	972051340.631	No
66	2, 4, 6-Trichlorophenol		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.414	85689.277	17137.855	No
67	Acenaphthene			0	0	-	-	-	-	0	0	-	-	-	-	578.512	5623437.508	1124687.502	No
68	Acenaphthylene			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
69	Anthracene			0	0	-	-	-	-	0	0	-	-	-	-	23333.333	226811979.481	45362395.896	No
70	Benzidine			0	0	-	-	-	-	0	0	-	-	-	-	0.000	1.127	0.225	No
71	Benzo(A)Anthracene		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.011	645.604	129.121	No
72	Benzo(A)Pyrene		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.011	645.604	129.121	No
73	Benzo(b)fluoranthene			0	0	-	-	-	-	0	0	-	-	-	-	0.011	103.567	20.713	No
74	Benzo(GHI)Perylene			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
75	Benzo(K)Fluoranthene			0	0	-	-	-	-	0	0	-	-	-	-	0.011	103.567	20.713	No
76	Bis (2-Chloroethoxy) Methane			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
77	Bis (2-Chloroethyl)-Ether		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.307	18628.104	3725.621	No
78	Bis (2-Chloroiso-Propyl) Ether			0	0	-	-	-	-	0	0	-	-	-	-	37786.775	367306849.361	73461369.872	No
79	Bis (2-Ethylhexyl) Phthalate		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.282	77685.334	15537.067	No
80	4-Bromophenyl Phenyl Ether			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
81	Butyl Benzyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-	1127.214	10957100.458	2191420.092	No
82	2-Chloronaphthalene			0	0	-	-	-	-	0	0	-	-	-	-	924.092	8982652.653	1796530.531	No
83	4-Chlorophenyl Phenyl Ether			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
84	Chrysene		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.011	645.604	129.121	No
85	Di-N-Butyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-	2621.723	25484492.076	5096898.415	No
86	Di-N-Octyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
87	Dibenzo(A,H)Anthracene		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.011	645.604	129.121	No
88	1, 2-Dichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-	755.396	7342833.868	1468566.774	No
89	1, 3-Dichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-	562.350	5466331.880	1093266.376	No
90	1, 4-Dichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-	112.470	1093266.376	218653.275	No
91	3, 3-Dichlorobenzidine		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.017	1007.032	201.406	No
92	Diethyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-	25570.776	248561073.403	49712214.681	No
93	Dimethyl Phthalate			0	0	-	-	-	-	0	0	-	-	-	-	648148.148	6300332763.348	1260066552.670	No
94	2, 4-Dinitrotoluene		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.981	120023.181	24004.636	No
95	2, 6-Dinitrotoluene			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
96	1,2-Diphenylhydrazine			0	0	-	-	-	-	0	0	-	-	-	-	0.117	1138.614	227.723	No
97	Endosulfan (alpha)		YES	0	0	0.22	1357.585	271.517	No	0	0	0.056	544.349	108.870	No	51.852	3141940.167	628388.033	No
98	Endosulfan (beta)		YES	0	0	0.22	1357.585	271.517	No	0	0	0.056	544.349	108.870	No	51.852	3141940.167	628388.033	No
99	Endosulfan sulfate		YES	0	0	-	-	-	-	0	0	-	-	-	-	51.852	3141940.167	628388.033	No
100	Endrin		YES	0	0	0.086	530.692	106.138	No	0	0	0.036	349.938	69.988	No	0.035	2136.836	427.367	No
101	Endrin Aldeyhde		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.176	10684.179	2136.836	No
102	Fluoranthene			0	0	-	-	-	-	0	0	-	-	-	-	81.159	788911.233	157782.247	No
103	Fluorene			0	0	-	-	-	-	0	0	-	-	-	-	3111.111	30241597.264	6048319.453	No
104	Heptochlor		YES	0	0	0.52	3208.838	641.768	No	0	0	0.0038	36.938	7.388	No	0.000	2.805	0.561	No
105	Heptachlor Epoxide		YES	0	0	0.52	3208.838	641.768	No	0	0	0.0038	36.938	7.388	No	0.000	1.387	0.277	No
106	Hexachlorobenzene		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.000	10.169	2.034	No
107	Hexachlorobutadiene		YES	0	0	-	-	-	-	0	0	-	-	-	-	10.761	652035.176	130407.035	No
108	Hexachlorocyclohexan (alpha)		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.003	172.634	34.527	No
109	Hexachlorocyclohexan (beta)		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.010	604.219	120.844	No
110	Hexachlorocyclohexan (gamma)		YES	0	0	0.95	5862.300	1172.460	No	0	0	-	-	-	-	1.077	65255.680	13051.136	No
111	HexachlorocycloPentadiene			0	0	-	-	-	-	0	0	-	-	-	-	645.161	6271298.972	1254259.794	No
112	Hexachloroethane			0	0	-	-	-	-	0	0	-	-	-	-	1.918	18643.102	3728.620	No
113	Indeno(1, 2, 3-CK)Pyrene		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.011	645.604	129.121	No
114	Isophorone			0	0	-	-	-	-	0	0	-	-	-	-	560.763	5450900.733	1090180.147	No
115	Naphthalene			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
116	Nitrobenzene			0	0	-	-	-	-	0	0	-	-	-	-	403.691	3924082.690	784816.538	No
117	N-Nitrosodi-N-Propylamine		YES	0	0	-	-	-	-	0	0	-	-	-	-	0.295	17874.502	3574.900	No
118	N-Nitrosodimethylamine		YES	0	0	-	-	-	-	0	0	-	-	-	-	1.760	106626.929	21325.386	No
119	N-Nitrosodiphenylamine		YES	0	0	-	-	-	-	0	0	-	-	-	-	3.501	212165.828	42433.166	No
120	PCB-1016		YES	0	0	-	-	-	-	0	0	0.014	136.087	27.217	No	0.000	2.266	0.453	No
121	PCB-1221		YES	0	0	-	-	-	-	0	0	0.014	136.087	27.217	No	0.000	2.266	0.453	No
122	PCB-1232		YES	0	0	-	-	-	-	0	0	0.014	136.087	27.217	No	0.000	2.266	0.453	No
123	PCB-1242		YES	0	0	-	-	-	-	0	0	0.014	136.087	27.217	No	0.000	2.266	0.453	No
124	PCB-1248		YES	0	0	-	-	-	-	0	0	0.014	136.087	27.217	No	0.000	2.266	0.453	No
125	PCB-1254		YES	0	0	-	-	-	-	0	0	0.014	136.087	27.217	No	0.000	2.266	0.453	No
126	PCB-1260		YES	0	0	-	-	-	-	0	0	0.014	136.087	27.217	No	0.000	2.266	0.453	No
127	Phenanthrene			0	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-
128	Pyrene			0	0	-	-	-	-	0	0	-	-	-	-	2333.333	22681197.948	4536239.590	No
129	1, 2, 4-Trichlorobenzene			0	0	-	-	-	-	0	0	-	-	-	-	40.936	397915.753	79583.151	No

Digitally signed by:
AEPACS
Date: 2022.12.28 13:49:51 -06:00
Reason: Submission Data
Location: State of Alabama

NPDES Individual Permit Mod/Reissue (Form 187) - Supplementary Information for Industrial Facilities

version 2.5

(Submission #: HPM-0HHV-56CE5, version 1)

Details

Submission ID HPM-0HHV-56CE5

Form Input

General Instructions

This form should be used to submit the following permit requests for permitted Industrial Individual NPDES facilities

-Permit Transfers
-Permittee/Facility Name Changes
-Minor Modifications, for example:
> Frequency of monitoring or reporting modifications
> Changes to interim compliance dates in a schedule of compliance, not including the final compliance date.
> Removal of a point source outfall, provided the discharge is terminated and does not result in discharge of pollutants from other outfalls, except in accordance with permit limits.
-Major Modifications, (Any modifications not covered by minor mod�s, whether Effluent Limit changes occur or not)
-Reissuances
-Reissuance of a permit due to approaching expiration
-Revocation and Reissuance of permit prior to its scheduled expiration

Applicable Base Fees:
-Permit Transfers and/or Permittee/Facility Name Changes
> $800
-Minor Modifications (see examples above)
> $3,940 (Major Sources)
> $3,120 (Minor Sources)
-Major Modifications
> $17,990 (Major Sources)
> $5,615 (Minor Sources)
-Reissuances
> $17,990 (Major Sources)
> $5,615 (Minor Sources)

For assistance, please click here to determine the permit staff responsible for the site or call (334) 271-7943

Processing Information

Purpose of Application
Reissuance of Permit Due to Approaching Expiration

Please indicate if the Permittee is applying for a permit transfer and/or name change in addition to permit modification or reissuance:
None

Action Type
Reissuance

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If applicable, briefly describe any planned changes at the facility that are included in this reissuance application:
NONE PROVIDED

General Information

SID Permit Number (if your facility currently holds an SID permit, please provide that number below):
NONE PROVIDED

NPDES or General Permit Numbers (if applicable, please list all permit numbers):
AL0022080

Is this facility/site only applying for permit coverage for discharges from stormwater?
Yes

Is a new stormwater outfall being added?
No

Permit Information

Permit Number
AL0022080

Current Permittee Name
Tennessee Valley Authority

Permittee

Permittee Name
Tennessee Valley Authority

Mailing Address

P O BOX 2000, NAB 2A

Decatur, AL 35609

Responsible Official

Prefix
Mr.

First Name	Last Name
Manu	*Sivaraman*

Title
Site Vice President

Organization Name
Tennessee Valley Authority Browns Ferry Nuclear Plant

Phone Type	Number	Extension
Business	8024516196	

Email
msivaraman@tva.gov

Mailing Address

P O Box 2000, NAB 2A

Decatur, AL 35609

Existing Permit Contacts

Affiliation Type	Contact Information	Remove?
Responsible Official,Notification Recipient	Matt Rasmussen, Tennessee Valley Authority Browns Ferry Nuclear Plant	NONE PROVIDED
Environmental Contact,DMR Contact	Steven W. Keenum, Tennessee Valley Authority Browns Ferry Nuclear Plant	Keep

ADEM Watermark

Affiliation Type	Contact Information	Remove?
Permittee	Tennessee Valley Authority	Keep

Facility/Site Information

Facility/Site Name
TVA Browns Ferry Nuclear Plant

Organization/Ownership Type
Federal

Facility/Site Address or Location Description

10835 Shaw Road

Athens, AL 35611

Facility/Site County
Limestone

Detailed Directions to the Facility/Site
T4S R6W S12 Tennessee River U.S. 72 turn onto shaw Rd. Left on Nuclear plant Road

Facility Map

BFN_Topo_Site_Map.pdf - 08/17/2022 03:27 PM

Comment
NONE PROVIDED

Please refer to the link below for Lat/Long map instruction help:
Map Instruction Help

Facility/Site Front Gate Latitude and Longitude
34.7041881,-87.11844909999999

SIC Code(s) [Please enter Primary SIC Code first followed by any additional applicable SIC Codes]
4911-Electric Services

NAICS Code(s) [Please enter Primary NAICS Code first followed by any additional applicable NAICS Codes]
221113-Nuclear Electric Power Generation

Facility/Site Contact

Prefix
Mr.

First Name	Last Name
Ethan	*Widener*

Title
Environmental Scientist

Organization Name
Tennessee Valley Authority Browns Ferry Nuclear Plant

Phone Type	Number	Extension
Business	2562215198	

Email
emwidener@tva.org

Address

P.O. Box 2000, NAB 2A

Decatur, AL 35609

DMR Contact(s) (1 of 2)

ADEM Watermark

DMR Contact

Prefix
Mrs.

First Name	Last Name
Lauren	*Vinson*

Title
Enironmental Scientist

Phone Type	Number	Extension
Business	256-614-6410	

Email
lavinson0@tva.gov

Address
PO Box 2000
Decatur, AL 35609

DMR Contact(s) (2 of 2)

DMR Contact

Prefix
Mr.

First Name	Last Name
Ethan	*Widener*

Title
Environmental Scientist

Phone Type	Number	Extension
Business	2562215198	

Email
emwidener@tva.org

Address
P.O. Box 2000, NAB 2A
Decatur, AL 35609

Enforcement History

Has the applicant been issued any Notices of Violation, Orders (Consent or Administrative/Unilateral), or Judicial Actions (Complaint, Settlement Agreement, Consent Decree, or Court Order) concerning water pollution or other permit violations within the State of Alabama in the past five years?
No

Business Activity

A facility with processes inclusive in the business areas shown below may be covered by Environmental Protection Agency's (EPA) categorical effluent guideline standards. These facilities are termed "categorical users". If unsure, please call the Industrial Section at (334) 271-7943 to discuss or use the link below to contact the Permit Engineer for the county the facility is/will be located in.
Industrial Section Assignment Map

If your facility conducts or will be conducting any of the processes listed below (regardless of whether they generate wastewater, waste sludge, or hazardous wastes), please check the category of business activity:
Steam and Electric

Give a brief description of all operations at this facility including primary products or services:
TVA Browns Ferry Nuclear Plant operates three boiling water reactors for the purpose of generating electric power.

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Water Supply

Water Sources (check all that apply):
Surface Water

Operator of Surface Intake	Million Gallons per Day (MGD)
TVA Browns Ferry Nuclear Plant	2840
	Sum: 2840

Cooling Water Intake Structure Information

Does the provider of your source water operate a surface water intake?
Yes

Name of Provider	Location of Provider	Latitude	Longitude
TVA	Browns Ferry Nuclear Plant	34.7011111	-87.11777

Is the provider a public water system (defined as a system which provides water to the public for human consumption or which provides only treated water, not raw water)?
No

Is any water withdrawn from the source water used for cooling?
Yes

Using the average monthly measurements over any 12-month period, approximately what percentage of water withdrawn is used exclusively for cooling purposes?
99

Does the cooling water consist of treated effluent that would otherwise be discharged?
No

Is the cooling water used in a once-through cooling system?
Yes

Is the cooling water used in a closed cycle cooling system?
No

When was the intake installed?
Commercial operation began in 1974 (Unit 1), 1975 (Unit 2), and 1977 (Unit 3)

What is the maximum intake volume (maximum pumping capacity in gallons per day)?
3060

What is the average intake volume (average intake pump rate in gallons per day average in any 30-day period)?
2840

What is the actual intake flow (AIF) as defined in 40 CFR §125.92(a) (MGD)?
2700.44

How is the intake operated?
Continuously

What is the mesh size of the screen on your intake (in inches)?
0.375

What is the intake screen flow-through area (in square feet)?
0.003888889

What is the through-screen design intake flow velocity (in ft/sec)?
1.72

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What is the through-screen actual velocity (in ft/sec)?
1.72

What is the mechanism for cleaning the screen (e.g., does it rotate for cleaning)?
Rotate and spray wash

Do you have any additional fish detraction technology on your intake?
Yes

Please describe the fish detraction technology:
Skimmer wall/ Talon Rake

Have there been any studies to determine the impact of the intake on aquatic organisms?
Yes

Please attach the results of the studies.
BFN_r(2-13)studies.pdf - 11/29/2022 02:11 PM
Comment
BFN 316(b) R studies

Attach a site map showing the location of the water intake in relation to the facility, shoreline, water depth, etc.
ADEM Form 187 - BFN Intake.pdf - 08/24/2022 02:21 PM
Comment
NONE PROVIDED

Outfalls (1 of 11)

001

Please click below if this discharge no longer exists or is no longer required:
NONE PROVIDED

Outfall Identifier
001

Receiving Water
Tennessee River

Does the discharge enter the named receiving water via an unnamed tributary?
NONE PROVIDED

Indicate if either of the following characteristics apply to this discharge:
None apply

Estimated Average Daily Flow (MGD)
2995.77

Monitoring/Sampling Point Location
34.71090000000000, -87.11200000000000

Outfalls (2 of 11)

005

Please click below if this discharge no longer exists or is no longer required:
NONE PROVIDED

Outfall Identifier
005

ADEM Watermark

Receiving Water
Tennessee River

Does the discharge enter the named receiving water via an unnamed tributary?
NONE PROVIDED

Indicate if either of the following characteristics apply to this discharge:
Intermittent Discharge

Estimated Average Daily Flow (MGD)
2.451

Monitoring/Sampling Point Location
34.71090000000000, -87.11200000000000

Outfalls (3 of 11)

013

Please click below if this discharge no longer exists or is no longer required:
NONE PROVIDED

Outfall Identifier
013

Receiving Water
Tennessee River

Does the discharge enter the named receiving water via an unnamed tributary?
NONE PROVIDED

Indicate if either of the following characteristics apply to this discharge:
Intermittent Discharge

Estimated Average Daily Flow (MGD)
0.027

Monitoring/Sampling Point Location
34.71090000000000, -87.11200000000000

Outfalls (4 of 11)

017

Please click below if this discharge no longer exists or is no longer required:
NONE PROVIDED

Outfall Identifier
017

Receiving Water
Tennessee River

Does the discharge enter the named receiving water via an unnamed tributary?
NONE PROVIDED

Indicate if either of the following characteristics apply to this discharge:
Intermittent Discharge

ADEM Watermark

Estimated Average Daily Flow (MGD)
0.1393

Monitoring/Sampling Point Location
34.71090000000000, -87.11200000000000

Outfalls (5 of 11)

018

Please click below if this discharge no longer exists or is no longer required:
NONE PROVIDED

Outfall Identifier
018

Receiving Water
Tennessee River

Does the discharge enter the named receiving water via an unnamed tributary?
NONE PROVIDED

Indicate if either of the following characteristics apply to this discharge:
Intermittent Discharge

Estimated Average Daily Flow (MGD)
0.366

Monitoring/Sampling Point Location
34.71090000000000, -87.11200000000000

Outfalls (6 of 11)

019

Please click below if this discharge no longer exists or is no longer required:
NONE PROVIDED

Outfall Identifier
019

Receiving Water
Tennessee River

Does the discharge enter the named receiving water via an unnamed tributary?
NONE PROVIDED

Indicate if either of the following characteristics apply to this discharge:
Intermittent Discharge

Estimated Average Daily Flow (MGD)
0.8517

Monitoring/Sampling Point Location
34.71090000000000, -87.11200000000000

Outfalls (7 of 11)

ADEM Watermark

01B

Please click below if this discharge no longer exists or is no longer required:
NONE PROVIDED

Outfall Identifier
01B

Receiving Water
Tennessee River

Does the discharge enter the named receiving water via an unnamed tributary?
NONE PROVIDED

Indicate if either of the following characteristics apply to this discharge:
Intermittent Discharge

Estimated Average Daily Flow (MGD)
0.03

Monitoring/Sampling Point Location
34.71090000000000, -87.11200000000000

Outfalls (8 of 11)

024

Please click below if this discharge no longer exists or is no longer required:
NONE PROVIDED

Outfall Identifier
024

Receiving Water
Tennessee River

Does the discharge enter the named receiving water via an unnamed tributary?
NONE PROVIDED

Indicate if either of the following characteristics apply to this discharge:
Intermittent Discharge

Estimated Average Daily Flow (MGD)
0.5240

Monitoring/Sampling Point Location
34.71090000000000, -87.11200000000000

Outfalls (9 of 11)

13A

Please click below if this discharge no longer exists or is no longer required:
NONE PROVIDED

Outfall Identifier
13A

ADEM Watermark

Receiving Water
Tennessee River

Does the discharge enter the named receiving water via an unnamed tributary?
NONE PROVIDED

Indicate if either of the following characteristics apply to this discharge:
Intermittent Discharge

Estimated Average Daily Flow (MGD)
1.7443

Monitoring/Sampling Point Location
34.71090000000000, -87.11200000000000

Outfalls (10 of 11)

13B

Please click below if this discharge no longer exists or is no longer required:
NONE PROVIDED

Outfall Identifier
13B

Receiving Water
Tennessee River

Does the discharge enter the named receiving water via an unnamed tributary?
NONE PROVIDED

Indicate if either of the following characteristics apply to this discharge:
Intermittent Discharge

Estimated Average Daily Flow (MGD)
0.3478

Monitoring/Sampling Point Location
34.71090000000000, -87.11200000000000

Outfalls (11 of 11)

13C

Please click below if this discharge no longer exists or is no longer required:
NONE PROVIDED

Outfall Identifier
13C

Receiving Water
Tennessee River

Does the discharge enter the named receiving water via an unnamed tributary?
NONE PROVIDED

Indicate if either of the following characteristics apply to this discharge:
Intermittent Discharge

ADEM Watermark

Estimated Average Daily Flow (MGD)
0.1349

Monitoring/Sampling Point Location
34.71090000000000, -87.11200000000000

Anti-Degradation Evaluation

Is this a new or increased discharge that began after April 3, 1991?
No

Additional Information

Do you share an outfall with another facility?
No

Indicate if automatic sampling equipment or continuous wastewater flow metering equipment is being operated at this facility:

Current	Yes/No
Continuous Wastewater Flow Metering Equipment	No
Automatic Sampling Equipment	No

Indicate if installation automatic sampling equipment or continuous wastewater flow metering equipment planned at this facility:

Planned	Yes/No
Continuous Wastewater Flow Metering Equipment	No
Automatic Sampling Equipment	No

Please attach the process schematic with sampling equipment locations.
2022 BFN Flow Schematic.pdf - 08/24/2022 03:36 PM
Comment
NONE PROVIDED

Are any process changes or expansions planned during the next three years that could alter wastewater volumes or characteristics (Consider production processes as well as air or water pollution treatment processes that may affect the discharge.)?
No

Do you use biocides, corrosion inhibitors, or chemical additives in your cooling or blowdown water?
Yes

The applicant must provide a list of the following information for each biocide or chemical:

(1) Name and general composition of biocide or chemical (if composition is not provided on MSDS sheet)
(2) 48-hour or 96-hour LC50 data for organisms representative of the biota of the waterway into which the discharge will ultimately reach. For freshwater, the fathead minnow (Pimephales promelas) and cladoceran (Ceriodaphnia dubia) are the test organisms. For salt water, the mysid shrimp and the sheepshead minnow or inland silverside are the test organisms. Other acceptable aquatic organisms may be allowed by the Department if sufficient information is provided. If the MSDS sheet does not provide data for the organisms specified above, the facility must provide the data unless the Department grants approval for an alternate organism.
(3) Quantities to be used
(4) Frequencies of use
(5) Maximum proposed discharge concentrations
(6) EPA registration of number, if applicable and is not provided on the MSDS sheet.

List of Biocides

Please list biocides below:
Depositrol PY5200
Flogard MS6237

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Please list biocides below:
Spectrus BD1500
NaOCL
Inhibitor AZ8100
Spectrus CT1300
Bentonite Clay

Biocide/Corrosion Inhibitor Summary Sheet

BFN Biocide_Corrosion Inhibitor Summary Sheet.doc - 12/13/2022 01:49 PM

Comment

NONE PROVIDED

Safety Data Sheets (SDS)

SDSBinder.pdf - 12/19/2022 10:24 AM

Comment

NONE PROVIDED

Treatment

Is any form of wastewater treatment (see list below) practiced at this facility?

Yes

Treatment devices or processes used or proposed for treating wastewater or sludge (check as many as appropriate).

Sedimentation
Neutralization, pH correction
Other chemical treatment

Other chemical treatment:

flocculation, coagulation

Is any form of wastewater treatment (or changes to an existing wastewater treatment) planned for this facility within the next three years?

No

Facility Operational Characteristics

Indicate whether the facility discharge is:

Continuous through the year

Comments:

NONE PROVIDED

Non-Discharged Wastes

Are any waste liquids or sludges generated and not disposed of in the sanitary sewer system?

No

Does any outside firm remove any of the above checked wastes?

No

EPA Application Forms

All Applicants must submit certain EPA permit application forms. More than one application form may be required.

Form 1 - General Information Form required for all applications

Form 2C - Should be submitted for facilities with existing discharge(s) of process wastewater.

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Form 2D - Should be submitted for facilities that have not yet commenced discharge(s) of process wastewater.

Form 2E - Should be submitted for facilities who discharge non-process wastewater, such as non-contact cooling water or boiler blowdown.

Form 2F - Should be submitted for all discharges of storm water associated with an industrial activity.
The EPA application forms are found on the Department's website here.

EPA Form 1

Signed by Manu Sivaraman - EPA_Form1_unsigned.pdf - 12/20/2022 09:17 AM
Comment
NONE PROVIDED

Additional EPA Forms (EPA Form 2C, 2D, 2E and/or 2F)

Signed by Manu Sivaraman - Form2C_combined.pdf - 12/20/2022 09:18 AM
Signed by Manu Sivaraman - Form 2E.pdf - 12/20/2022 09:18 AM
Signed by Manu Sivaraman - EPA_form2F_No_Tables.pdf - 12/20/2022 09:18 AM
Comment
NONE PROVIDED

Other attachments (as needed)

2_Attachment 1 AL Permits.pdf - 12/13/2022 02:39 PM
Outfall_table.pdf - 12/13/2022 03:04 PM
BFN Form 2F Attach 1 - Drainage Area Description.pdf - 12/20/2022 02:57 PM
Comment
NONE PROVIDED

Additional Attachments

Please attach any additional information as needed.

Evaluating the Presence and Maintenance of a Balanced Indigenous Population of Fish and Wildlife in the Tennessee River Downstream of TVAs Browns Ferry Nuclear Plant Autumn 2020.pdf - 11/29/2022 09:28 AM
Comment
316(a) document.

Application Preparer

Application Preparer

Prefix
Mr.

First Name	Last Name
Craig	*Phillips*

Title
Water Permitting Specalist

Organization Name
Water Permits, Compliance, and Monitoring

Phone Type	Number	Extension
Mobile	865-599-6183	

Email
clphillips@tva.gov

Address
400 West Summit Hill Drive
Knoxville, TN 37902

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Agreements and Signature(s)

SUBMISSION AGREEMENTS

- ☑ I am the owner of the account used to perform the electronic submission and signature.
- ☑ I have the authority to submit the data on behalf of the facility I am representing.
- ☑ I agree that providing the account credentials to sign the submission document constitutes an electronic signature equivalent to my written signature.
- ☑ I have reviewed the electronic form being submitted in its entirety, and agree to the validity and accuracy of the information contained within it to the best of my knowledge.

"I certify under penalty of lawthat this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted; based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment for knowing violations."

"I further certify under penalty of lawthat all analyses reported as less than detectable in this application or attachments thereto were performed using the EPA approved test method having the lowest detection limit for the substance tested."

NOTE: 335-6-5-.14 SIGNATORIES TO PERMIT APPLICATIONS AND REPORTS.
The application shall be signed by a responsible official, a request for variance from categorical pretreatment standards, and a category determination request shall be signed by a responsible official, as indicated below:

- *In the case of a corporation, by a principal executive officer of at least the level of vice president;*
- *In the case of a partnership, by a general partner;*
- *In the case of a sole proprietorship, by the proprietor; or*
- *In the case of a municipal, state, federal, or other public entity, by either a principal executive officer, or ranking elected official*

Signed By Manu Sivaraman on 12/28/2022 at 1:42 PM

ADEM Watermark

ENVIRONMENTAL PERMITS - NPDES PERMIT RENEWAL APPLICATION
TVA BROWNS FERRY NUCLEAR PLANT - NPDES PERMIT NO. AL0022080

Permit Name	Permit Number	Held by
NPDES Permit	AL0024635	Bellefonte Nuclear Plant
RCRA ID	AL5640090002 (ID#)	Bellefonte Nuclear Plant
Synthetic Minor Operating Permit	705-0021-X004	Bellefonte Nuclear Plant
NPDES Permit	AL0022080	Browns Ferry Nuclear Plant
RCRA ID	AL8640015410 (ID#)	Browns Ferry Nuclear Plant
PSD Permit	708-0003-Z003	Browns Ferry Nuclear Plant
Synthetic Minor Operating Permit	708-0003-X005	Browns Ferry Nuclear Plant
Inert Landfill Permit	42-02	Browns Ferry Nuclear Plant
Title V Air Permit	701-0010	Colbert Fossil Plant
NPDES Permit	AL0003867	Colbert Fossil Plant
Construction Storm Water	ALR10C0X4	Colbert Fossil Plant
Construction Storm Water	ALR10C1R8	Colbert Fossil Plant
Construction Storm Water	ALR10C1VX	Colbert Fossil
RCRA ID	AL7640006675 (ID#)	Colbert Fossil Plant
NPDES Permit	AL0003891	Environmental Research Center
General NPDES Permit	ALG360011	Guntersville Hydro Plant
RCRA ID	ALD982083461 (ID#)	M. S. Heavy Equipment Department
General NPDES Permit	ALG140643	M. S. Power Service Center
RCRA (Operating Permit)	AL2640090005	M. S. Power Service Center
General NPDES Permit	ALG360009	Wheeler Hydro Plant
NPDES Permit	AL0003875	Widows Creek Fossil Plant
RCRA ID	AL8640006690 (ID#)	Widows Creek Fossil Plant
Solid Waste Disposal Permit	36-07	Widows Creek Fossil Plant
General NPDES Permit	ALG360012	Wilson Hydro Plant
General NPDES Permit	ALR100000	Various TVA Transmission Line & Substation Construction Projects

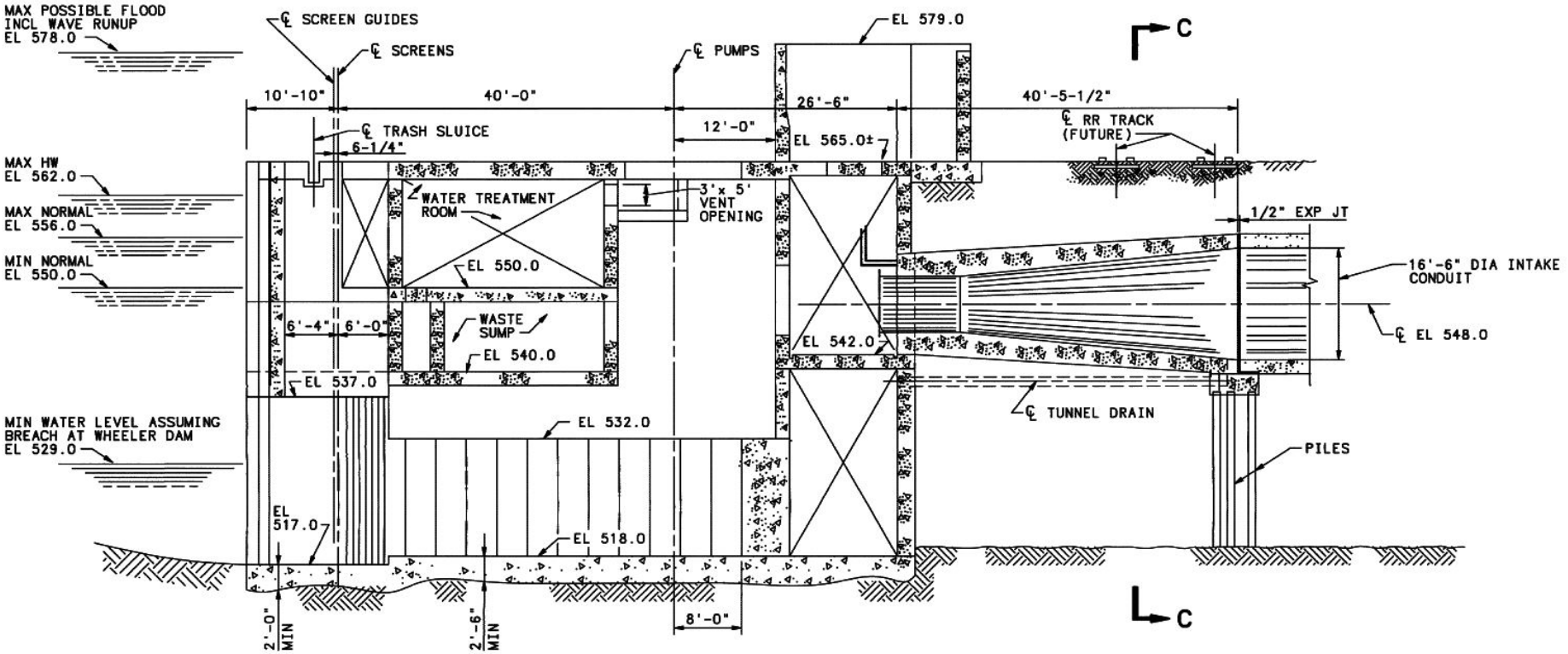
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NPDES Permit Renewal Application
Browns Ferry Nuclear Plant - NPDES Permit No. AL0022080
Intake Structure



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NPDES Permit Renewal Application
Browns Ferry Nuclear Plant - NPDES Permit No. AL0022080
Intake Structure
Page 2 of 2
Source Drawing 0-31E201 R2



B-B
TYPICAL SECTION

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ATTACHMENT 3 TO ADEM FORM 187

BROWNS FERRY NUCLEAR PLANT
RAW WATER TREATMENT PROGRAM
MAXIMUM PROJECTED USAGE RATES

EMERGENCY EQUIPMENT COOLING WATER
(EECW) SYSTEM (8000 GPM AVERAGE FLOW)

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM) (AT DSN0011)	DISCHARGE CONC. ACTIVE (PPM) (AT DSN0011)	AQUATIC TOXICOLOGY INFORMATION 96-HR BIOASSAY
Depositrol PY5200	Co-polymer	30	3.3	1.0	Continuous	0.017	0.005	Fathead Minnow LC50 = 1960 mg/L
Flogard MS6237	Zinc & Orthophosphate	12.6 36	2 2	0.252 0.72	Continuous	0.01 0.01	0.001 0.004	Fathead Minnow LC50 = 7.8 mg/L
Spectrus BD1500	Biodispersant	15	20	3	4/week	0.10	0.015	Fathead Minnow 0% Mortality at 2000 mg/L
NaOCl	NaOCl	10	51	5.1	28-56 hrs/wk(1)	NA	< 0.05(3)	Fathead Minnow LC50 = 5.9 mg/L
Inhibitor AZ8100	Tolytriazole (TTA)	50	2	1	Continuous	0.01	0.005	Fathead Minnow LC50 = 105 mg/L
Spectrus CT1300(2)	QUAT	50	5	2.5	4/yr (72 hrs each)	(3)	(3)	Fathead Minnow LC50 = 0.72 mg/L
Bentonite Clay	Bentonite Clay	(3)	(3)	(3)	(3)	NA	NA	NA

Emergency Equipment Cooling Water (EECW) System has an average flow of 8,000 GPM. The EECW system discharges into the intake forebay where it mixes with intake water and is withdrawn through the condenser circulating water (CCW) system (2,259.68-3,389.52 MGD dilution) into the plant and discharges through DSN 0011. The CCW flow of 3,389.52 MGD is typical during three unit operation with all CCW pumps in service and would be considered normal operation. During outages, the flow for CCW would be 2,259.68 MGD. The discharge concentrations calculated above are based on what is considered to be two unit CCW flow (2,259.68 MGD).

The following molluscicide treatment regime and options should be in accordance with SPP-9.7/CHTP-108 and BFN Raw Water Team concurrence.
(1) 28-56 hours/week is normal operation for MIC control. Treatment time required varies due to seasonal demand. Continuous treatment (or some variation) may be used as an alternative to or in conjunction with non-oxidizing treatments, as required, for macrofouling (invertebrate) control.
(2) Treatment with Spectrus CT1300 is an alternative treatment plan (non-oxidizing biocide) in place of EVAC.
(3) Bentonite Clay is used to detoxify the Spectrus CT1300. It is applied at a 5:1 ratio of clay to CT1300 and is fed a minimum of 2 hours after CT1300 injection is completed.

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RAW COOLING WATER/RAW SERVICE WATER
HIGH PRESSURE FIRE PROTECTION SYSTEMS
(58,000 GPM TOTAL AVERAGE FLOW)

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM) (AT DSN0011)	DISCHARGE CONC. ACTIVE (PPM) (AT DSN0011)	AQUATIC TOXICOLOGY INFORMATION 96-HR BIOASSAY
Depositrol PY5200	Co-polymer	30	3.3	1.0	Continuous	0.12	0.04	Fathead Minnow LC50 = 1960 mg/L
Flogard MS6237	Zinc & Orthophosphate	12.6 36	2 2	0.252 0.72	Continuous	0.07 0.07	0.009 0.03	Fathead Minnow LC50 = 7.8 mg/L
Spectrus BD1500	Biodispersant	15	20	3	4/week	0.74	0.11	Fathead Minnow 0% Mortality at 2000 mg/L
NaOCl	NaOCl	10	51	5.1	28-56 hrs/wk(1)	NA	< 0.05(3)	Fathead Minnow LC50 = 5.9 mg/L
Spectrus CT1300	QUAT	50	5	2.5	4/yr (72 hrs each)	(2)	(2)	Fathead Minnow LC50 = 0.72 mg/L
Bentonite Clay	Bentonite Clay	(2)	(2)	(2)	(2)	NA	NA	NA

Raw Cooling Water / Raw Service Water / High Pressure Fire Protection Systems have an average flow of approximately 58,000 GPM. Portions of these systems discharge into the intake forebay where it mixes with intake water and is withdrawn through the CCW system. The remainder discharges directly into the CCW and all flows discharge through DSN 0011. The CCW flow of 3,389.52 MGD is typical during three unit operation with all CCW pumps in service and would be considered normal operation. During outages, the flow for CCW would be approximately 2,259.68 MGD. The discharge concentrations calculated above are based on what is considered to be two unit CCW flow (2,259.68 MGD).

The following molluscicide treatment regime and options should be in accordance with SPP-9.7/RCTP-108 and BFN Raw Water Team concurrence.
(1) 28-56 hours/week is normal operation for MIC control. Treatment time required varies due to seasonal demand. Continuous treatment (or some variation) may be used as an alternative to or in conjunction with non-oxidizing treatments, as required, for macrofouling (invertebrate) control.
(2) Bentonite Clay is used to detoxify the Spectrus CT1300 not diluted by CCW (where dilution is acceptable). It is applied at a 5:1 ratio of clay to Spectrus CT1300. It is fed a minimum of 2 hours after Spectrus CT1300 injection is completed.
(3) Measured in accordance with effluent monitoring requirements for DSN 0011.

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RHRSW SYSTEM-STAGNANT TREATMENT MODE
(2000 GPM AVERAGE FLOW)*

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM)	DISCHARGE CONC. ACTIVE (PPM)	AQUATIC TOXICOLOGY INFORMATION 96-HR BIOASSAY
Depositrol PY5200	Co-polymer	28.5	66.5	20	2/Quarter	66.5	20	Fathead Minnow LC50 = 1960 mg/L
Flogard MS6237	Zinc & Orthophosphate	12.6 36	2 2	0.252 0.72	2/Quarter	2 2	0.25 0.72	Fathead Minnow LC50 = 7.8 mg/L
Spectrus BD1500	Biodispersant	15	20	3	2/Quarter	20	3	Fathead Minnow 0% Mortality at 2000 mg/L

The Residual Heat Removal Service Water System in stagnant treatment mode has a flow rate of approximately 2,000 GPM. Amounts are based on flushes twice per quarter for each of 10 heat exchangers for approximately 80 flushes per year. Each flush consists of 20 minutes at less than 2,000 GPM which discharges through DSN 0051.

RHRSW SYSTEM-NORMAL TREATMENT MODE
(4500 GPM AVERAGE FLOW)*

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM)	DISCHARGE CONC. ACTIVE (PPM)	AQUATIC TOXICOLOGY INFORMATION 96-HR BIOASSAY
Depositrol PY5200	Co-polymer	30	3.3	1.0	Weekly(2)	3.3	1.0	Fathead Minnow LC50 = 1960 mg/L
Flogard MS6237	Zinc & Orthophosphate	12.6 36	2 2	0.252 0.72	Weekly(2)	2 2	0.25 0.72	Fathead Minnow LC50 = 7.8 mg/L
Spectrus BD1500	Biodispersant	15	20	3	Weekly(2)	20	3	Fathead Minnow 0% Mortality at 2000 mg/L
NaOCl	NaOCl	10	51	5.1	Weekly(2)	NA	< 2.0	Fathead Minnow LC50 = 5.9 mg/L
Inhibitor AZ8100(1)	Tolytriazole (TTA)	50	2	1	Weekly(2)	2.0	1.0	Fathead Minnow LC50 = 105 mg/L
Spectrus CT1300(1)	QUAT	50	5	2.5	Weekly(2)	5	2.5	Fathead Minnow LC50 = 0.72 mg/L

The RHRSW normal treatment mode has a typical flow rate of approximately 4,500 GPM; however, other flow rates may be used, if necessary or desired, as long as the discharge concentrations are not exceeded. The normal treatment schedule is weekly for approximately 30 minutes per heat exchanger but may receive more frequent treatment simply based on normal plant operation and intermittent use of the RHRSW pumps. During unit refueling outages (about 30 days average), RHRSW pumps are utilized in extended intervals for shutdown cooling and reactor coolant temperature control. Such outages typically occur every two years per unit.

(1) These chemicals are not intended for treatment of this system, but may as a part of normal Plant operation (intermittent use of RHRSW pumps), be observed at the indicated concentrations. Reference use of these chemicals in previous Tables.
(2) The intended treatment schedule is weekly for approximately 30 minutes per heat exchanger, but as indicated in footnote 1, the system may receive treatment due to intermittent use of RHRSW pumps. Intermittent use is considered to be normal Plant operation of RHRSW pumps. During Unit Refueling Outages (~30 days average), RHRSW pumps are utilized in extended intervals for shutdown cooling and reactor coolant temperature control. Such outages typically occur every two years per unit with Units 1 and 3 scheduled during even numbered years and Unit 2 scheduled during odd numbered years.

ADEM Watermark

Pinson, Theo

Subject: FW: BFN proposed new chemicals
Attachments: BFN Biocide_Corrosion Inhibitor Summary Sheet_2025_update.doc

---

From: Phillips, Craig Lee <clphillips@tva.gov>
Sent: Tuesday, April 29, 2025 9:53 AM
To: Pinson, Theo <tpinson@adem.alabama.gov>
Subject: RE: BFN proposed new chemicals

Theo,

I have attached the updated BFN Biocide Corrosion Inhibitor plan that includes the proposed new chemicals previously discussed.

Thanks,

Craig L. Phillips
Specialist, Water Permits, Compliance, & Monitoring
Regulatory Environmental Programs

TENNESSEE VALLEY AUTHORITY

M. 865-599-6183 **E.** clphillips@tva.gov
400 West Summit Hill Drive, Knoxville, TN 37902

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From: Pinson, Theo <tpinson@adem.alabama.gov>
Sent: Friday, March 21, 2025 11:21 AM
To: Phillips, Craig Lee <clphillips@tva.gov>
Subject: RE: BFN proposed new chemicals

This is an EXTERNAL EMAIL from outside TVA. THINK BEFORE you CLICK links or OPEN attachments. If suspicious, please click the "Report Phishing" button located on the Outlook Toolbar at the top of your screen.

Craig,

I think you can delete the columns for % active ingredient, active ingredient feed rate, and concentration of active ingredient at discharge. We can evaluate the chemicals based on the entire product and if we have any concerns, we could then look into the active ingredient info if needed.

Thank you,

Theo

Theo Pinson
Industrial Section
Water Division
Alabama Department of Environmental Management
(334) 274 – 4202

NEW ADEM ELECTRONIC SYSTEM: Alabama Environmental Permitting and Compliance System (AEPACS)

AEPACS is an electronic system that allows facilities to apply for and maintain permits as well as submit other required applications, registrations, and certifications. In addition, the system allows facilities to submit required compliance reports or other information to the Department. For general information about AEPACS, visit http://adem.alabama.gov/egov/AEPACS.cnt. For NPDES and SID program specific information about AEPACS, visit http://adem.alabama.gov/egov/AEPACSwater.cnt.

If you have questions or need assistance with AEPACS, please contact the ADEM Web Portal/AEPACS Help Desk at ademwebportal@adem.alabama.gov. The email box is monitored Monday through Friday, 7:00 am –5:00 pm.

From: Phillips, Craig Lee <clphillips@tva.gov>
Sent: Friday, March 21, 2025 8:42 AM
To: Pinson, Theo <tpinson@adem.alabama.gov>
Subject: BFN proposed new chemicals

Theo,

I am working on the table you requested and the Chemical Vendor has indicated that the % active ingredient is proprietary in order to protect them from competitors. I have the percentages but is there a way to not list them in the BCIP table? I have not encountered this scenario before.

Thanks,

Craig L. Phillips
Specialist, Water Permits, Compliance, & Monitoring
Regulatory Environmental Programs

TVA TENNESSEE VALLEY AUTHORITY

M. 865-599-6183 **E.** clphillips@tva.gov
400 West Summit Hill Drive, Knoxville, TN 37902

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ATTACHMENT 3 TO ADEM FORM 187

BROWNS FERRY NUCLEAR PLANT
RAW WATER TREATMENT PROGRAM
MAXIMUM PROJECTED USAGE RATES

EMERGENCY EQUIPMENT COOLING WATER
(EECW) SYSTEM (8000 GPM AVERAGE FLOW)

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM) (AT DSN0011)	DISCHARGE CONC. ACTIVE (PPM) (AT DSN0011)	AQUATIC TOXICOLOGY INFORMATION 96-HR BIOASSAY
Depositrol PY5200	Co-polymer	30	3.3	1.0	Continuous	0.017	0.005	Fathead Minnow LC50 = 1960 mg/L
Gengard GN8004	STP	30	3	0.9	Continuous	0.012	0.004	Fathead Minnow LC50 = 2367 mg/L
Flogard MS6237	Zinc & Orthophosphate	12.6 36	2 2	0.252 0.72	Continuous	0.01 0.01	0.001 0.004	Fathead Minnow LC50 = 7.8 mg/L
Spectrus BD1500	Biodispersant	15	20	3	4/week	0.10	0.015	Fathead Minnow 0% Mortality at 2000 mg/L
NaOCl	NaOCl	10	51	5.1	28-56 hrs/wk(1)	NA	< 0.05(3)	Fathead Minnow LC50 = 5.9 mg/L
Inhibitor AZ8100	Tolytriazole (TTA)	50	2	1	Continuous	0.01	0.005	Fathead Minnow LC50 = 105 mg/L
Inhibitor AZ8104	HRA	12.5	3	0.38	Continuous	0.012	0.001	Fathead Minnow LC50 = 135 mg/L
Spectrus CT1300(2)	QUAT	50	5	2.5	4/yr (72 hrs each)	(3)	(3)	Fathead Minnow LC50 = 0.72 mg/L
Bentonite Clay	Bentonite Clay	(3)	(3)	(3)	(3)	NA	NA	NA

Emergency Equipment Cooling Water (EECW) System has an average flow of 8,000 GPM. The EECW system discharges into the intake forebay where it mixes with intake water and is withdrawn through the condenser circulating water (CCW) system (2,259.68-3,389.52 MGD dilution) into the plant and discharges through DSN 0011. The CCW flow of 3,389.52 MGD is typical during three unit operation with all CCW pumps in service and would be considered normal operation. During outages, the flow for CCW would be 2,259.68 MGD. The discharge concentrations calculated above are based on what is considered to be two unit CCW flow (2,259.68 MGD).

The following molluscicide treatment regime and options should be in accordance with SPP-9.7/CHTP-108 and BFN Raw Water Team concurrence.

(1) 28-56 hours/week is normal operation for MIC control. Treatment time required varies due to seasonal demand. Continuous treatment (or some variation) may be used as an alternative to or in conjunction with non-oxidizing treatments, as required, for macrofouling (invertebrate) control.

(2) Treatment with Spectrus CT1300 is an alternative treatment plan (non-oxidizing biocide) in place of EVAC.

(3) Bentonite Clay is used to detoxify the Spectrus CT1300. It is applied at a 5:1 ratio of clay to CT1300 and is fed a minimum of 2 hours after CT1300 injection is completed.

RAW COOLING WATER/RAW SERVICE WATER
HIGH PRESSURE FIRE PROTECTION SYSTEMS
(58,000 GPM TOTAL AVERAGE FLOW)

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM) (AT DSN0011)	DISCHARGE CONC. ACTIVE (PPM) (AT DSN0011)	AQUATIC TOXICOLOGY INFORMATION 96-HR BIOASSAY
Depositrol PY5200	Co-polymer	30	3.3	1.0	Continuous	0.12	0.04	Fathead Minnow LC50 = 1960 mg/L
Gengard GN8004	STP	12.5	3	0.9	Continuous	0.086	0.026	Fathead Minnow LC50 = 2367 mg/L
Flogard MS6237	Zinc & Orthophosphate	12.6 36	2 2	0.252 0.72	Continuous	0.07 0.07	0.009 0.03	Fathead Minnow LC50 = 7.8 mg/L
Spectrus BD1500	Biodispersant	15	20	3	4/week	0.74	0.11	Fathead Minnow 0% Mortality at 2000 mg/L
NaOCl	NaOCl	10	51	5.1	28-56 hrs/wk(1)	NA	< 0.05(3)	Fathead Minnow LC50 = 5.9 mg/L
Spectrus CT1300	QUAT	50	5	2.5	4/yr (72 hrs each)	(2)	(2)	Fathead Minnow LC50 = 0.72 mg/L
Bentonite Clay	Bentonite Clay	(2)	(2)	(2)	(2)	NA	NA	NA

Raw Cooling Water / Raw Service Water / High Pressure Fire Protection Systems have an average flow of approximately 58,000 GPM. Portions of these systems discharge into the intake forebay where it mixes with intake water and is withdrawn through the CCW system. The remainder discharges directly into the CCW and all flows discharge through DSN 0011. The CCW flow of 3,389.52 MGD is typical during three unit operation with all CCW pumps in service and would be considered normal operation. During outages, the flow for CCW would be approximately 2,259.68 MGD. The discharge concentrations calculated above are based on what is considered to be two unit CCW flow (2,259.68 MGD).

The following molluscicide treatment regime and options should be in accordance with SPP-9.7/RCTP-108 and BFN Raw Water Team concurrence.

(1) 28-56 hours/week is normal operation for MIC control. Treatment time required varies due to seasonal demand. Continuous treatment (or some variation) may be used as an alternative to or in conjunction with non-oxidizing treatments, as required, for macrofouling (invertebrate) control.

(2) Bentonite Clay is used to detoxify the Spectrus CT1300 not diluted by CCW (where dilution is acceptable). It is applied at a 5:1 ratio of clay to Spectrus CT1300. It is fed a minimum of 2 hours after Spectrus CT1300 injection is completed.

(3) Measured in accordance with effluent monitoring requirements for DSN 0011.

RHRSW SYSTEM-STAGNANT TREATMENT MODE
(2000 GPM AVERAGE FLOW)*

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM)	DISCHARGE CONC. ACTIVE (PPM)	AQUATIC TOXICOLOGY INFORMATION 96-HR BIOASSAY
Depositrol PY5200	Co-polymer	28.5	66.5	20	2/Quarter	66.5	20	Fathead Minnow LC50 = 1960 mg/L
Flogard MS6237	Zinc & Orthophosphate	12.6 36	2 2	0.252 0.72	2/Quarter	2 2	0.25 0.72	Fathead Minnow LC50 = 7.8 mg/L
Spectrus BD1500	Biodispersant	15	20	3	2/Quarter	20	3	Fathead Minnow 0% Mortality at 2000 mg/L

The Residual Heat Removal Service Water System in stagnant treatment mode has a flow rate of approximately 2,000 GPM. Amounts are based on flushes twice per quarter for each of 10 heat exchangers for approximately 80 flushes per year. Each flush consists of 20 minutes at less than 2,000 GPM which discharges through DSN 0051.

RHRSW SYSTEM-NORMAL TREATMENT MODE
(4500 GPM AVERAGE FLOW)*

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM)	DISCHARGE CONC. ACTIVE (PPM)	AQUATIC TOXICOLOGY INFORMATION 96-HR BIOASSAY
Depositrol PY5200	Co-polymer	30	3.3	1.0	Weekly(2)	3.3	1.0	Fathead Minnow LC50 = 1960 mg/L
Gengard GN8004	STP	30	3	0.9	Continuous	3	0.9	Fathead Minnow LC50 = 2367 mg/L
Flogard MS6237	Zinc & Orthophosphate	12.6 36	2 2	0.252 0.72	Weekly(2)	2 2	0.25 0.72	Fathead Minnow LC50 = 7.8 mg/L
Spectrus BD1500	Biodispersant	15	20	3	Weekly(2)	20	3	Fathead Minnow 0% Mortality at 2000 mg/L
NaOCl	NaOCl	10	51	5.1	Weekly(2)	NA	< 2.0	Fathead Minnow LC50 = 5.9 mg/L
Inhibitor AZ8100(1)	Tolytriazole (TTA)	50	2	1	Weekly(2)	2.0	1.0	Fathead Minnow LC50 = 105 mg/L
Inhibitor AZ8104	HRA	12.5	3	0.38	Continuous	3	0.38	Fathead Minnow LC50 = 135 mg/L
Spectrus CT1300(1)	QUAT	50	5	2.5	Weekly(2)	5	2.5	Fathead Minnow LC50 = 0.72 mg/L

The RHRSW normal treatment mode has a typical flow rate of approximately 4,500 GPM; however, other flow rates may be used, if necessary or desired, as long as the discharge concentrations are not exceeded. The normal treatment schedule is weekly for approximately 30 minutes per heat exchanger but may receive more frequent treatment simply based on normal plant operation and intermittent use of the RHRSW pumps. During unit refueling outages (about 30 days average), RHRSW pumps are utilized in extended intervals for shutdown cooling and reactor coolant temperature control. Such outages typically occur every two years per unit.

(1) These chemicals are not intended for treatment of this system, but may as a part of normal Plant operation (intermittent use of RHRSW pumps), be observed at the indicated concentrations. Reference use of these chemicals in previous Tables.
(2) The intended treatment schedule is weekly for approximately 30 minutes per heat exchanger, but as indicated in footnote 1, the system may receive treatment due to intermittent use of RHRSW pumps. Intermittent use is considered to be normal Plant operation of RHRSW pumps. During Unit Refueling Outages (~30 days average), RHRSW pumps are utilized in extended intervals for shutdown cooling and reactor coolant temperature control. Such outages typically occur every two years per unit with Units 1 and 3 scheduled during even numbered years and Unit 2 scheduled during odd numbered years.

CONDENSER COOLING WATER
(CCW) SYSTEM (650,000 GPM AVERAGE FLOW)

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM) (AT DSN0011)	DISCHARGE CONC. ACTIVE (PPM) (AT DSN0011)	AQUATIC TOXICOLOGY INFORMATION 96-HR BIOASSAY
Spectrus BD1500	Biodispersant	15	20	3	2-5/week	1.609	0.241	Fathead Minnow 0% Mortality at 2000 mg/L
NaOCl	NaOCl	12.5	8	1	3-5 days/week	2.574	0.322	Fathead Minnow LC50 = 5.9 mg/L
Sodium Bisulfite	Sodium Bisulfite	40	3-5	1.2-2	3-5 days/week	1.609	0.643	Fathead Minnow LC50= 175
Spectrus CT1300	QUAT	50	5	2.5	2x/year	1.287	0.643	Fathead Minnow LC50 = 0.72 mg/L
Gengard GN8008	STP	50	2	1	3x/week continuous or shock	0.643	0.322	Fathead Minnow LC50 > 8000 mg/L

SAFETY DATA SHEET
INHIBITOR AZ8100

1. Identification

Product identifier **INHIBITOR AZ8100**

Other means of identification None.

Recommended use Water-based corrosion inhibitor

Recommended restrictions None known.

Company/undertaking identification

SUEZ WTS USA, Inc.
4636 Somerton Road
Trevose, PA 19053
T 215 355 3300, F 215 953 5524

Emergency telephone

(800) 877 1940

2. Hazard(s) identification

Physical hazards	Corrosive to metals	Category 1
Health hazards	Acute toxicity, oral	Category 4
	Skin corrosion/irritation	Category 1B
	Serious eye damage/eye irritation	Category 1
	Specific target organ toxicity, single exposure	Category 3 respiratory tract irritation

OSHA defined hazards Not classified.

Label elements



Signal word Danger

Hazard statement May be corrosive to metals. Harmful if swallowed. Causes severe skin burns and eye damage. Causes serious eye damage. May cause respiratory irritation.

Precautionary statement

Prevention Keep only in original container. Do not breathe mist or vapor. Wash thoroughly after handling. Do not eat, drink or smoke when using this product. Use only outdoors or in a well-ventilated area. Wear protective gloves/protective clothing/eye protection/face protection.

Response If swallowed: Rinse mouth. Do NOT induce vomiting. If on skin (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower. If inhaled: Remove person to fresh air and keep comfortable for breathing. If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a poison center/doctor/. Specific treatment (see on this label). Wash contaminated clothing before reuse. Absorb spillage to prevent material damage.

Storage Store in a well-ventilated place. Keep container tightly closed. Store locked up. Store in corrosive resistant/ container with a resistant inner liner.

Disposal Dispose of contents/container in accordance with local/regional/national/international regulations.

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Hazard(s) not otherwise classified (HNOC)	None known.
Supplemental information	None.

3. Composition/information on ingredients

Mixtures

Components	CAS #	Percent
Sodium 4(or 5)-methyl-1H-benzotriazolide	64665-57-2	40 - 60

*Designates that a specific chemical identity and/or percentage of composition has been withheld as a trade secret.

Composition comments	Information for specific product ingredients as required by the U.S. OSHA HAZARD COMMUNICATION STANDARD is listed. Refer to additional sections of this SDS for our assessment of the potential hazards of this formulation.

4. First-aid measures

Inhalation	Remove victim to fresh air and keep at rest in a position comfortable for breathing. Call a POISON CENTER or doctor/physician if you feel unwell.
Skin contact	Take off immediately all contaminated clothing. Rinse skin with water/shower. Call a physician or poison control center immediately. Chemical burns must be treated by a physician. Wash contaminated clothing before reuse.
Eye contact	Immediately flush eyes with plenty of low-pressure water for at least 20 minutes while removing contact lenses. Hold eyelids apart. Continue rinsing. Call a physician or poison control center immediately.
Ingestion	Do not feed anything by mouth to an unconscious or convulsive victim. Do not induce vomiting. Immediately contact a physician. Rinse mouth. If the victim is fully conscious dilute contents of stomach using 3-4 glasses of water.
Most important symptoms/effects, acute and delayed	Burning pain and severe corrosive skin damage. Causes serious eye damage. Symptoms may include stinging, tearing, redness, swelling, and blurred vision. Permanent eye damage including blindness could result. May cause respiratory irritation.
Indication of immediate medical attention and special treatment needed	Corrosive material It may not be advisable to induce vomiting. Possible mucosal damage may contraindicate the use of gastric lavage. Provide general supportive measures and treat symptomatically. Chemical burns: Flush with water immediately. While flushing, remove clothes which do not adhere to affected area. Call an ambulance. Continue flushing during transport to hospital. In case of shortness of breath, give oxygen. Keep victim warm. Keep victim under observation. Symptoms may be delayed.
General information	In the case of accident or if you feel unwell, seek medical advice immediately (show the label where possible). Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

5. Fire-fighting measures

Suitable extinguishing media	Water fog. Foam. Dry chemical powder. Carbon dioxide (CO2).
Unsuitable extinguishing media	Do not use water jet as an extinguisher, as this will spread the fire.
Specific hazards arising from the chemical	During fire, gases hazardous to health may be formed.
Special protective equipment and precautions for firefighters	Wear full protective clothing, including helmet, self-contained positive pressure or pressure demand breathing apparatus, protective clothing and face mask.
Fire fighting equipment/instructions	In case of fire and/or explosion do not breathe fumes. Use standard firefighting procedures and consider the hazards of other involved materials. Move containers from fire area if you can do so without risk. Cool containers / tanks with water spray.
Specific methods	Use standard firefighting procedures and consider the hazards of other involved materials.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures	Keep unnecessary personnel away. Keep people away from and upwind of spill/leak. Keep out of low areas. Wear appropriate protective equipment and clothing during clean-up. Do not breathe mist or vapor. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Ensure adequate ventilation. Local authorities should be advised if significant spillages cannot be contained. For personal protection, see section 8 of the SDS.

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Methods and materials for containment and cleaning up	Prevent entry into waterways, sewer, basements or confined areas. Large Spills: Stop the flow of material, if this is without risk. Dike the spilled material, where this is possible. Cover with plastic sheet to prevent spreading. Absorb spillage to prevent material damage. Absorb in vermiculite, dry sand or earth and place into containers. Following product recovery, flush area with water. Small Spills: Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination. Never return spills to original containers for re-use. For waste disposal, see section 13 of the SDS.
Environmental precautions	Avoid discharge into drains, water courses or onto the ground. Water contaminated with this product may be sent to a sanitary sewer treatment facility, or a permitted waste treatment facility, in accordance with any local agreements.

7. Handling and storage

Precautions for safe handling	Alkaline. Do not mix with acidic material. Do not breathe mist or vapor. Do not get this material in contact with eyes. Do not get this material in contact with skin. Do not taste or swallow. Avoid prolonged exposure. Do not get this material on clothing. Provide adequate ventilation. Wear appropriate personal protective equipment. Observe good industrial hygiene practices. When using, do not eat, drink or smoke. Wash hands thoroughly after handling. Use care in handling/storage.
Conditions for safe storage, including any incompatibilities	Store locked up. Store in corrosive resistant container with a resistant inner liner. Store away from oxidizers. Store in original tightly closed container. Store in a cool, dry place out of direct sunlight. Store away from incompatible materials (see Section 10 of the SDS). Store in accordance with local/regional/national/international regulation. Do not freeze. If frozen, thaw completely and mix thoroughly prior to use.

8. Exposure controls/personal protection

Biological limit values	No biological exposure limits noted for the ingredient(s).
Appropriate engineering controls	Good general ventilation (typically 10 air changes per hour) should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level. Eye wash facilities and emergency shower must be available when handling this product. Good general ventilation should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level.
Individual protection measures, such as personal protective equipment	
Eye/face protection	Splash proof chemical goggles. Face shield.
Skin protection	
Hand protection	Chemical resistant gloves. The choice of an appropriate glove does not only depend on its material but also on other quality features and is different from one producer to the other. Glove selection must take into account any solvents and other hazards present.
Other	Wear appropriate chemical resistant clothing. Use of an impervious apron is recommended. Gauntlet-type rubber, butyl or neoprene gloves. Wash off after each use. Replace as necessary.
Respiratory protection	Chemical respirator with organic vapor cartridge and full facepiece. If air-purifying respirator use is appropriate, use any of the following particulate respirators: N95, N99, N100, R95, R99, R100, P95, P99 or P100. A RESPIRATORY PROTECTION PROGRAM THAT MEETS OSHA'S 29 CFR 1910.134 AND ANSI Z88.2 REQUIREMENTS MUST BE FOLLOWED WHENEVER WORKPLACE CONDITIONS WARRANT A RESPIRATOR'S USE.
Thermal hazards	Wear appropriate thermal protective clothing, when necessary.
General hygiene considerations	When using, do not eat, drink or smoke. Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

9. Physical and chemical properties

Appearance	
Color	Yellow to brown
Physical state	Liquid
Odor	Mild
Odor threshold	Not available.

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pH in aqueous solution	11.7 (10% SOL.)
Melting point/freezing point	-25 °F (-32 °C)
Initial boiling point and boiling range	Not available.
Flash point	> 200 °F (> 93 °C) SETA(CC)
Evaporation rate	< 1 (Ether = 1)
Flammability (solid, gas)	Not available.
Upper/lower flammability or explosive limits	
Flammability limit - lower (%)	Not available.
Flammability limit - upper (%)	Not available.
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	18 mm Hg
Vapor pressure temp.	70 °F (21 °C)
Vapor density	< 1 (Air = 1)
Relative density	1.22
Relative density temperature	70 °F (21 °C)
Solubility(ies)	
Solubility (water)	100 %
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	190 cps
Viscosity temperature	78 °F (26 °C)
Other information	
Pour point	-20 °F (-29 °C)
Specific gravity	1.215
VOC	0 % (ASTM 3960-93)

10. Stability and reactivity

Reactivity	The product is stable and non-reactive under normal conditions of use, storage and transport.
Chemical stability	Material is stable under normal conditions.
Possibility of hazardous reactions	No dangerous reaction known under conditions of normal use.
Conditions to avoid	Contact with incompatible materials.
Incompatible materials	Contact with strong acids may cause a violent reaction releasing heat. Strong oxidizing agents.
Hazardous decomposition products	Oxides of carbon and nitrogen evolved in fire.

11. Toxicological information

Information on likely routes of exposure

Inhalation	May cause irritation to the respiratory system.
Skin contact	No adverse effects due to skin contact are expected.
Eye contact	Causes serious eye damage.
Ingestion	Causes digestive tract burns. Harmful if swallowed.
Symptoms related to the physical, chemical and toxicological characteristics	Causes serious eye damage. Symptoms may include stinging, tearing, redness, swelling, and blurred vision. May cause respiratory irritation.

Information on toxicological effects

Acute toxicity	Harmful if swallowed. May cause respiratory irritation.

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Product	Species	Test Results
INHIBITOR AZ8100 (CAS N/A)		
Acute		
Dermal		
LD50	Rabbit	> 4000 mg/kg, (Calculated according to GHS additivity formula)
Oral		
LD50	Rat	1470 mg/kg, (Calculated according to GHS additivity formula)

Components	Species	Test Results
Sodium 4(or 5)-methyl-1H-benzotriazolide (CAS 64665-57-2)		
Acute		
Dermal		
LD50	Rabbit	> 2000 mg/kg
Oral		
LD50	Rat	735 mg/kg

* Estimates for product may be based on additional component data not shown.

Skin corrosion/irritation Causes severe skin burns and eye damage.

Serious eye damage/eye irritation Causes serious eye damage.

Respiratory or skin sensitization

Respiratory sensitization Not available.

Skin sensitization This product is not expected to cause skin sensitization.

Germ cell mutagenicity No data available to indicate product or any components present at greater than 0.1% are mutagenic or genotoxic.

Carcinogenicity This product is not considered to be a carcinogen by IARC, ACGIH, NTP, or OSHA.

IARC Monographs. Overall Evaluation of Carcinogenicity

Not listed.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not regulated.

US. National Toxicology Program (NTP) Report on Carcinogens

Not listed.

Reproductive toxicity This product is not expected to cause reproductive or developmental effects.

Specific target organ toxicity - single exposure May cause respiratory irritation.

Specific target organ toxicity - repeated exposure Not available.

Aspiration hazard Not classified. Aspiration of this product may cause the same corrosiveness/irritation impacts as if it were ingested.

Chronic effects Prolonged inhalation may be harmful.

12. Ecological information

Ecotoxicity The product is not classified as environmentally hazardous. However, this does not exclude the possibility that large or frequent spills can have a harmful or damaging effect on the environment.

Product		Species	Test Results
INHIBITOR AZ8100 (CAS N/A)			
	IC25	Ceriodaphnia	20 mg/L, Static Renewal Bioassay, 7 day
		Fathead Minnow	56 mg/L, Static Renewal Bioassay, 7 day
	LC50	Bluegill Sunfish	109.3 mg/L, Static Acute Bioassay, 96 hour
		Ceriodaphnia	147 mg/L, Static Renewal Bioassay, 48 hour

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Product		Species	Test Results
		Fathead Minnow	105 mg/L, Static Renewal Bioassay, 96 hour, (pH adjusted)
		Mysid Shrimp	166 mg/L, Static Acute Bioassay, 48 hour
		Sheepshead Minnow	475 mg/L, Static Acute Bioassay, 48 hour
	NOEL	Bluegill Sunfish	42 mg/L, Static Acute Bioassay, 96 hour
		Ceriodaphnia	37 mg/L, Static Renewal Bioassay, 48 hour
		Fathead Minnow	75 mg/L, Static Renewal Bioassay, 96 hour, (pH adjusted)
		Mysid Shrimp	10 mg/L, Static Acute Bioassay, 48 hour
		Sheepshead Minnow	370 mg/L, Static Acute Bioassay, 48 hour
Aquatic			
Crustacea	LC50	Daphnia magna	243 mg/L, Static Renewal Bioassay, 48 hour, (pH adjusted)
	NOEL	Daphnia magna	75 mg/L, Static Renewal Bioassay, 48 hour, (pH adjusted)
Fish	LC50	Rainbow Trout	34 mg/L, Static Renewal Bioassay, 96 hour
	NOEL	Rainbow Trout	15 mg/L, Static Renewal Bioassay, 96 hour

Bioaccumulative potential No data available.

Mobility in soil No data available.

Other adverse effects No other adverse environmental effects (e.g. ozone depletion, photochemical ozone creation potential, endocrine disruption, global warming potential) are expected from this component.

Environmental fate The product is not classified as environmentally hazardous. However, this does not exclude the possibility that large or frequent spills can have a harmful or damaging effect on the environment.

Persistence and degradability

No data is available on the degradability of this product.

- **COD (mgO2/g)** 810
- **BOD 5 (mgO2/g)** 4
- **BOD 28 (mgO2/g)** 22
- **Closed Bottle Test (% Degradation in 28 days)** 3
- **Zahn-Wellens Test (% Degradation in 28 days)** 9
- **TOC (mg C/g)** 280

13. Disposal considerations

Disposal instructions Collect and reclaim or dispose in sealed containers at licensed waste disposal site. Incinerate the material under controlled conditions in an approved incinerator. Dispose of contents/container in accordance with local/regional/national/international regulations.

Local disposal regulations Dispose in accordance with all applicable regulations.

Hazardous waste code D002: Waste Corrosive material [pH <=2 or =>12.5, or corrosive to steel]
The waste code should be assigned in discussion between the user, the producer and the waste disposal company.

Waste from residues / unused products Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions).

Contaminated packaging Since emptied containers may retain product residue, follow label warnings even after container is emptied. Empty containers should be taken to an approved waste handling site for recycling or disposal.

ADEM Watermark

14. Transport information

DOT

UN number	UN1719
UN proper shipping name	Caustic alkali liquids, n.o.s. (SODIUM HYDROXIDE, BENZOTRIAZOLE,METHYL,SODIUM SALT (SODIUM TOLYLTRIAZOLE),(TTA))
Transport hazard class(es)	
Class	8
Subsidiary risk	-
Packing group	II
Special precautions for user	Read safety instructions, SDS and emergency procedures before handling.
ERG number	154

Some containers may be exempt from Dangerous Goods/Hazmat Transport Regulations, please check BOL for exact container classification.

IATA

UN number	UN1719
UN proper shipping name	Caustic alkali liquid, n.o.s. (SODIUM HYDROXIDE, Sodium 4(or 5)-methyl-1H-benzotriazolide)
Transport hazard class(es)	
Class	8
Subsidiary risk	-
Packing group	II
Environmental hazards	No.
ERG Code	154
Special precautions for user	Read safety instructions, SDS and emergency procedures before handling.

IMDG

UN number	UN1719
UN proper shipping name	CAUSTIC ALKALI LIQUID, N.O.S. (SODIUM HYDROXIDE, BENZOTRIAZOLE,METHYL,SODIUM SALT (SODIUM TOLYLTRIAZOLE),(TTA))
Transport hazard class(es)	
Class	8
Subsidiary risk	-
Packing group	II
Environmental hazards	
Marine pollutant	No.
EmS	F-A, S-B
Special precautions for user	Read safety instructions, SDS and emergency procedures before handling.

DOT



IATA; IMDG



15. Regulatory information

US federal regulations

This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.
All components are on the U.S. EPA TSCA Inventory List.

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TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

CERCLA Hazardous Substance List (40 CFR 302.4)

Not listed.

SARA 304 Emergency release notification

Not regulated.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not regulated.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

Hazard categories

Immediate Hazard - Yes
Delayed Hazard - No
Fire Hazard - No
Pressure Hazard - No
Reactivity Hazard - No

SARA 302 Extremely hazardous substance

Not listed.

SARA 311/312 Hazardous chemical Yes

SARA 313 (TRI reporting)

Not regulated.

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

Not regulated.

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Not regulated.

Safe Drinking Water Act (SDWA) Not regulated.

Inventory status

Country(s) or region	Inventory name	On inventory (yes/no)*
Canada	Domestic Substances List (DSL)	Yes
Canada	Non-Domestic Substances List (NDSL)	No
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s)
A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

US state regulations California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): This material is not known to contain any chemicals currently listed as carcinogens or reproductive toxins.

US - California Proposition 65 - CRT: Listed date/Carcinogenic substance

No ingredient listed.

US - California Proposition 65 - CRT: Listed date/Developmental toxin

No ingredient listed.

US - California Proposition 65 - CRT: Listed date/Female reproductive toxin

No ingredient listed.

US - California Proposition 65 - CRT: Listed date/Male reproductive toxin

No ingredient listed.

US - Massachusetts RTK - Substance List

Not regulated.

US - Pennsylvania RTK - Hazardous Substances

Not regulated.

US - Rhode Island RTK

Not regulated.

US. California Proposition 65

California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): This material is not known to contain any chemicals currently listed as carcinogens or reproductive toxins.

16. Other information, including date of preparation or last revision

Issue date Nov-05-2014

Revision date Dec-16-2017

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Version #	1.1
List of abbreviations	CAS: Chemical Abstract Service Registration Number ACGIH: American Conference of Governmental Industrial Hygienists TWA: Time Weighted Average STEL: Short Term Exposure Limit LD50: Lethal Dose, 50% LC50: Lethal Concentration, 50% NOEL: No Observed Effect Level COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon IATA: International Air Transport Association IMDG: International Maritime Dangerous Goods Code TSRN indicates a Trade Secret Registry Number is used in place of the CAS number.
References:	No data available
Disclaimer	The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text. The information in the sheet was written based on the best knowledge and experience currently available.
Revision information	This document has undergone significant changes and should be reviewed in its entirety.
Prepared by	This SDS has been prepared by SUEZ Regulatory Department (1-215-355-3300).

ADEM Watermark

SAFETY DATA SHEET
SPECTRUS* BD1500

1. Identification

Product identifier **SPECTRUS BD1500**

Other means of identification None.

Recommended use Biodispersant

Recommended restrictions None known.

Company/undertaking identification

SUEZ WTS USA, Inc.
4636 Somerton Road
Trevose, PA 19053
T 215 355 3300, F 215 953 5524

Emergency telephone

(800) 877 1940

2. Hazard(s) identification

Physical hazards Not classified.

Health hazards Not classified.

OSHA defined hazards Not classified.

Label elements

Hazard symbol None.

Signal word None.

Hazard statement The mixture does not meet the criteria for classification.

Precautionary statement

Prevention Observe good industrial hygiene practices.

Response Wash hands after handling.

Storage Store away from incompatible materials.

Disposal Dispose of waste and residues in accordance with local authority requirements.

Hazard(s) not otherwise classified (HNOC) None known.

Supplemental information None.

3. Composition/information on ingredients

Mixtures

The manufacturer lists no ingredients as hazardous according to OSHA 29 CFR 1910.1200.

Composition comments Information for specific product ingredients as required by the U.S. OSHA HAZARD COMMUNICATION STANDARD is listed. Refer to additional sections of this SDS for our assessment of the potential hazards of this formulation.

4. First-aid measures

Inhalation Move to fresh air. For breathing difficulties, oxygen may be necessary. If breathing stops, provide artificial respiration. Get medical attention immediately.

Skin contact Wash with plenty of soap and water. Get medical attention if irritation develops or persists.

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Eye contact	Immediately flush eyes with plenty of water for at least 15 minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Get medical attention if irritation develops and persists.
Ingestion	Do not induce vomiting. Rinse mouth. Get medical attention if symptoms occur.
Most important symptoms/effects, acute and delayed	Direct contact with eyes may cause temporary irritation.
Indication of immediate medical attention and special treatment needed	Treat symptomatically.
General information	Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

5. Fire-fighting measures

Suitable extinguishing media	Water fog. Foam. Dry chemical powder. Carbon dioxide (CO2).
Unsuitable extinguishing media	None known.
Specific hazards arising from the chemical	During fire, gases hazardous to health may be formed.
Special protective equipment and precautions for firefighters	Wear full protective clothing, including helmet, self-contained positive pressure or pressure demand breathing apparatus, protective clothing and face mask.
Fire fighting equipment/instructions	In case of fire and/or explosion do not breathe fumes. Use standard firefighting procedures and consider the hazards of other involved materials. Move containers from fire area if you can do so without risk. Cool containers / tanks with water spray.
Specific methods	Use standard firefighting procedures and consider the hazards of other involved materials.
General fire hazards	No unusual fire or explosion hazards noted.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures	Alkaline. Wear appropriate protective equipment and clothing during clean-up. See Section 8 of the SDS for Personal Protective Equipment. Ventilate area, use specified protective equipment.
Methods and materials for containment and cleaning up	Stop the flow of material, if this is without risk. Following product recovery, flush area with water. Never return spills to original containers for re-use.
Environmental precautions	Water contaminated with this product may be sent to a sanitary sewer treatment facility, or a permitted waste treatment facility, in accordance with any local agreements.

7. Handling and storage

Precautions for safe handling	Alkaline. Do not mix with acidic material. Observe good industrial hygiene practices.
Conditions for safe storage, including any incompatibilities	Store in original tightly closed container.

8. Exposure controls/personal protection

Biological limit values	No biological exposure limits noted for the ingredient(s).
Appropriate engineering controls	Not available.

Individual protection measures, such as personal protective equipment

Eye/face protection	Splash proof chemical goggles.
Skin protection	
Hand protection	Wear appropriate chemical resistant gloves. The choice of an appropriate glove does not only depend on its material but also on other quality features and is different from one producer to the other. Glove selection must take into account any solvents and other hazards present.
Other	Wear suitable protective clothing. Protective clothing if splashing or repeated contact with product is likely.
Respiratory protection	A RESPIRATORY PROTECTION PROGRAM THAT MEETS OSHA'S 29 CFR 1910.134 AND ANSI Z88.2 REQUIREMENTS MUST BE FOLLOWED WHENEVER WORKPLACE CONDITIONS WARRANT A RESPIRATOR'S USE. If engineering controls do not maintain airborne concentrations below recommended exposure limits (where applicable) or to an acceptable level (in countries where exposure limits have not been established), an approved respirator must be worn.
Thermal hazards	Wear appropriate thermal protective clothing, when necessary.

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General hygiene considerations	Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

9. Physical and chemical properties

Appearance	
Color	Colorless
Physical state	Liquid
Odor	Slight
Odor threshold	Not available.
Melting point/freezing point	31 °F (-1 °C)
Initial boiling point and boiling range	220 °F (104 °C)
Flash point	Not applicable.
Evaporation rate	< 1 (Ether = 1)
Flammability (solid, gas)	Not applicable.
Upper/lower flammability or explosive limits	
Flammability limit - lower (%)	Not available.
Flammability limit - upper (%)	Not available.
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	18 mm Hg
Vapor pressure temp.	70 °F (21 °C)
Vapor density	< 1 (Air = 1)
Relative density	1.02
Relative density temperature	70 °F (21 °C)
Solubility(ies)	
Solubility (water)	100 %
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	11 cps
Viscosity temperature	70 °F (21 °C)
Other information	
Pour point	26 °F (-3 °C)
Specific gravity	1.02
VOC	0 % (Estimated)
pH (concentrated product)	12.5
pH in aqueous solution	Not available.

10. Stability and reactivity

Reactivity	The product is stable and non-reactive under normal conditions of use, storage and transport.
Chemical stability	Material is stable under normal conditions.
Possibility of hazardous reactions	Hazardous polymerization does not occur.
Conditions to avoid	Contact with incompatible materials.
Incompatible materials	Strong oxidizing agents.
Hazardous decomposition products	Oxides of carbon evolved in fire.

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11. Toxicological information

Information on likely routes of exposure

Inhalation	Mists/aerosols may cause irritation to upper respiratory tract.
Skin contact	Prolonged or repeated contact may cause transient irritation.
Eye contact	Direct contact with eyes may cause temporary irritation.
Ingestion	Expected to be a low ingestion hazard.
Symptoms related to the physical, chemical and toxicological characteristics	Prolonged and repetitive exposure, depending on the route(s), may develop transient irritation on skin, eyes, ingestion tract, and/or respiratory tract.

Information on toxicological effects

Acute toxicity

Product	Species	Test Results
SPECTRUS BD1500 (CAS Mixture)		
Acute		
Dermal		
LD50	Rabbit	> 5000 mg/kg, (Calculated according to GHS additivity formula)
Oral		
LD50	Rat	> 5000 mg/kg, (Calculated according to GHS additivity formula)

* Estimates for product may be based on additional component data not shown.

Skin corrosion/irritation	Prolonged skin contact may cause temporary irritation.
Serious eye damage/eye irritation	Direct contact with eyes may cause temporary irritation.
Respiratory or skin sensitization	
Respiratory sensitization	This product is not expected to cause respiratory sensitization.
Skin sensitization	This product is not expected to cause skin sensitization.
Germ cell mutagenicity	No data available to indicate product or any components present at greater than 0.1% are mutagenic or genotoxic.
Carcinogenicity	This product is not considered to be a carcinogen by IARC, ACGIH, NTP, or OSHA.

IARC Monographs. Overall Evaluation of Carcinogenicity

Not listed.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1052)

Not regulated.

US. National Toxicology Program (NTP) Report on Carcinogens

Not listed.

Reproductive toxicity	This product is not expected to cause reproductive or developmental effects.
Specific target organ toxicity - single exposure	Not classified.
Specific target organ toxicity - repeated exposure	Not classified.
Aspiration hazard	Based on available data, the classification criteria are not met.

12. Ecological information

Ecotoxicity

Product		Species	Test Results
SPECTRUS BD1500 (CAS Mixture)			
Aquatic			
Algae	EC50	Selenastrum (algae)	> 8000 mg/l, Growth Inhibition, 96 hour, (pH adjusted)
	NOEL	Selenastrum (algae)	8000 mg/l, Growth Inhibition, 96 hour, (pH adjusted)

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Product		Species	Test Results
Crustacea	0% Mortality	Daphnia magna	2000 mg/l, Static Acute Bioassay, 48 hour
	25% Mortality	Mysid Shrimp	5000 mg/l, Static Acute Bioassay, 96 hour
	IC25	Ceriodaphnia	652 mg/l, Static Renewal Bioassay, 7 day
	LC50	Ceriodaphnia	> 3000 mg/l, Static Renewal Bioassay, 48 hour
	NOEL	Mysid Shrimp	2500 mg/l, Static Acute Bioassay, 96 hour
Fish	0% Mortality	Fathead Minnow	2000 mg/l, Static Bioassay with 48-Hour Renewal, 96 hour
		Menidia beryllina (Silversides)	5000 mg/l, Static Acute Bioassay, 96 hour
	IC25	Fathead Minnow	3000 mg/l, Static Renewal Bioassay, 7 day
	LC50	Fathead Minnow	> 3000 mg/l, Static Renewal Bioassay, 7 day
	NOEL	Rainbow Trout	3000 mg/l, Static Renewal Bioassay, 96 hour

Bioaccumulative potential Not available.

Mobility in soil No data available.

Other adverse effects Not available.

Persistence and degradability

Testing has shown product not to be readily biodegradable.

- **COD (mgO2/g)** 291
- **BOD 5 (mgO2/g)** 13,35
- **BOD 28 (mgO2/g)** 45,3
- **Closed Bottle Test (% Degradation in 28 days)** 15 OECD 301D
- **Zahn-Wellens Test (% Degradation in 28 days)** 9 (calculated data)
- **TOC (mg C/g)** 80 (calculated data)

13. Disposal considerations

Disposal instructions Collect and reclaim or dispose in sealed containers at licensed waste disposal site.

Local disposal regulations Dispose in accordance with all applicable regulations.

Hazardous waste code The waste code should be assigned in discussion between the user, the producer and the waste disposal company.

Waste from residues / unused products Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions).

Contaminated packaging Since emptied containers may retain product residue, follow label warnings even after container is emptied. Empty containers should be taken to an approved waste handling site for recycling or disposal.

14. Transport information

DOT

Not regulated as dangerous goods.

Some containers may be exempt from Dangerous Goods/Hazmat Transport Regulations, please check BOL for exact container classification.

IATA

Not regulated as dangerous goods.

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IMDG

Not regulated as dangerous goods.

15. Regulatory information

US federal regulations

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

CERCLA Hazardous Substance List (40 CFR 302.4)

Not listed.

SARA 304 Emergency release notification

Not regulated.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1052)

Not regulated.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

SARA 302 Extremely hazardous substance

Not listed.

SARA 311/312 Hazardous chemical	No

SARA 313 (TRI reporting)

Not regulated.

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

Not regulated.

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Not regulated.

Clean Water Act (CWA) Section 112(r) (40 CFR 68.130)	Hazardous substance
Safe Drinking Water Act (SDWA)	Not regulated.

Inventory status

Country(s) or region	Inventory name	On inventory (yes/no)*
Canada	Domestic Substances List (DSL)	Yes
Canada	Non-Domestic Substances List (NDSL)	No
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s)
A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

Food and drug administration	21 CFR 176.170 (components of paper and paperboard in contact with aqueous and fatty foods)
NSF Registered and/or meets USDA (according to 1998 guidelines):	Registration No. – 141059 Category Code(s): G5 Cooling and retort water treatment products G7 Boiler, steam line treatment products – nonfood contact

US state regulations

California Proposition 65

California Safe Drinking Water and Toxic Enforcement Act of 2016 (Proposition 65): This material is not known to contain any chemicals currently listed as carcinogens or reproductive toxins. For more information go to www.P65Warnings.ca.gov.

US - California Proposition 65 - CRT: Listed date/Carcinogenic substance

No ingredient listed.

US - California Proposition 65 - CRT: Listed date/Developmental toxin

No ingredient listed.

US - California Proposition 65 - CRT: Listed date/Female reproductive toxin

No ingredient listed.

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US - California Proposition 65 - CRT: Listed date/Male reproductive toxin

No ingredient listed.

16. Other information, including date of preparation or last revision

Issue date	Dec-03-2014
Revision date	Jun-17-2020
Version #	3.1
NFPA ratings	Health: 0 Flammability: 0 Instability: 0
NFPA ratings	
List of abbreviations	CAS: Chemical Abstract Service Registration Number TWA: Time Weighted Average STEL: Short Term Exposure Limit LD50: Lethal Dose, 50% LC50: Lethal Concentration, 50% NOEL: No Observed Effect Level COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon IATA: International Air Transport Association IMDG: International Maritime Dangerous Goods Code ACGIH: American Conference of Governmental Industrial Hygienists OSHA: Occupational Safety & Health Administration. NFPA: National Fire Protection Association GHS: Globally Harmonized System of Classification and Labeling of Chemicals.
References:	No data available
Disclaimer	The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.
Revision information	Composition / Information on Ingredients: Disclosure Overrides Composition/information on ingredients: Composition comments Exposure controls/personal protection: Hand protection Physical & Chemical Properties: Multiple Properties Ecological information: Persistence / degradability Ecological information: Other adverse effects Other information, including date of preparation or last revision: List of abbreviations HazReg Data: Europe - EU GHS: Classification
Prepared by	This SDS has been prepared by SUEZ Regulatory Department (1-215-355-3300).

* Trademark of SUEZ. May be registered in one or more countries.

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SAFETY DATA SHEET
SPECTRUS* CT1300

1. Identification

Product identifier	**SPECTRUS CT1300**
Other means of identification	None.
Recommended use	Water-based microbial control agent.
Recommended restrictions	Industrial use only.

Company/undertaking identification

SUEZ WTS USA, Inc.
4636 Somerton Road
Trevose, PA 19053
T 215 355 3300, F 215 953 5524

Emergency telephone

(800) 877 1940

2. Hazard(s) identification

Physical hazards	Flammable liquids	Category 3
Health hazards	Acute toxicity, oral	Category 4
	Skin corrosion/irritation	Category 1B
	Serious eye damage/eye irritation	Category 1
OSHA defined hazards	Not classified.	

Label elements



Signal word	Danger
Hazard statement	Flammable liquid and vapor. Harmful if swallowed. Causes severe skin burns and eye damage.
Precautionary statement	
Prevention	Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking. Keep container tightly closed. Ground and bond container and receiving equipment. Use explosion-proof electrical/ventilating/lighting equipment. Use non-sparking tools. Take action to prevent static discharges. Do not breathe mist or vapor. Wash thoroughly after handling. Do not eat, drink or smoke when using this product. Wear protective gloves/protective clothing/eye protection/face protection.
Response	If swallowed: Rinse mouth. Do NOT induce vomiting. If on skin (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower. If inhaled: Remove person to fresh air and keep comfortable for breathing. If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a POISON CENTER/doctor. Wash contaminated clothing before reuse. In case of fire: Use appropriate media to extinguish.
Storage	Store in a well-ventilated place. Keep cool. Store locked up.
Disposal	Dispose of contents/container in accordance with local/regional/national/international regulations.

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Hazard(s) not otherwise classified (HNOC)	None known.
Supplemental information	None.

3. Composition/information on ingredients

Mixtures

Components	CAS #	Percent
Alkyl dimethyl benzyl ammonium chloride	68424-85-1	40 - 60
Ethanol	64-17-5	10 - 20

Composition comments Information for specific product ingredients as required by the U.S. OSHA HAZARD COMMUNICATION STANDARD is listed. Refer to additional sections of this SDS for our assessment of the potential hazards of this formulation.

4. First-aid measures

Inhalation Move to fresh air. Call a physician if symptoms develop or persist.

Skin contact Take off immediately all contaminated clothing. Rinse skin with water/shower. Call a physician or poison control center immediately. Chemical burns must be treated by a physician. Wash contaminated clothing before reuse.

Eye contact Rinse with water. Remove contact lenses, if present and easy to do. Continue rinsing. Call a physician or poison control center immediately.

Ingestion Call a physician or poison control center immediately. Rinse mouth. Do not induce vomiting. If vomiting occurs, keep head low so that stomach content doesn't get into the lungs.

Most important symptoms/effects, acute and delayed Burning pain and severe corrosive skin damage. Causes serious eye damage. Symptoms may include stinging, tearing, redness, swelling, and blurred vision. Permanent eye damage including blindness could result. Vapors have a narcotic effect and may cause headache, fatigue, dizziness and nausea.

Indication of immediate medical attention and special treatment needed Provide general supportive measures and treat symptomatically. Thermal burns: Flush with water immediately. While flushing, remove clothes which do not adhere to affected area. Call an ambulance. Continue flushing during transport to hospital. Chemical burns: Flush with water immediately. While flushing, remove clothes which do not adhere to affected area. Call an ambulance. Continue flushing during transport to hospital. Keep victim warm. Keep victim under observation. Symptoms may be delayed.

General information Take off all contaminated clothing immediately. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves. Show this safety data sheet to the doctor in attendance. Wash contaminated clothing before reuse.

5. Fire-fighting measures

Suitable extinguishing media Alcohol resistant foam. Carbon dioxide (CO2). Avoid water if possible. Water fog. Powder.

Unsuitable extinguishing media Water. Do not use water jet as an extinguisher, as this will spread the fire.

Specific hazards arising from the chemical Vapors may form explosive mixtures with air. Vapors may travel considerable distance to a source of ignition and flash back. During fire, gases hazardous to health may be formed.

Special protective equipment and precautions for firefighters Wear full protective clothing, including helmet, self-contained positive pressure or pressure demand breathing apparatus, protective clothing and face mask.

Fire fighting equipment/instructions In case of fire and/or explosion do not breathe fumes. Use standard firefighting procedures and consider the hazards of other involved materials. Move containers from fire area if you can do so without risk. Cool containers / tanks with water spray.

Specific methods Use standard firefighting procedures and consider the hazards of other involved materials.

General fire hazards Flammable liquid and vapor.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures Keep unnecessary personnel away. Eliminate all ignition sources (no smoking, flares, sparks, or flames in immediate area). Wear appropriate protective equipment and clothing during clean-up. Do not breathe mist or vapor. Ventilate closed spaces before entering them. Local authorities should be advised if significant spillages cannot be contained. For personal protection, see section 8 of the SDS.

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Methods and materials for containment and cleaning up

Eliminate all ignition sources (no smoking, flares, sparks, or flames in immediate area). Keep combustibles (wood, paper, oil, etc.) away from spilled material. Take precautionary measures against static discharge. Use only non-sparking tools. Prevent entry into waterways, sewer, basements or confined areas. Use a non-combustible material like vermiculite, sand or earth to soak up the product and place into a container for later disposal. Following product recovery, flush area with water. Absorb with earth, sand or other non-combustible material and transfer to containers for later disposal.

Never return spills to original containers for re-use. For waste disposal, see section 13 of the SDS.

Environmental precautions

Avoid discharge into drains, water courses or onto the ground. Do not empty into drains, dispose of this material and its container to hazardous or special waste collection point.

7. Handling and storage

Precautions for safe handling

Do not handle, store or open near an open flame, sources of heat or sources of ignition. Protect material from direct sunlight. Explosion-proof general and local exhaust ventilation. Take precautionary measures against static discharges. All equipment used when handling the product must be grounded. Use non-sparking tools and explosion-proof equipment. Do not get in eyes, on skin, or on clothing. Do not taste or swallow. Avoid prolonged exposure. When using, do not eat, drink or smoke. Wear appropriate personal protective equipment. Wash hands thoroughly after handling. Observe good industrial hygiene practices.

Conditions for safe storage, including any incompatibilities

Store locked up. Keep away from heat, sparks and open flame. Prevent electrostatic charge build-up by using common bonding and grounding techniques. Store in a cool, dry place out of direct sunlight. Store in tightly closed container. Store in a well-ventilated place. Keep in an area equipped with sprinklers. Store away from incompatible materials (see Section 10 of the SDS).

8. Exposure controls/personal protection

Occupational exposure limits

US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000)

Components	Type	Value
Ethanol (CAS 64-17-5)	PEL	1900 mg/m3 1000 ppm

US. ACGIH Threshold Limit Values

Components	Type	Value
Ethanol (CAS 64-17-5)	STEL	1000 ppm

US. NIOSH: Pocket Guide to Chemical Hazards

Components	Type	Value
Ethanol (CAS 64-17-5)	TWA	1900 mg/m3 1000 ppm

Biological limit values

No biological exposure limits noted for the ingredient(s).

Appropriate engineering controls

Explosion-proof general and local exhaust ventilation. Eye wash facilities and emergency shower must be available when handling this product. Good general ventilation should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level.

Individual protection measures, such as personal protective equipment

Eye/face protection

Wear safety glasses with side shields (or goggles) and a face shield.

Skin protection

Hand protection

Wear appropriate chemical resistant gloves. The choice of an appropriate glove does not only depend on its material but also on other quality features and is different from one producer to the other. Glove selection must take into account any solvents and other hazards present.

Other

Wear appropriate chemical resistant clothing.

Respiratory protection

A RESPIRATORY PROTECTION PROGRAM THAT MEETS OSHA'S 29 CFR 1910.134 AND ANSI Z88.2 REQUIREMENTS MUST BE FOLLOWED WHENEVER WORKPLACE CONDITIONS WARRANT A RESPIRATOR'S USE. If air-purifying respirator use is appropriate, use a respirator with organic vapor cartridges.

Thermal hazards

Wear appropriate thermal protective clothing, when necessary.

General hygiene considerations

When using do not smoke. Keep away from food and drink. Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

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9. Physical and chemical properties

Appearance	
Color	Colorless to yellow
Physical state	Liquid
Odor	Mild
Odor threshold	Not available.
pH (concentrated product)	7.5 Neat
pH in aqueous solution	6.3 (10% Solution)
Melting point/freezing point	-7 °F (-22 °C)
Initial boiling point and boiling range	Not available.
Flash point	129 °F (54 °C) P-M(CC)
Evaporation rate	Slower than Ether
Flammability (solid, gas)	Not applicable.
Upper/lower flammability or explosive limits	
Flammability limit - lower (%)	Not available.
Flammability limit - upper (%)	Not available.
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	44 mmHg
Vapor pressure temp.	70 °F (21 °C)
Vapor density	< 1
Relative density	0.96
Relative density temperature	70 °F (21 °C)
Solubility(ies)	
Solubility (water)	100 %
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	73 mPa.s
Viscosity temperature	70 °F (21 °C)
Other information	
Explosive properties	Not explosive.
Oxidizing properties	Not oxidizing.
Pour point	-2 °F (-19 °C)
Specific gravity	0.965

10. Stability and reactivity

Reactivity	The product is stable and non-reactive under normal conditions of use, storage and transport.
Chemical stability	Material is stable under normal conditions.
Possibility of hazardous reactions	Hazardous polymerization does not occur.
Conditions to avoid	Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. Avoid temperatures exceeding the flash point. Contact with incompatible materials.
Incompatible materials	Strong oxidizing agents.
Hazardous decomposition products	Thermal decomposition or combustion may produce oxides of carbon, ammonia, oxides of nitrogen and/or hydrogen chloride.

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11. Toxicological information

Information on likely routes of exposure

Inhalation	Prolonged inhalation may be harmful.
Skin contact	Causes severe skin burns.
Eye contact	Causes serious eye damage.
Ingestion	Causes digestive tract burns. Harmful if swallowed.
Symptoms related to the physical, chemical and toxicological characteristics	Burning pain and severe corrosive skin damage. Causes serious eye damage. Symptoms may include stinging, tearing, redness, swelling, and blurred vision. Permanent eye damage including blindness could result.

Information on toxicological effects

Acute toxicity Harmful if swallowed.

Product	Species	Test Results
SPECTRUS CT1300 (CAS Mixture)		
Acute		
Dermal		
LD50	Rabbit	> 5000 mg/kg, (Calculated according to GHS additivity formula)
Oral		
LD50	Rat	688 mg/kg, (Calculated according to GHS additivity formula)

Components	Species	Test Results
Alkyl dimethyl benzyl ammonium chloride (CAS 68424-85-1)		
Acute		
Dermal		
LD50	Rabbit	3340 mg/kg
Oral		
LD50	Rat	344 mg/kg
Ethanol (CAS 64-17-5)		
Acute		
Dermal		
LD50	Rabbit	> 5000 mg/kg
Inhalation		
LC50	Rat	124.7 mg/l/4h
Oral		
LD50	Rat	> 5000 mg/kg

Skin corrosion/irritation	Causes severe skin burns.
Serious eye damage/eye irritation	Causes serious eye damage.

Respiratory or skin sensitization

Respiratory sensitization	This product is not expected to cause respiratory sensitization.
Skin sensitization	This product is not expected to cause skin sensitization.
Germ cell mutagenicity	No data available to indicate product or any components present at greater than 0.1% are mutagenic or genotoxic.

Carcinogenicity

IARC Monographs. Overall Evaluation of Carcinogenicity

Not listed.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1052)

Not regulated.

US. National Toxicology Program (NTP) Report on Carcinogens

Not listed.

Reproductive toxicity	Not classified.
Specific target organ toxicity - single exposure	Not classified.

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Specific target organ toxicity - repeated exposure	Not classified.
Aspiration hazard	Based on available data, the classification criteria are not met.
Chronic effects	Prolonged inhalation may be harmful.

12. Ecological information

Ecotoxicity

Product		Species	Test Results
SPECTRUS CT1300 (CAS Mixture)			
	LC10	Annelida(Lumbriculus variegatus)	0.37 mg/L, Acute Toxicity, 96 hour
	LC50	Annelida(Lumbriculus variegatus)	1.47 mg/L, Acute Toxicity, 96 hour
		Benthic Crustacean(Gammerus pseutolimnaeus)	0.07 mg/L, Acute Toxicity, 96 hour
		Channel Catfish	0.86 mg/L, Acute Toxicity, 96 hour
		Freshwater Snail(Physa sp.)	0.46 mg/L, Acute Toxicity, 96 hour
		Midge larvae (Chironomus tentans)	0.5 mg/L, Acute Toxicity, 96 hour
	NOEL	Channel Catfish	0.54 mg/L, Acute Toxicity, 96 hour
		Freshwater Snail(Physa sp.)	0.36 mg/L, Acute Toxicity, 96 hour
		Midge larvae (Chironomus tentans)	0.13 mg/L, Acute Toxicity, 96 hour
Aquatic			
Crustacea	IC25	Ceriodaphnia	0.098 mg/L, Chronic Bioassay, 7 day
	LC50	Ceriodaphnia	0.35 mg/L, Static Renewal Bioassay, 48 hour
		Daphnia magna	0.11 mg/L, Static Acute Bioassay, 48 hour
			0.04 mg/L, Flow-Thru Bioassay, 48 hour
		Daphnia pulex	0.05 mg/L, Static Renewal Bioassay, 48 hour
		Mysid Shrimp	0.16 mg/L, Flow-Thru Bioassay, 96 hour
	NOEL	Ceriodaphnia	0.15 mg/L, Static Renewal Bioassay, 48 hour
		Daphnia magna	0.06 mg/L, Static Acute Bioassay, 48 hour
			0.026 mg/L, Flow-Thru Bioassay, 48 hour
		Daphnia pulex	0.031 mg/L, Static Renewal Bioassay, 48 hour
		Mysid Shrimp	0.03 mg/L, Flow-Thru Bioassay, 96 hour
Fish	IC25	Fathead Minnow	0.259 mg/L, Chronic Bioassay, 7 day
	LC50	Fathead Minnow	0.72 mg/L, Flow-Thru Bioassay, 96 hour
		Menidia beryllina (Silversides)	0.62 mg/L, Flow-Thru Bioassay, 96 hour
		Rainbow Trout	2 mg/L, Flow-Thru Bioassay, 96 hour
		Sheepshead Minnow	1.76 mg/L, Flow-Thru Bioassay, 96 hour
	NOEL	Fathead Minnow	0.41 mg/L, Flow-Thru Bioassay, 96 hour
		Menidia beryllina (Silversides)	0.35 mg/L, Flow-Thru Bioassay, 96 hour
		Rainbow Trout	1.2 mg/L, Flow-Thru Bioassay, 96 hour
		Sheepshead Minnow	1 mg/L, Flow-Thru Bioassay, 96 hour

Components		Species	Test Results
Alkyl dimethyl benzyl ammonium chloride (CAS 68424-85-1)			
	EC50	Active Sludge	10 mg/l
		Daphnia Magna	0.016 mg/l, 48 hour

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Components		Species	Test Results
Aquatic			
Fish	LC50	Rainbow Trout	0.93 mg/l, 96 hour

Bioaccumulative potential

Partition coefficient n-octanol / water (log Kow)
Ethanol -0.31

Mobility in soil No data available.

Other adverse effects Not available.

Persistence and degradability

66% CO_2 Evolution (Modified Sturm Test) (OECD 301B)

- COD (mgO2/g)	1470
- BOD 5 (mgO2/g)	43
- BOD 28 (mgO2/g)	156
- Closed Bottle Test (% Degradation in 28 days)	14
- Zahn-Wellens Test (% Degradation in 28 days)	0
- TOC (mg C/g)	380
- CO2 evolution (modified Sturm test)	66

13. Disposal considerations

Disposal instructions Collect and reclaim or dispose in sealed containers at licensed waste disposal site. Incinerate the material under controlled conditions in an approved incinerator. Do not incinerate sealed containers. If discarded, this product is considered a RCRA ignitable waste, D001. Dispose of contents/container in accordance with local/regional/national/international regulations.

Local disposal regulations Dispose in accordance with all applicable regulations.

Hazardous waste code The waste code should be assigned in discussion between the user, the producer and the waste disposal company. D002: Waste Corrosive material [pH <=2 or =>12.5, or corrosive to steel] D001: Waste Flammable material with a flash point <140 F

Waste from residues / unused products Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions).

Contaminated packaging Since emptied containers may retain product residue, follow label warnings even after container is emptied. Empty containers should be taken to an approved waste handling site for recycling or disposal.

14. Transport information

DOT

UN number	UN1903
UN proper shipping name	Disinfectants, liquid, corrosive n.o.s. (QUATERNARY AMMONIUM COMPOUNDS)
Transport hazard class(es)	
Class	8
Subsidiary risk	-
Packing group	II
Special precautions for user	Read safety instructions, SDS and emergency procedures before handling.
ERG number	153

Some containers may be exempt from Dangerous Goods/Hazmat Transport Regulations, please check BOL for exact container classification.

IATA

UN number	UN2920
UN proper shipping name	Corrosive liquid, flammable, n.o.s. (ETHANOL, QUATERNARY AMMONIUM COMPOUNDS)
Transport hazard class(es)	
Class	8
Subsidiary risk	3
Packing group	II

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Environmental hazards	Yes
ERG Code	132
Special precautions for user	Read safety instructions, SDS and emergency procedures before handling.

IMDG

UN number	UN2920
UN proper shipping name	CORROSIVE LIQUID, FLAMMABLE, N.O.S. (ETHANOL, QUATERNARY AMMONIUM COMPOUNDS), MARINE POLLUTANT
Transport hazard class(es)	
Class	8
Subsidiary risk	3
Packing group	II
Environmental hazards	
Marine pollutant	Yes
EmS	F-E, S-C
Special precautions for user	Read safety instructions, SDS and emergency procedures before handling.

DOT



IATA; IMDG



Marine pollutant



General information	IMDG Regulated Marine Pollutant.

15. Regulatory information

US federal regulations	This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

CERCLA Hazardous Substance List (40 CFR 302.4)

Not listed.

SARA 304 Emergency release notification

Not regulated.

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OSHA Specifically Regulated Substances (29 CFR 1910.1001-1052)

Not regulated.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

SARA 302 Extremely hazardous substance

Not listed.

SARA 311/312 Hazardous chemical	Yes
Classified hazard categories	Flammable (gases, aerosols, liquids, or solids) Acute toxicity (any route of exposure) Skin corrosion or irritation Serious eye damage or eye irritation

SARA 313 (TRI reporting)

Not regulated.

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

Methanol (CAS 67-56-1)

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Not regulated.

Safe Drinking Water Act (SDWA)	Not regulated.

FEMA Priority Substances Respiratory Health and Safety in the Flavor Manufacturing Workplace

Ethanol (CAS 64-17-5)	Low priority

Inventory status

Country(s) or region	Inventory name	On inventory (yes/no)*
Canada	Domestic Substances List (DSL)	Yes
Canada	Non-Domestic Substances List (NDSL)	No
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s)
A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

FIFRA registration number	3876-149
TSCA	This is an EPA registered biocide and is exempt from TSCA inventory requirements.
Food and drug administration	21 CFR 176.300 (slimicides for wet end use)

US state regulations

US. California Proposition 65

WARNING: This product can expose you to chemicals including Ethanol, which is known to the State of California to cause cancer and birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov.

US - California Proposition 65 - CRT: Listed date/Carcinogenic substance

Ethanol (CAS 64-17-5)	Listed: April 29, 2011 Listed: July 1, 1988

US - California Proposition 65 - CRT: Listed date/Developmental toxin

Ethanol (CAS 64-17-5)	Listed: October 1, 1987
Methanol (CAS 67-56-1)	Listed: March 16, 2012

US - California Proposition 65 - CRT: Listed date/Female reproductive toxin

No ingredient listed.

US - California Proposition 65 - CRT: Listed date/Male reproductive toxin

No ingredient listed.

16. Other information, including date of preparation or last revision

Issue date	Dec-18-2014
Revision date	May-17-2019
Version #	2.0
NFPA ratings	Health: 3 Flammability: 3 Instability: 0

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NFPA ratings



List of abbreviations

CAS: Chemical Abstract Service Registration Number
TWA: Time Weighted Average
STEL: Short Term Exposure Limit
LD50: Lethal Dose, 50%
LC50: Lethal Concentration, 50%
NOEL: No Observed Effect Level
COD: Chemical Oxygen Demand
BOD: Biochemical Oxygen Demand
TOC: Total Organic Carbon
IATA: International Air Transport Association
IMDG: International Maritime Dangerous Goods Code
ACGIH: American Conference of Governmental Industrial Hygienists
DOT: Department of Transportation (49 CFR 172.101).
GHS: Globally Harmonized System of Classification and Labeling of Chemicals.
IARC: International Agency for Research on Cancer.
HMIRA: Hazardous Materials Information Review Act (Canada).
HPR: Hazardous Products Regulations (Canada).
OSHA: Occupational Safety & Health Administration.
TDG: Transportation of Dangerous Goods Regulations, Canada
TSRN indicates a Trade Secret Registry Number is used in place of the CAS number.
WHMIS: Workplace Hazardous Materials Information System.

References: No data available

Disclaimer The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

Revision information This document has undergone significant changes and should be reviewed in its entirety.

Prepared by This SDS has been prepared by SUEZ Regulatory Department (1-215-355-3300).

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SAFETY DATA SHEET
DEPOSITROL* PY5200

1. Identification

Product identifier **DEPOSITROL PY5200**

Other means of identification None.

Recommended use Deposit control agent

Recommended restrictions Industrial use only.

Company/undertaking identification

SUEZ WTS USA, Inc.
4636 Somerton Road
Trevose, PA 19053
T 215 355 3300, F 215 953 5524

Emergency telephone

(800) 877 1940

2. Hazard(s) identification

Physical hazards Not classified.

Health hazards Not classified.

OSHA defined hazards Not classified.

Label elements

Hazard symbol None.

Signal word None.

Hazard statement The mixture does not meet the criteria for classification. The material is not hazardous under the criteria of the Federal OSHA Hazard Communication Standard's (29CFR 1910.1200) implementation of the Globally Harmonized System (GHS), i.e., material is not a dangerous substance or mixture requiring GHS classification.

Precautionary statement

Prevention Observe good industrial hygiene practices.

Response Wash hands after handling.

Storage Store away from incompatible materials.

Disposal Dispose of waste and residues in accordance with local authority requirements.

Hazard(s) not otherwise classified (HNOC) None known.

Supplemental information None.

3. Composition/information on ingredients

Mixtures

The manufacturer lists no ingredients as hazardous to health according to OSHA 29 CFR 1910.1200.

Composition comments Information for specific product ingredients as required by the U.S. OSHA HAZARD COMMUNICATION STANDARD is listed. Refer to additional sections of this SDS for our assessment of the potential hazards of this formulation.

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4. First-aid measures

Inhalation	Move to fresh air. Call a physician if symptoms develop or persist.
Skin contact	Rinse skin with water/shower. Get medical attention if irritation develops and persists.
Eye contact	Rinse with water. Get medical attention if irritation develops and persists.
Ingestion	Rinse mouth. Get medical attention if symptoms occur.
Most important symptoms/effects, acute and delayed	Direct contact with eyes may cause temporary irritation.
Indication of immediate medical attention and special treatment needed	Treat symptomatically.
General information	Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

5. Fire-fighting measures

Suitable extinguishing media	Water fog. Foam. Dry chemical powder. Carbon dioxide (CO2).
Unsuitable extinguishing media	Do not use water jet as an extinguisher, as this will spread the fire.
Specific hazards arising from the chemical	During fire, gases hazardous to health may be formed.
Special protective equipment and precautions for firefighters	Wear full protective clothing, including helmet, self-contained positive pressure or pressure demand breathing apparatus, protective clothing and face mask.
Fire fighting equipment/instructions	In case of fire and/or explosion do not breathe fumes. Use standard firefighting procedures and consider the hazards of other involved materials. Move containers from fire area if you can do so without risk. Cool containers / tanks with water spray.
Specific methods	Use standard firefighting procedures and consider the hazards of other involved materials.
General fire hazards	No unusual fire or explosion hazards noted.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures	Keep unnecessary personnel away. Wear appropriate protective equipment and clothing during clean-up. See Section 8 of the SDS for Personal Protective Equipment. For personal protection, see section 8 of the SDS.
Methods and materials for containment and cleaning up	Large Spills: Dike the spilled material, where this is possible. Absorb in vermiculite, dry sand or earth and place into containers. Following product recovery, flush area with water. Small Spills: Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination. Never return spills to original containers for re-use. For waste disposal, see section 13 of the SDS.
Environmental precautions	Avoid discharge into drains, water courses or onto the ground.

7. Handling and storage

Precautions for safe handling	Observe good industrial hygiene practices. See Section 8 of the SDS for Personal Protective Equipment.
Conditions for safe storage, including any incompatibilities	Do not freeze. If frozen, thaw completely and mix thoroughly prior to use. Store in tightly closed container. Store away from incompatible materials (see Section 10 of the SDS).

8. Exposure controls/personal protection

Biological limit values	No biological exposure limits noted for the ingredient(s).
Appropriate engineering controls	Provide adequate ventilation.

Individual protection measures, such as personal protective equipment

Eye/face protection	Wear safety glasses with side shields (or goggles).
Skin protection	
Hand protection	Wear appropriate chemical resistant gloves. The choice of an appropriate glove does not only depend on its material but also on other quality features and is different from one producer to the other. Glove selection must take into account any solvents and other hazards present.
Other	Wear suitable protective clothing.

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Respiratory protection	In case of insufficient ventilation, wear suitable respiratory equipment. A respiratory protection program that meets OSHA's 29 CFR 1910.34 and ANSI Z88.2 requirements must be followed whenever workplace conditions warrant a respirator's use.
Thermal hazards	Wear appropriate thermal protective clothing, when necessary.
General hygiene considerations	Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

9. Physical and chemical properties

Appearance	Liquid
Physical state	Liquid.
Form	Liquid.
Color	Yellow
Odor	Slight
Odor threshold	Not available.
pH (concentrated product)	5.2
Melting point/freezing point	25 °F (-4 °C)
Initial boiling point and boiling range	220 °F (104 °C)
Flash point	> 212 °F (> 100 °C) P-M(CC)
Evaporation rate	< 1 (Ether = 1)
Flammability (solid, gas)	Not applicable.
Upper/lower flammability or explosive limits	
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	18 mm Hg
Vapor pressure temp.	70 °F (21 °C)
Vapor density	< 1 (Air = 1)
Relative density	1.17
Relative density temperature	70 °F (21 °C)
Solubility(ies)	
Solubility (water)	100 %
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	20 cps
Viscosity temperature	70 °F (21 °C)
Other information	
Explosive properties	Not explosive.
Oxidizing properties	Not oxidizing.
pH in aqueous solution	6 (5% SOL.)
Pour point	30 °F (-1 °C)
VOC	0 % (Calculated)

10. Stability and reactivity

Reactivity	The product is stable and non-reactive under normal conditions of use, storage and transport.
Chemical stability	Material is stable under normal conditions.
Possibility of hazardous reactions	Hazardous polymerization does not occur.
Conditions to avoid	Contact with incompatible materials.
Incompatible materials	Strong oxidizing agents.
Hazardous decomposition products	Oxides of carbon and sulphur evolved in fire.

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11. Toxicological information

Information on likely routes of exposure

Inhalation	Prolonged inhalation may be harmful.
Skin contact	Prolonged or repeated contact may cause irritation.
Eye contact	Direct contact with eyes may cause temporary irritation.
Ingestion	Expected to be a low ingestion hazard.
Symptoms related to the physical, chemical and toxicological characteristics	Direct contact with eyes may cause temporary irritation.

Information on toxicological effects

Acute toxicity Not known.

Product	Species	Test Results
DEPOSITROL PY5200		
Acute		
Dermal		
LD50	Rabbit	> 5000 mg/kg (Calculated according to GHS additivity formula)
Inhalation		
LC50	Rat	> 20 mg/L, 4 Hour (Calculated according to GHS additivity formula)
Oral		
LD50	Rat	> 5000 mg/kg (Calculated according to GHS additivity formula)

Skin corrosion/irritation	Prolonged skin contact may cause temporary irritation.
Serious eye damage/eye irritation	Direct contact with eyes may cause temporary irritation.
Respiratory or skin sensitization	
Respiratory sensitization	This product is not expected to cause respiratory sensitization.
Skin sensitization	This product is not expected to cause skin sensitization.
Germ cell mutagenicity	Not classified.
Carcinogenicity	Not classified.

IARC Monographs. Overall Evaluation of Carcinogenicity

Not listed.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1053)

Not listed.

US. National Toxicology Program (NTP) Report on Carcinogens

Not listed.

Reproductive toxicity	Not classified.
Specific target organ toxicity - single exposure	Not classified.
Specific target organ toxicity - repeated exposure	Not classified.
Aspiration hazard	Not classified.

12. Ecological information

Ecotoxicity

Product		Species	Test Results
Aquatic			
Crustacea	0% Mortality	Mysid Shrimp	8000 mg/L, 48 hour (pH adjusted)
	10% Mortality	Mysid Shrimp	16000 mg/L, 48 hour (pH adjusted)
	IC25	Ceriodaphnia	538 mg/L, 7 day
	LC50	Ceriodaphnia	1265 mg/L, 48 hour

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Product		Species	Test Results
		Daphnia magna	1767 mg/L, 48 hour (pH adjusted)
	NOEL	Daphnia magna	1250 mg/L, 48 hour (pH adjusted)
Fish	0% Mortality	Sheepshead Minnow	16000 mg/L, 96 hour (pH adjusted)
	IC25	Fathead Minnow	2000 mg/L, 7 day
	LC50	Fathead Minnow	> 2000 mg/L, 7 day
			1960 mg/L, 96 hour (pH adjusted)
	NOEL	Fathead Minnow	313 mg/L, 96 hour (pH adjusted)

Persistence and degradability

- COD (mgO2/g)	368 (calculated data)
- BOD 5 (mgO2/g)	10 (calculated data)
- BOD 28 (mgO2/g)	32 (calculated data)
- Closed Bottle Test (% Degradation in 28 days)	21 (calculated data)
- Zahn-Wellens Test (% Degradation in 28 days)	54 (calculated data)
- TOC (mg C/g)	144 (calculated data)
Bioaccumulative potential	
Mobility in soil	No data available.
Other adverse effects	Nutrients: P : 0 mg/g, N : < 0,01 mg/g

13. Disposal considerations

Disposal instructions	Collect and reclaim or dispose in sealed containers at licensed waste disposal site.
Local disposal regulations	Dispose in accordance with all applicable regulations.
Hazardous waste code	The waste code should be assigned in discussion between the user, the producer and the waste disposal company.
Waste from residues / unused products	Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions). Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner.
Contaminated packaging	Since emptied containers may retain product residue, follow label warnings even after container is emptied. Empty containers should be taken to an approved waste handling site for recycling or disposal.

14. Transport information

DOT

Not regulated as dangerous goods.

Some containers may be exempt from Dangerous Goods/Hazmat Transport Regulations, please check BOL for exact container classification.

IATA

Not regulated as dangerous goods.

IMDG

Not regulated as dangerous goods.

15. Regulatory information

US federal regulations This product is not known to be a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

Toxic Substances Control Act (TSCA) All components of the mixture on the TSCA 8(b) inventory are designated “active”.

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

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CERCLA Hazardous Substance List (40 CFR 302.4)

Not listed.

SARA 304 Emergency release notification

Not regulated.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1053)

Not listed.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

SARA 302 Extremely hazardous substance

Not listed.

SARA 311/312 Hazardous chemical No

SARA 313 (TRI reporting)

Not regulated.

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

Acrylic acid (CAS 79-10-7)

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Allyl alcohol (CAS 107-18-6)

Safe Drinking Water Act (SDWA) Contains component(s) regulated under the Safe Drinking Water Act.

Inventory status

Country(s) or region	Inventory name	On inventory (yes/no)*
Canada	Domestic Substances List (DSL)	Yes
Canada	Non-Domestic Substances List (NDSL)	No
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s)
A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

NSF Registered and/or meets USDA (according to 1998 guidelines): Registration No. – 141020
Category Code(s):
G5 Cooling and retort water treatment products
G7 Boiler, steam line treatment products – nonfood contact

US state regulations

California Proposition 65

California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): This material is not known to contain any chemicals currently listed as carcinogens or reproductive toxins. For more information go to www.P65Warnings.ca.gov.

US - California Proposition 65 - CRT: Listed date/Carcinogenic substance

No ingredient listed.

US - California Proposition 65 - CRT: Listed date/Developmental toxin

No ingredient listed.

US - California Proposition 65 - CRT: Listed date/Female reproductive toxin

No ingredient listed.

US - California Proposition 65 - CRT: Listed date/Male reproductive toxin

No ingredient listed.

16. Other information, including date of preparation or last revision

Issue date Oct-23-2014

Revision date Aug-04-2022

Version # 5.0

NFPA ratings Health: 0
Flammability: 0
Instability: 0

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NFPA ratings



List of abbreviations

DOT: Department of Transportation (49 CFR 172.101).
GHS: Globally Harmonized System of Classification and Labeling of Chemicals.
IARC: International Agency for Research on Cancer.
OSHA: Occupational Safety & Health Administration.
WHMIS: Workplace Hazardous Materials Information System.
CAS: Chemical Abstract Service Registration Number
TWA: Time Weighted Average
STEL: Short Term Exposure Limit
LD50: Lethal Dose, 50%
LC50: Lethal Concentration, 50%
EC50: Effect Concentration, 50%
NOEL: No Observed Effect Level
COD: Chemical Oxygen Demand
BOD: Biochemical Oxygen Demand
TOC: Total Organic Carbon
CEN: European Committee for Standardisation
IATA: International Air Transport Association
IMDG: International Maritime Dangerous Goods Code
NFPA: National Fire Protection Association
ACGIH: American Conference of Governmental Industrial Hygienists
TSRN indicates a Trade Secret Registry Number is used in place of the CAS number.

References: No data available

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Revision information This document has undergone significant changes and should be reviewed in its entirety.

Prepared by This SDS has been prepared by SUEZ Regulatory Department (1-215-355-3300).

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BRENNTAG

SAFETY DATA SHEET

1. Identification

Other means of identification None known.

Product identifier **SODIUM HYPOCHLORITE 12.5% NSF/ANSI 60**

Recommended use ALL PROPER AND LEGAL PURPOSES

Recommended restrictions None known.

Manufacturer/Importer/Supplier/Distributor information

Manufacturer

Company name Brenntag Mid-South, Inc.

Address 1405 Highway 136, West
Henderson, KY 42420

Telephone 270-830-1222

E-mail Not available.

Emergency phone number 800-424-9300 CHEMTREC

2. Hazard(s) identification

Physical hazards Not classified.

Health hazards Skin corrosion/irritation Category 1B

Serious eye damage/eye irritation Category 1

Environmental hazards Not classified.

OSHA defined hazards Not classified.

Label elements



Signal word Danger

Hazard statement Causes severe skin burns and eye damage. Causes serious eye damage.

Precautionary statement

Prevention Do not breathe mist/vapors. Wash thoroughly after handling. Wear protective gloves/protective clothing/eye protection/face protection.

Response If swallowed: Rinse mouth. Do NOT induce vomiting. If on skin (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower. If inhaled: Remove person to fresh air and keep comfortable for breathing. If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a poison center/doctor. Take off contaminated clothing and wash it before reuse.

Storage Store locked up.

Disposal Dispose of contents/container in accordance with local/regional/national/international regulations.

Hazard(s) not otherwise classified (HNOC) None known.

Supplemental information 12.5% of the mixture consists of component(s) of unknown acute dermal toxicity. 99.3% of the mixture consists of component(s) of unknown acute inhalation toxicity.

3. Composition/information on ingredients

Mixtures

Chemical name	Common name and synonyms	CAS number	%
HYPOCHLOROUS ACID, SODIUM SALT (1:1)		7681-52-9	12.5
SODIUM HYDROXIDE (NA(OH))		1310-73-2	0.7
Other components below reportable levels			86.8

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4. First-aid measures

Inhalation	Move to fresh air. Call a physician if symptoms develop or persist.
Skin contact	Take off immediately all contaminated clothing. Rinse skin with water/shower. Call a physician or poison control center immediately. Chemical burns must be treated by a physician. Wash contaminated clothing before reuse.
Eye contact	Immediately flush eyes with plenty of water for at least 15 minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Call a physician or poison control center immediately.
Ingestion	Call a physician or poison control center immediately. Rinse mouth. Do not induce vomiting. If vomiting occurs, keep head low so that stomach content doesn't get into the lungs.
Most important symptoms/effects, acute and delayed	Burning pain and severe corrosive skin damage. Causes serious eye damage. Symptoms may include stinging, tearing, redness, swelling, and blurred vision. Permanent eye damage including blindness could result.
Indication of immediate medical attention and special treatment needed	Provide general supportive measures and treat symptomatically. Chemical burns: Flush with water immediately. While flushing, remove clothes which do not adhere to affected area. Call an ambulance. Continue flushing during transport to hospital. Keep victim under observation. Symptoms may be delayed.
General information	Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

5. Fire-fighting measures

Suitable extinguishing media	Foam. Powder. Carbon dioxide (CO2).
Unsuitable extinguishing media	Do not use water jet as an extinguisher, as this will spread the fire.
Specific hazards arising from the chemical	During fire, gases hazardous to health may be formed.
Special protective equipment and precautions for firefighters	Self-contained breathing apparatus and full protective clothing must be worn in case of fire.
Fire fighting equipment/instructions	Move containers from fire area if you can do so without risk.
Specific methods	Use standard firefighting procedures and consider the hazards of other involved materials.
General fire hazards	No unusual fire or explosion hazards noted.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures	Keep unnecessary personnel away. Keep people away from and upwind of spill/leak. Wear appropriate protective equipment and clothing during clean-up. Do not breathe mist/vapors. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Ensure adequate ventilation. Local authorities should be advised if significant spillages cannot be contained. For personal protection, see section 8 of the SDS.
Methods and materials for containment and cleaning up	Use water spray to reduce vapors or divert vapor cloud drift. Prevent entry into waterways, sewer, basements or confined areas. Large Spills: Stop the flow of material, if this is without risk. Dike the spilled material, where this is possible. Absorb in vermiculite, dry sand or earth and place into containers. Following product recovery, flush area with water. Small Spills: Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination. Never return spills to original containers for re-use. For waste disposal, see section 13 of the SDS.
Environmental precautions	Avoid discharge into drains, water courses or onto the ground.

7. Handling and storage

Precautions for safe handling	Do not breathe mist/vapors. Do not get in eyes, on skin, or on clothing. Avoid prolonged exposure. Provide adequate ventilation. Wear appropriate personal protective equipment. Observe good industrial hygiene practices.
Conditions for safe storage, including any incompatibilities	Store locked up. Store in tightly closed container. Store away from incompatible materials (see Section 10 of the SDS).

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8. Exposure controls/personal protection

Occupational exposure limits

US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000)

Components	Type	Value
SODIUM HYDROXIDE (NA(OH)) (CAS 1310-73-2)	PEL	2 mg/m3

US. ACGIH Threshold Limit Values

Components	Type	Value
SODIUM HYDROXIDE (NA(OH)) (CAS 1310-73-2)	Ceiling	2 mg/m3

US. NIOSH: Pocket Guide to Chemical Hazards

Components	Type	Value
SODIUM HYDROXIDE (NA(OH)) (CAS 1310-73-2)	Ceiling	2 mg/m3

US. Workplace Environmental Exposure Level (WEEL) Guides

Components	Type	Value
HYPOCHLOROUS ACID, SODIUM SALT (1:1) (CAS 7681-52-9)	STEL	2 mg/m3

Biological limit values No biological exposure limits noted for the ingredient(s).

Appropriate engineering controls Good general ventilation should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level. Eye wash facilities and emergency shower must be available when handling this product.

Individual protection measures, such as personal protective equipment

The following are recommendations for Personnel Protective Equipment (PPE). The employer/user of this product must perform a Hazard Assessment of the workplace according to OSHA regulations 29 CFR 1910.132 to determine the appropriate PPE for use while performing any task involving potential exposure to this product.

Eye/face protection Wear safety glasses with side shields (or goggles) and a face shield.

Skin protection

Hand protection Wear appropriate chemical resistant gloves.

Other Wear appropriate chemical resistant clothing.

Respiratory protection In case of insufficient ventilation, wear suitable respiratory equipment.

Thermal hazards Wear appropriate thermal protective clothing, when necessary.

General hygiene considerations Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

9. Physical and chemical properties

Appearance

Physical state Liquid.

Form Liquid.

Color CLEAR PALE YELLOW

Odor CHLORINE

Odor threshold Not available.

pH Not available.

Melting point/freezing point -3 °F (-19.44 °C)

Initial boiling point and boiling range 230.55 °F (110.3 °C) estimated

Flash point Not available.

Evaporation rate Not available.

Flammability (solid, gas) Not applicable.

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Upper/lower flammability or explosive limits

Flammability limit - lower (%)	Not available.
Flammability limit - upper (%)	Not available.
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	Not available.
Vapor density	Not available.
Relative density	Not available.
Solubility(ies)	
Solubility (water)	Not available.
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	Not available.
Other information	
Density	10.06 lbs/gal 1.21 g/ml
Explosive properties	Not explosive.
Oxidizing properties	Not oxidizing.
Percent volatile	86.8 % estimated
Specific gravity	1.21

10. Stability and reactivity

Reactivity	The product is stable and non-reactive under normal conditions of use, storage and transport.
Chemical stability	Material is stable under normal conditions.
Possibility of hazardous reactions	Hazardous polymerization does not occur.
Conditions to avoid	Contact with incompatible materials.
Incompatible materials	Strong oxidizing agents.
Hazardous decomposition products	No hazardous decomposition products are known.

11. Toxicological information

Information on likely routes of exposure

Inhalation	May cause irritation to the respiratory system. Prolonged inhalation may be harmful.
Skin contact	Causes severe skin burns.
Eye contact	Causes serious eye damage.
Ingestion	Causes digestive tract burns.
Symptoms related to the physical, chemical and toxicological characteristics	Burning pain and severe corrosive skin damage. Causes serious eye damage. Symptoms may include stinging, tearing, redness, swelling, and blurred vision. Permanent eye damage including blindness could result.

Information on toxicological effects

Acute toxicity Not known.

Components	Species	Test Results
HYPOCHLOROUS ACID, SODIUM SALT (1:1) (CAS 7681-52-9)		
Acute		
Oral		
LD50	Rat	8.91 g/kg

Skin corrosion/irritation Causes severe skin burns and eye damage.

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Serious eye damage/eye irritation Causes serious eye damage.

Respiratory or skin sensitization

Respiratory sensitization Due to partial or complete lack of data the classification is not possible.

Skin sensitization Due to partial or complete lack of data the classification is not possible.

Germ cell mutagenicity Due to partial or complete lack of data the classification is not possible.

Carcinogenicity Due to partial or complete lack of data the classification is not possible.

IARC Monographs. Overall Evaluation of Carcinogenicity

Not listed.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1053)

Not listed.

US. National Toxicology Program (NTP) Report on Carcinogens

Not listed.

Reproductive toxicity Due to partial or complete lack of data the classification is not possible.

Specific target organ toxicity - single exposure Due to partial or complete lack of data the classification is not possible.

Specific target organ toxicity - repeated exposure Due to partial or complete lack of data the classification is not possible.

Aspiration hazard Due to partial or complete lack of data the classification is not possible.

Chronic effects Prolonged inhalation may be harmful.

12. Ecological information

Ecotoxicity The product is not classified as environmentally hazardous. However, this does not exclude the possibility that large or frequent spills can have a harmful or damaging effect on the environment.

Components		Species	Test Results
HYPOCHLOROUS ACID, SODIUM SALT (1:1) (CAS 7681-52-9)			
Aquatic			
Crustacea	EC50	Water flea (Ceriodaphnia dubia)	0.11 - 0.13 mg/l, 24 hours
	LC50	Calanoid copepod (Acartia tonsa)	0.313 - 0.497 mg/l, 24 hours
		Coon stripe shrimp (Pandalus danae)	0.246 - 0.333 mg/l, 96 hours
		Daggerblade grass shrimp (Palaemonetes pugio)	46 - 58.8 mg/l, 96 hours
		Opossum shrimp (Americamysis bahia)	0.229 - 0.321 mg/l, 96 hours
		Rotifer (Brachionus calyciflorus)	0.35 - 0.39 mg/l, 24 hours
		Scud (Hyalella azteca)	0.252 - 0.362 mg/l, 96 hours
		Water flea (Ceriodaphnia dubia)	0.14 mg/l, 24 hours
		Water flea (Daphnia magna)	0.045 - 0.068 mg/l, 48 hours
Fish	LC50	Bleak (Alburnus alburnus)	30 - 35 mg/l, 96 hours
		Brown trout (Salmo trutta)	0.02 - 0.05 mg/l, 1.5 hours
		California grunion (Leuresthes tenuis)	0.139 mg/l, 24 hours
		Carp (Cyprinus carpio)	1.75 - 1.89 mg/l, 160 minutes
		Channel catfish (Ictalurus punctatus)	0.45 mg/l, 96 hours
		Chinook salmon (Oncorhynchus tshawytscha)	0.038 - 0.065 mg/l, 96 hours
		Coho salmon,silver salmon (Oncorhynchus kisutch)	0.245 - 0.328 mg/l, 15 minutes
		Fathead minnow (Pimephales promelas)	4.4 - 7.1 mg/l, 24 hours
		Freshwater drum (Aplodinotus grunniens)	1.67 - 1.83 mg/l, 160 minutes
		Rainbow trout,donaldson trout (Oncorhynchus mykiss)	0.05 - 0.071 mg/l, 96 hours
		Shiner perch (Cymatogaster aggregata)	0.045 - 0.098 mg/l, 96 hours

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Components		Species	Test Results
		Yellow perch (Perca flavescens)	18 - 28.7 mg/l, 15 minutes
		Yellowtail flounder (Pleuronectes ferrugineus)	0.1 mg/l, 24 hours
SODIUM HYDROXIDE (NA(OH)) (CAS 1310-73-2)			
Aquatic			
Crustacea	EC50	Water flea (Ceriodaphnia dubia)	34.59 - 47.13 mg/l, 48 hours
Fish	LC50	Western mosquitofish (Gambusia affinis)	125 mg/l, 96 hours

Persistence and degradability No data is available on the degradability of any ingredients in the mixture.

Bioaccumulative potential No data available.

Mobility in soil No data available.

Other adverse effects No other adverse environmental effects (e.g. ozone depletion, photochemical ozone creation potential, endocrine disruption, global warming potential) are expected from this component.

13. Disposal considerations

Disposal instructions Collect and reclaim or dispose in sealed containers at licensed waste disposal site. Incinerate the material under controlled conditions in an approved incinerator. Dispose of contents/container in accordance with local/regional/national/international regulations.

Local disposal regulations Dispose in accordance with all applicable regulations.

Hazardous waste code D002: Waste Corrosive material [pH <=2 or =>12.5, or corrosive to steel]
The waste code should be assigned in discussion between the user, the producer and the waste disposal company.

Waste from residues / unused products Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions).

Contaminated packaging Since emptied containers may retain product residue, follow label warnings even after container is emptied. Empty containers should be taken to an approved waste handling site for recycling or disposal.

14. Transport information

DOT

UN number UN1791
UN proper shipping name HYPOCHLORITE SOLUTIONS
Transport hazard class(es)
Class 8
Subsidiary risk -
Packing group III
Special precautions for user Read safety instructions, SDS and emergency procedures before handling.
Transportation information on packaging may be different from that listed.

IMDG

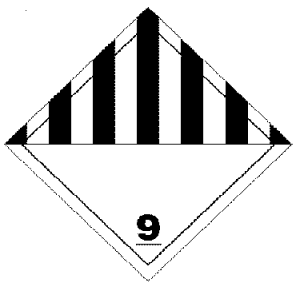
UN number UN3082
UN proper shipping name ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S., MARINE POLLUTANT
Transport hazard class(es)
Class 9
Subsidiary risk -
Packing group III
Environmental hazards
Marine pollutant Yes
EmS F-A, S-F
Special precautions for user Read safety instructions, SDS and emergency procedures before handling.

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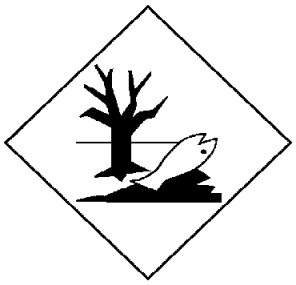
DOT



IMDG



Marine pollutant



General information IMDG Regulated Marine Pollutant.

15. Regulatory information

US federal regulations This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

Toxic Substances Control Act (TSCA)

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

CERCLA Hazardous Substance List (40 CFR 302.4)

HYPOCHLOROUS ACID, SODIUM SALT (1:1) (CAS 7681-52-9)	Listed.
SODIUM HYDROXIDE (NA(OH)) (CAS 1310-73-2)	Listed.

SARA 304 Emergency release notification

Not regulated.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1053)

Not listed.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

SARA 302 Extremely hazardous substance

Not listed.

SARA 311/312 Hazardous chemical Yes

Classified hazard categories Skin corrosion or irritation
Serious eye damage or eye irritation

SARA 313 (TRI reporting)

Not regulated.

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Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

Not regulated.

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Not regulated.

Safe Drinking Water Act (SDWA) Not regulated.

US state regulations

California Proposition 65

California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): This material is not known to contain any chemicals currently listed as carcinogens or reproductive toxins. For more information go to www.P65Warnings.ca.gov.

US. California. Candidate Chemicals List. Safer Consumer Products Regulations (Cal. Code Regs, tit. 22, 69502.3, subd. (a))

SODIUM HYDROXIDE (NA(OH)) (CAS 1310-73-2)

International Inventories

Country(s) or region	Inventory name	On inventory (yes/no)*
Australia	Australian Inventory of Chemical Substances (AICS)	Yes
Canada	Domestic Substances List (DSL)	Yes
Canada	Non-Domestic Substances List (NDSL)	No
China	Inventory of Existing Chemical Substances in China (IECSC)	Yes
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	Yes
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	Yes
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	Yes
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	Yes
Taiwan	Taiwan Chemical Substance Inventory (TCSI)	Yes
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s)
A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

16. Other information, including date of preparation or last revision

Issue date 10-11-2021

Revision date 05-21-2022

Version # 02

HMIS® ratings
Health: 3
Flammability: 0
Physical hazard: 0

NFPA ratings
Health: 3
Flammability: 0
Instability: 0

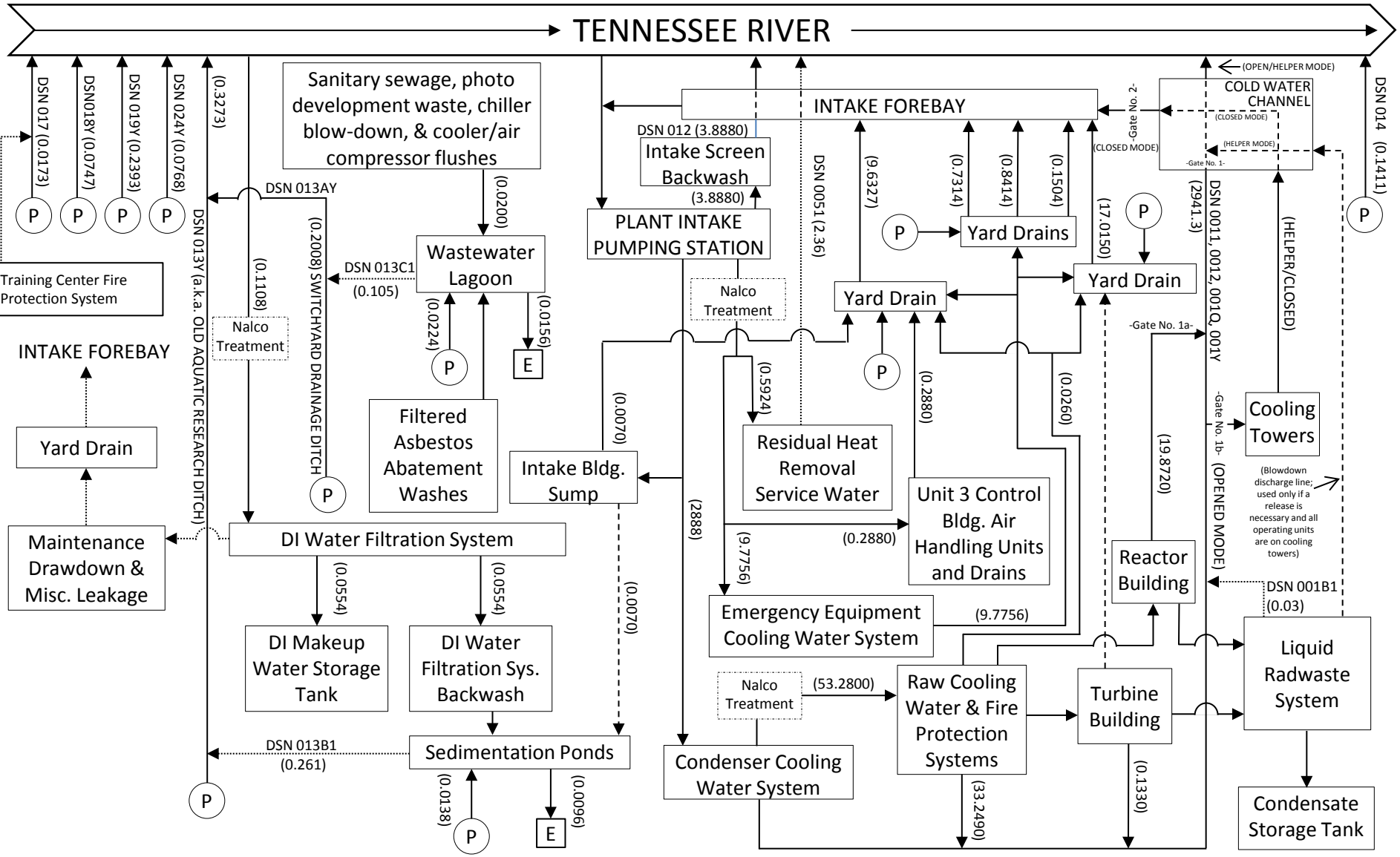
Disclaimer
While Brenntag believes the information contained herein to be accurate, Brenntag makes no representation or warranty, express or implied, regarding, and assumes no liability for, the accuracy or completeness of the information. The Buyer assumes all responsibility for handling, using and/or reselling the Product in accordance with applicable federal, state, and local law. This SDS shall not in any way limit or preclude the operation and effect of any of the provisions of Brenntag's terms and conditions of sale.

Revision information
Hazard(s) identification: Hazard statement
Hazard(s) identification: Response
Hazard(s) identification: Supplemental information
Exposure controls/personal protection: Respiratory protection
Exposure controls/personal protection: PPE Symbols
Physical and chemical properties: Color
Physical and chemical properties: Odor
Stability and reactivity: Incompatible materials

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BROWNS FERRY NUCLEAR PLANT – DISCHARGE FLOW SCHEMATIC

NPDES PERMIT AL0022080
Schematic Revised January 2018



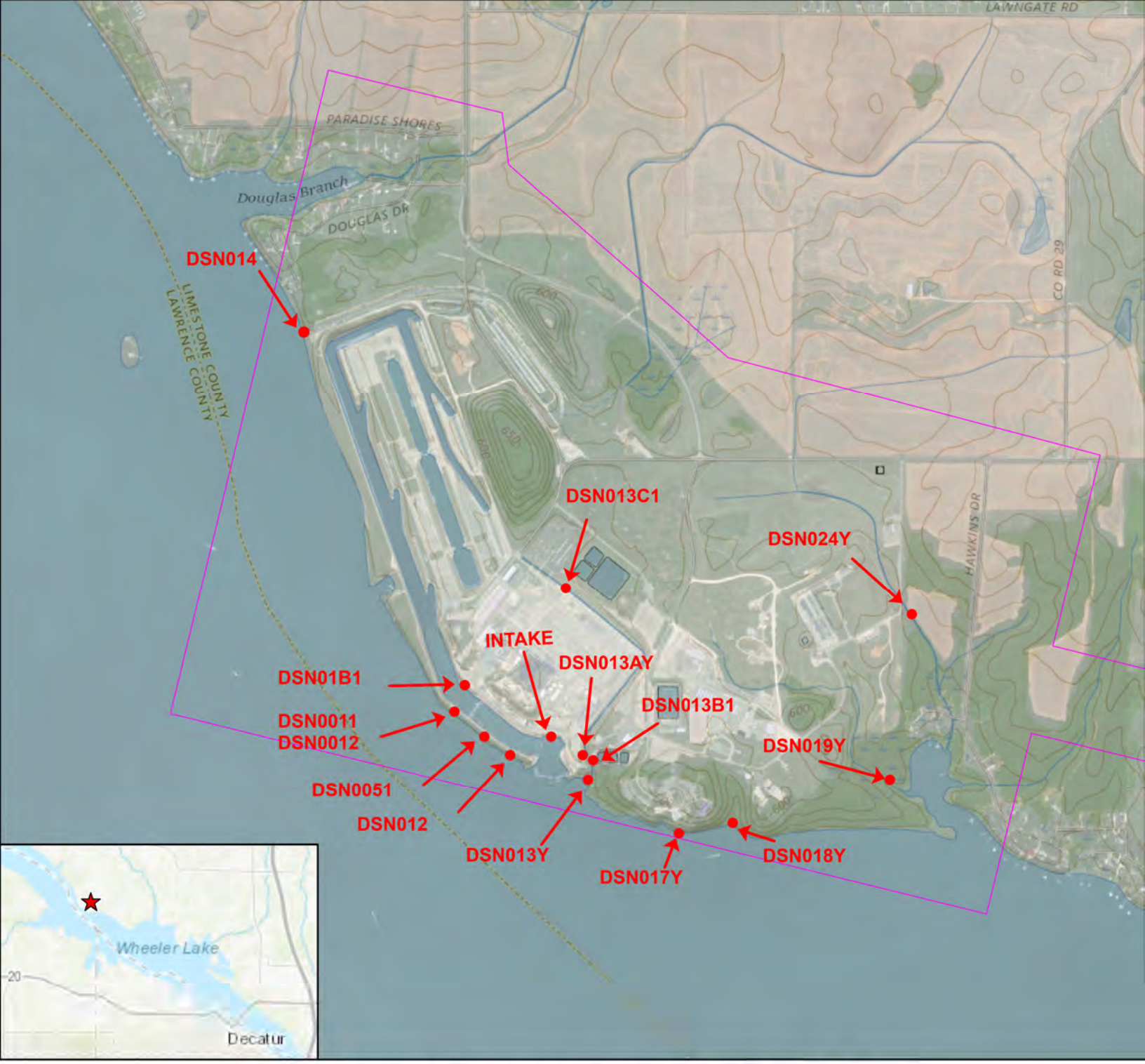
DSN 0XX — Permitted Outfall
Primary Pathway
Alternate Pathway
Intermittent Flow

P — Precipitation
E — Evaporation

EECW
+Standby diesel engine coolers
+Core spray pump room coolers
+RHR pump room coolers
+Electric board on ACU condensers
+RHR pump seal coolers
+Shutdown board on ACU condensers
+Shutdown board on Chillers
+Control Bay chillers
+H2O2 analyzers
+Backup for several RCW components

RCW/FP
+Turbine lube oil coolers
+Gen. stator water & hydrogen coolers
+Reactor feed pump turbine oil coolers
+Svs. & control air compressors
+Steam jet air ejector precoolers
+Gen. alternator coolers
+Air conditioning condensers
+Recirc. Pump M-G sel coolers
+RBCCW heat exchangers
+Gen. breakers to main 500kV
+Misc. coolers

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TVA BROWNS FERRY NUCLEAR PLANT
NPDES PERMIT NO. AL0022080

Athens, Limestone Co., Alabama

34° 42’ 30” N 87° 07’ 30” W

Boundary

Magnetic North (Degrees): 3.65°W

Scale: 1:23,627

0 1,250 2,500 5,000 Feet

0 0.25 0.5 1 Miles

August 2022

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EPA Identification Number	NPDES Permit Number	Facility Name	Form Approved 03/05/19 OMB No. 2040-0004
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	

Form 1 NPDES

U.S. Environmental Protection Agency
Application for NPDES Permit to Discharge Wastewater

GENERAL INFORMATION

SECTION 1. ACTIVITIES REQUIRING AN NPDES PERMIT (40 CFR 122.21(f) and (f)(1))

Activities Requiring an NPDES Permit

1.1 Applicants *Not Required* to Submit Form 1

1.1.1	Is the facility a new or existing **publicly owned treatment works**? If yes, STOP. Do NOT complete Form 1. Complete Form 2A. ☑ No	1.1.2	Is the facility a new or existing **treatment works treating domestic sewage**? If yes, STOP. Do NOT complete Form 1. Complete Form 2S. ☑ No

1.2 Applicants *Required* to Submit Form 1

1.2.1	Is the facility a **concentrated animal feeding operation** or a **concentrated aquatic animal production facility**? ☐ Yes ➔ Complete Form 1 *and* Form 2B. ☑ No	1.2.2	Is the facility an **existing** manufacturing, commercial, mining, or silvicultural **facility** that **is currently discharging process wastewater**? ☐ Yes ➔ Complete Form 1 *and* Form 2C. ☑ No
1.2.3	Is the facility a **new** manufacturing, commercial, mining, or silvicultural **facility** that has **not yet commenced to discharge**? ☐ Yes ➔ Complete Form 1 *and* Form 2D. ☑ No	1.2.4	Is the facility a **new or existing** manufacturing, commercial, mining, or silvicultural **facility** that **discharges only nonprocess wastewater**? ☐ Yes ➔ Complete Form 1 *and* Form 2E. ☑ No
1.2.5	Is the facility a **new or existing facility** whose discharge is composed entirely of **stormwater associated with industrial activity** or whose discharge is composed of **both stormwater and non-stormwater**? ☑ Yes ➔ Complete Form 1 *and* Form 2F unless exempted by 40 CFR 122.26(b)(14)(x) or (b)(15). ☐ No		

SECTION 2. NAME, MAILING ADDRESS, AND LOCATION (40 CFR 122.21(f)(2))

Name, Mailing Address, and Location

2.1 Facility Name

TVA Browns Ferry Nuclear Plant

2.2 EPA Identification Number

AL8640015410

2.3 Facility Contact

Name (first and last)	Title	Phone number
Manu Sivaraman	Site Vice President	(802) 451-6196

Email address
msivaraman@tva.gov

2.4 Facility Mailing Address

Street or P.O. box
P.O. Box 2000 NAB 2A

City or town	State	ZIP code
Decatur	AL	35609

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EPA Identification Number	NPDES Permit Number	Facility Name	Form Approved 03/05/19 OMB No. 2040-0004
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	

Name, Mailing Address, and Location Continued

2.5 Facility Location

Street, route number, or other specific identifier: Nuclear Plant RD

County name	County code (if known)	
Limestone		

City or town	State	ZIP code
Athens	AL	35609

SECTION 3. SIC AND NAICS CODES (40 CFR 122.21(f)(3))

SIC and NAICS Codes

3.1

SIC Code(s)	Description (optional)
4911	Electric Services

3.2

NAICS Code(s)	Description (optional)
221113	Nuclear Electric Power Generation

SECTION 4. OPERATOR INFORMATION (40 CFR 122.21(f)(4))

Operator Information

4.1 Name of Operator

Tennessee Valley Authority

4.2 Is the name you listed in Item 4.1 also the owner?

☑ Yes ☐ No

4.3 Operator Status

☑ Public—federal ☐ Public—state ☐ Other public (specify)_____

☐ Private ☐ Other (specify) _____

4.4 Phone Number of Operator

(256) 729-3675

Operator Information Continued

4.5 Operator Address

Street or P.O. Box: Nuclear Plant RD

City or town	State	ZIP code
Athens	AL	35611

Email address of operator: msivaraman@tva.gov

SECTION 5. INDIAN LAND (40 CFR 122.21(f)(5))

Indian Land

5.1 Is the facility located on Indian Land?

☐ Yes ☑ No

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SECTION 6. EXISTING ENVIRONMENTAL PERMITS (40 CFR 122.21(f)(6))

Existing Environmental Permits

6.1 Existing Environmental Permits (check all that apply and print or type the corresponding permit number for each)

☑ NPDES (discharges to surface water) AL0022080	☑ RCRA (hazardous wastes) AL8640015410	☐ UIC (underground injection of fluids)
☑ PSD (air emissions) 708-0003-Z003	☐ Nonattainment program (CAA)	☐ NESHAPs (CAA)
☐ Ocean dumping (MPRSA)	☐ Dredge or fill (CWA Section 404)	☑ Other (specify) Inert Landfill 42-02

SECTION 7. MAP (40 CFR 122.21(f)(7))

Map

7.1 Have you attached a topographic map containing all required information to this application? (See instructions for specific requirements.)

☑ Yes ☐ No ☐ CAFO—Not Applicable (See requirements in Form 2B.)

SECTION 8. NATURE OF BUSINESS (40 CFR 122.21(f)(8))

Nature of Business

8.1 Describe the nature of your business.

Browns Ferry Nuclear Plant (BFN) operates three boiling water reactors for the purpose of generating electric power. The combined generating capacity is approximately 3,440 megawatts.

SECTION 9. COOLING WATER INTAKE STRUCTURES (40 CFR 122.21(f)(9))

Cooling Water Intake Structures

9.1 Does your facility use cooling water?

☑ Yes ☐ No ➔ SKIP to Item 10.1.

9.2 Identify the source of cooling water. (Note that facilities that use a cooling water intake structure as described at 40 CFR 125, Subparts I and J may have additional application requirements at 40 CFR 122.21(r). Consult with your NPDES permitting authority to determine what specific information needs to be submitted and when.)

Wheeler Reservoir (Tennessee River) intake.

SECTION 10. VARIANCE REQUESTS (40 CFR 122.21(f)(10))

Variance Requests

10.1 Do you intend to request or renew one or more of the variances authorized at 40 CFR 122.21(m)? (Check all that apply. Consult with your NPDES permitting authority to determine what information needs to be submitted and when.)

- ☐ Fundamentally different factors (CWA Section 301(n))
- ☐ Non-conventional pollutants (CWA Section 301(c) and (g))
- ☐ Not applicable
- ☐ Water quality related effluent limitations (CWA Section 302(b)(2))
- ☑ Thermal discharges (CWA Section 316(a))

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EPA Identification Number	NPDES Permit Number	Facility Name	Form Approved 03/05/19 OMB No. 2040-0004
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	

SECTION 11. CHECKLIST AND CERTIFICATION STATEMENT (40 CFR 122.22(a) and (d))

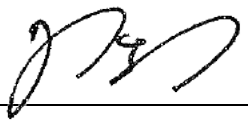
Checklist and Certification Statement

11.1 In Column 1 below, mark the sections of Form 1 that you have completed and are submitting with your application. For each section, specify in Column 2 any attachments that you are enclosing to alert the permitting authority. Note that not all applicants are required to provide attachments.

Column 1	Column 2
☑ Section 1: Activities Requiring an NPDES Permit	☐ w/ attachments
☑ Section 2: Name, Mailing Address, and Location	☐ w/ attachments
☑ Section 3: SIC Codes	☐ w/ attachments
☑ Section 4: Operator Information	☐ w/ attachments
☑ Section 5: Indian Land	☐ w/ attachments
☑ Section 6: Existing Environmental Permits	☑ w/ attachments
☑ Section 7: Map	☑ w/ topographic map ☐ w/ additional attachments
☑ Section 8: Nature of Business	☐ w/ attachments
☑ Section 9: Cooling Water Intake Structures	☐ w/ attachments
☑ Section 10: Variance Requests	☐ w/ attachments
☑ Section 11: Checklist and Certification Statement	☐ w/ attachments

11.2 Certification Statement

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name (print or type first and last name)	Official title
Manu Sivaraman	Site Vice President
Signature 	Date signed 12/19/2022

Click to go back to the beginning of Form

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ENVIRONMENTAL PERMITS - NPDES PERMIT RENEWAL APPLICATION
TVA BROWNS FERRY NUCLEAR PLANT - NPDES PERMIT NO. AL0022080

Permit Name	Permit Number	Held by
NPDES Permit	AL0024635	Bellefonte Nuclear Plant
RCRA ID	AL5640090002 (ID#)	Bellefonte Nuclear Plant
Synthetic Minor Operating Permit	705-0021-X004	Bellefonte Nuclear Plant
NPDES Permit	AL0022080	Browns Ferry Nuclear Plant
RCRA ID	AL8640015410 (ID#)	Browns Ferry Nuclear Plant
PSD Permit	708-0003-Z003	Browns Ferry Nuclear Plant
Synthetic Minor Operating Permit	708-0003-X005	Browns Ferry Nuclear Plant
Inert Landfill Permit	42-02	Browns Ferry Nuclear Plant
Title V Air Permit	701-0010	Colbert Fossil Plant
NPDES Permit	AL0003867	Colbert Fossil Plant
Construction Storm Water	ALR10C0X4	Colbert Fossil Plant
Construction Storm Water	ALR10C1R8	Colbert Fossil Plant
Construction Storm Water	ALR10C1VX	Colbert Fossil
RCRA ID	AL7640006675 (ID#)	Colbert Fossil Plant
NPDES Permit	AL0003891	Environmental Research Center
General NPDES Permit	ALG360011	Guntersville Hydro Plant
RCRA ID	ALD982083461 (ID#)	M. S. Heavy Equipment Department
General NPDES Permit	ALG140643	M. S. Power Service Center
RCRA (Operating Permit)	AL2640090005	M. S. Power Service Center
General NPDES Permit	ALG360009	Wheeler Hydro Plant
NPDES Permit	AL0003875	Widows Creek Fossil Plant
RCRA ID	AL8640006690 (ID#)	Widows Creek Fossil Plant
Solid Waste Disposal Permit	36-07	Widows Creek Fossil Plant
General NPDES Permit	ALG360012	Wilson Hydro Plant
General NPDES Permit	ALR100000	Various TVA Transmission Line & Substation Construction Projects

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EPA Identification Number	NPDES Permit Number	Facility Name	Form Approved 03/05/19 OMB No. 2040-0004
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	

Form 2C NPDES

U.S. Environmental Protection Agency
Application for NPDES Permit to Discharge Wastewater

EXISTING MANUFACTURING, COMMERCIAL, MINING, AND SILVICULTURE OPERATIONS

SECTION 1. OUTFALL LOCATION (40 CFR 122.21(g)(1))

Outfall Location

1.1 Provide information on each of the facility's outfalls in the table below.

Outfall Number	Receiving Water Name	Latitude	Longitude
	See Attachment	° ' "	° ' "
		° ' "	° ' "
		° ' "	° ' "

SECTION 2. LINE DRAWING (40 CFR 122.21(g)(2))

Line Drawing

2.1 Have you attached a line drawing to this application that shows the water flow through your facility with a water balance? (See instructions for drawing requirements. See Exhibit 2C–1 at end of instructions for example.)

☑ Yes ☐ No

SECTION 3. AVERAGE FLOWS AND TREATMENT (40 CFR 122.21(g)(3))

Average Flows and Treatment

3.1 For each outfall identified under Item 1.1, provide average flow and treatment information. Add additional sheets if necessary.

Outfall Number 0011/0012

Operations Contributing to Flow

Operation	Average Flow
Diffuser Discharge: (1) Treated Raw Cooling Water (RCW)	2941.3 mgd
(2) Turbine building station sumps	mgd
(3)Reactor Building cooling water (4)Liquid Radwaste System	mgd
(5) Condenser cooling water system	mgd

Treatment Units

Description (include size, flow rate through each treatment unit, retention time, etc.)	Code from Table 2C-1	Final Disposal of Solid or Liquid Wastes Other Than by Discharge
Mixing	1-O	
Discharge to surface water	4-A	
Coagulation	2-D	
Flocculation	1-G	

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Average Flows and Treatment Continued

3.1 cont.

Outfall Number 0051

Operations Contributing to Flow

Operation	Average Flow
Residual Heat Removal Service Water (RHRSW) System	2.36 mgd
	mgd
	mgd
	mgd

Treatment Units

Description (include size, flow rate through each treatment unit, retention time, etc.)	Code from Table 2C-1	Final Disposal of Solid or Liquid Wastes Other Than by Discharge
Discharge to surface water	4-A	

Outfall Number 013B1

Operations Contributing to Flow

Operation	Average Flow
Sedimentation Pond discharges which include:	0.261 mgd
(1)Water Filtration System Backwash	mgd
(2)Intake Building sump; diesel generator sump	mgd
(3)rainwater minus evaporation	mgd

Treatment Units

Description (include size, flow rate through each treatment unit, retention time, etc.)	Code from Table 2C-1	Final Disposal of Solid or Liquid Wastes Other Than by Discharge
Coagulation	2-D	
Flocculation	1-G	
Sedimentation	1-U	
Discharge to surface water	4-A	

System Users

3.2 Are you applying for an NPDES permit to operate a privately owned treatment works?

☐ Yes ☑ No ➔ SKIP to Section 4.

3.3 Have you attached a list that identifies each user of the treatment works?

☐ Yes ☐ No

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SECTION 4. INTERMITTENT FLOWS (40 CFR 122.21(g)(4))

Intermittent Flows

4.1 Except for storm runoff, leaks, or spills, are any discharges described in Sections 1 and 3 intermittent or seasonal?

☑ Yes ☐ No ➔ SKIP to Section 5.

4.2 Provide information on intermittent or seasonal flows for each applicable outfall. Attach additional pages, if necessary.

Outfall Number	Operation (list)	Frequency		Flow Rate		Duration
		Average Days/Week	Average Months/Year	Long-Term Average	Maximum Daily	
0051	Residual Heat Removal	3 days/week	12 months/year	2.36 mgd	22.03 mgd	47 days
		days/week	months/year	mgd	mgd	days
		days/week	months/year	mgd	mgd	days
013B1	Sedimentation Ponds	5 days/week	12 months/year	0.26 mgd	0.768 mgd	217 days
		days/week	months/year	mgd	mgd	days
		days/week	months/year	mgd	mgd	days
013C1	Wastewater Lagoons	4 days/week	10 months/year	0.105 mgd	0.278 mgd	32 days
		days/week	months/year	mgd	mgd	days
		days/week	months/year	mgd	mgd	days

SECTION 5. PRODUCTION (40 CFR 122.21(g)(5))

Applicable ELGs

5.1 Do any effluent limitation guidelines (ELGs) promulgated by EPA under Section 304 of the CWA apply to your facility?

☑ Yes ☐ No ➔ SKIP to Section 6.

5.2 Provide the following information on applicable ELGs.

ELG Category	ELG Subcategory	Regulatory Citation
Steam Electric Power Generating I		40CFR 4023

Production-Based Limitations

5.3 Are any of the applicable ELGs expressed in terms of production (or other measure of operation)?

☐ Yes ☑ No ➔ SKIP to Section 6.

5.4 Provide an actual measure of daily production expressed in terms and units of applicable ELGs.

Outfall Number	Operation, Product, or Material	Quantity per Day	Unit of Measure

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SECTION 6. IMPROVEMENTS (40 CFR 122.21(g)(6))

Upgrades and Improvements

6.1 Are you presently required by any federal, state, or local authority to meet an implementation schedule for constructing, upgrading, or operating wastewater treatment equipment or practices or any other environmental programs that could affect the discharges described in this application?

☐ Yes ☑ No ➔ SKIP to Item 6.3.

6.2 Briefly identify each applicable project in the table below.

Brief Identification and Description of Project	Affected Outfalls (list outfall number)	Source(s) of Discharge	Final Compliance Dates	
			Required	Projected

6.3 Have you attached sheets describing any additional water pollution control programs (or other environmental projects that may affect your discharges) that you now have underway or planned? *(optional item)*

☐ Yes ☐ No ☑ Not applicable

SECTION 7. EFFLUENT AND INTAKE CHARACTERISTICS (40 CFR 122.21(g)(7))

Effluent and Intake Characteristics

See the instructions to determine the pollutants and parameters you are required to monitor and, in turn, the tables you must complete. Not all applicants need to complete each table.

Table A. Conventional and Non-Conventional Pollutants

7.1 Are you requesting a waiver from your NPDES permitting authority for one or more of the Table A pollutants for any of your outfalls?

☐ Yes ☑ No ➔ SKIP to Item 7.3.

7.2 If yes, indicate the applicable outfalls below. Attach waiver request and other required information to the application.

Outfall Number _____ Outfall Number _____ Outfall Number _____

7.3 Have you completed monitoring for all Table A pollutants at each of your outfalls for which a waiver has not been requested and attached the results to this application package?

☑ Yes ☐ No; a waiver has been requested from my NPDES permitting authority for all pollutants at all outfalls.

Table B. Toxic Metals, Cyanide, Total Phenols, and Organic Toxic Pollutants

7.4 Do any of the facility's processes that contribute wastewater fall into one or more of the primary industry categories listed in Exhibit 2C-3? (See end of instructions for exhibit.)

☑ Yes ☐ No ➔ SKIP to Item 7.8.

7.5 Have you checked "Testing Required" for all toxic metals, cyanide, and total phenols in Section 1 of Table B?

☑ Yes ☐ No

7.6 List the applicable primary industry categories and check the boxes indicating the required GC/MS fraction(s) identified in Exhibit 2C-3.

Primary Industry Category	Required GC/MS Fraction(s) (Check applicable boxes.)			
Steam Electric Power Plant	☐ Volatile	☑ Acid	☐ Base/Neutral	☐ Pesticide
	☐ Volatile	☐ Acid	☐ Base/Neutral	☐ Pesticide
	☐ Volatile	☐ Acid	☐ Base/Neutral	☐ Pesticide

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Effluent and Intake Characteristics Continued

7.7	Have you checked "Testing Required" for all required pollutants in Sections 2 through 5 of Table B for each of the GC/MS fractions checked in Item 7.6? ☑ Yes ☐ No
7.8	Have you checked "Believed Present" or "Believed Absent" for all pollutants listed in Sections 1 through 5 of Table B where testing is not required? ☑ Yes ☐ No
7.9	Have you provided (1) quantitative data for those Section 1, Table B, pollutants for which you have indicated testing is required or (2) quantitative data or other required information for those Section 1, Table B, pollutants that you have indicated are "Believed Present" in your discharge? ☑ Yes ☐ No
7.10	Does the applicant qualify for a small business exemption under the criteria specified in the instructions? ☐ Yes ➔ Note that you qualify at the top of Table B, then SKIP to Item 7.12. ☑ No
7.11	Have you provided (1) quantitative data for those Sections 2 through 5, Table B, pollutants for which you have determined testing is required or (2) quantitative data or an explanation for those Sections 2 through 5, Table B, pollutants you have indicated are "Believed Present" in your discharge? ☑ Yes ☐ No
	Table C. Certain Conventional and Non-Conventional Pollutants
7.12	Have you indicated whether pollutants are "Believed Present" or "Believed Absent" for all pollutants listed on Table C for all outfalls? ☑ Yes ☐ No
7.13	Have you completed Table C by providing (1) quantitative data for those pollutants that are limited either directly or indirectly in an ELG and/or (2) quantitative data or an explanation for those pollutants for which you have indicated "Believed Present"? ☑ Yes ☐ No
	Table D. Certain Hazardous Substances and Asbestos
7.14	Have you indicated whether pollutants are "Believed Present" or "Believed Absent" for all pollutants listed in Table D for all outfalls? ☑ Yes ☐ No
7.15	Have you completed Table D by (1) describing the reasons the applicable pollutants are expected to be discharged and (2) by providing quantitative data, if available? ☑ Yes ☐ No
	Table E. 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (2,3,7,8-TCDD)
7.16	Does the facility use or manufacture one or more of the 2,3,7,8-TCDD congeners listed in the instructions, or do you know or have reason to believe that TCDD is or may be present in the effluent? ☐ Yes ➔ Complete Table E. ☑ No ➔ SKIP to Section 8.
7.17	Have you completed Table E by reporting *qualitative* data for TCDD? ☐ Yes ☐ No

SECTION 8. USED OR MANUFACTURED TOXICS (40 CFR 122.21(g)(9))

Used or Manufactured Toxics

8.1	Is any pollutant listed in Table B a substance or a component of a substance used or manufactured at your facility as an intermediate or final product or byproduct? ☐ Yes ☑ No ➔ SKIP to Section 9.
8.2	List the pollutants below.

1.	4.	7.
2.	5.	8.
3.	6.	9.

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SECTION 9. BIOLOGICAL TOXICITY TESTS (40 CFR 122.21(g)(11))

Biological Toxicity Tests

9.1 Do you have any knowledge or reason to believe that any biological test for acute or chronic toxicity has been made within the last three years on (1) any of your discharges or (2) on a receiving water in relation to your discharge?

☑ Yes ☐ No ➔ SKIP to Section 10.

9.2 Identify the tests and their purposes below.

Test(s)	Purpose of Test(s)	Submitted to NPDES Permitting Authority?	Date Submitted
Annual Biotoxicity Submitted with DMR	Acute Whole Effluent Toxicity	☑ Yes ☐ No	01/27/2022
		☐ Yes ☐ No	
		☐ Yes ☐ No	

SECTION 10. CONTRACT ANALYSES (40 CFR 122.21(g)(12))

Contract Analyses

10.1 Were any of the analyses reported in Section 7 performed by a contract laboratory or consulting firm?

☐ Yes ☐ No ➔ SKIP to Section 11.

10.2 Provide information for each contract laboratory or consulting firm below.

	Laboratory Number 1	Laboratory Number 2	Laboratory Number 3
Name of laboratory/firm	GEL Laboratories, LLC		
Laboratory address	2040 Savage Road Charleston, SC 29407		
Phone number	(846) 556-8171		
Pollutant(s) analyzed	All pollutants except field parameters.		

SECTION 11. ADDITIONAL INFORMATION (40 CFR 122.21(g)(13))

Additional Information

11.1 Has the NPDES permitting authority requested additional information?

☐ Yes ☑ No ➔ SKIP to Section 12.

11.2 List the information requested and attach it to this application.

1.	4.
2.	5.
3.	6.

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SECTION 12. CHECKLIST AND CERTIFICATION STATEMENT (40 CFR 122.22(a) and (d))

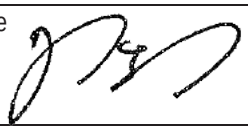
Checklist and Certification Statement

12.1 In Column 1 below, mark the sections of Form 2C that you have completed and are submitting with your application. For each section, specify in Column 2 any attachments that you are enclosing to alert the permitting authority. Note that not all applicants are required to complete all sections or provide attachments.

Column 1	Column 2
☑ Section 1: Outfall Location	☑ w/ attachments
☑ Section 2: Line Drawing	☑ w/ line drawing ☐ w/ additional attachments
☑ Section 3: Average Flows and Treatment	☑ w/ attachments ☐ w/ list of each user of privately owned treatment works
☑ Section 4: Intermittent Flows	☐ w/ attachments
☑ Section 5: Production	☐ w/ attachments
☑ Section 6: Improvements	☐ w/ attachments ☐ w/ optional additional sheets describing any additional pollution control plans
☑ Section 7: Effluent and Intake Characteristics	☐ w/ request for a waiver and supporting information ☐ w/ explanation for identical outfalls ☐ w/ small business exemption request ☐ w/ other attachments ☑ w/ Table A ☑ w/ Table B ☑ w/ Table C ☑ w/ Table D ☑ w/ Table E ☐ w/ analytical results as an attachment
☑ Section 8: Used or Manufactured Toxics	☐ w/ attachments
☑ Section 9: Biological Toxicity Tests	☐ w/ attachments
☑ Section 10: Contract Analyses	☐ w/ attachments
☑ Section 11: Additional Information	☐ w/ attachments
☑ Section 12: Checklist and Certification Statement	☐ w/ attachments

12.2 Certification Statement

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name (print or type first and last name)	Official title
Manu Sivaraman	Site VP, Browns Ferry Nuclear
Signature 	Date signed 12-19-2022

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410		TVA Browns Ferry Nuclear Plant	0011

Form Approved 03/05/19
OMB No. 2040-0004

TABLE A. CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(iii))[1]

	Pollutant	Waiver Requested (if applicable)	Units (specify)		Effluent				Intake (Optional)	
					Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you have applied to your NPDES permitting authority for a waiver for *all* of the pollutants listed on this table for the noted outfall.									
1.	Biochemical oxygen demand (BOD_5)	☐	Concentration	mg/L	<1.00			1	1.12	1
			Mass							
2.	Chemical oxygen demand (COD)	☐	Concentration	mg/L	26.0			1	22.3	1
			Mass							
3.	Total organic carbon (TOC)	☐	Concentration	mg/L	2.45			1	1.76	1
			Mass							
4.	Total suspended solids (TSS)	☐	Concentration	mg/L	7.60			1	6.90	1
			Mass							
5.	Ammonia (as N)	☐	Concentration	mg/L	0.0734			1	0.0864	1
			Mass							
6.	Flow	☐	Rate							
7.	Temperature (winter)	☐	°C	°C						
	Temperature (summer)	☐	°C	°C						
8.	pH (minimum)	☐	Standard units	s.u.						
	pH (maximum)	☐	Standard units	s.u.						

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410		TVA Browns Ferry Nuclear Plant	0011

Form Approved 03/05/19
OMB No. 2040-0004

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you qualify as a small business per the instructions to Form 2C and, therefore, do not need to submit quantitative data for any of the organic toxic pollutants in Sections 2 through 5 of this table. Note, however, that you must still indicate in the appropriate column of this table if you believe any of the pollutants listed are present in your discharge.											
Section 1. Toxic Metals, Cyanide, and Total Phenols												
1.1	Antimony, total (7440-36-0)	☑	☐	☐	Concentration	ug/L	<1.00			1	<1.00	1
					Mass							
1.2	Arsenic, total (7440-38-2)	☑	☐	☐	Concentration	ug/L	<2.00			1	<2.00	1
					Mass							
1.3	Beryllium, total (7440-41-7)	☑	☐	☐	Concentration	ug/L	<0.200			1	<0.200	1
					Mass							
1.4	Cadmium, total (7440-43-9)	☑	☐	☐	Concentration	ug/L	<0.300			1	<0.300	1
					Mass							
1.5	Chromium, total (7440-47-3)	☑	☐	☐	Concentration	ug/L	<3.00			1	<3.00	1
					Mass							
1.6	Copper, total (7440-50-8)	☑	☐	☐	Concentration	ug/L	1.54					
					Mass							
1.7	Lead, total (7439-92-1)	☑	☐	☐	Concentration	ug/L						
					Mass							
1.8	Mercury, total (7439-97-6)	☑	☐	☐	Concentration	ug/L						
					Mass							
1.9	Nickel, total (7440-02-0)	☑	☐	☐	Concentration	ug/L						
					Mass							
1.10	Selenium, total (7782-49-2)	☑	☐	☐	Concentration	ug/L						
					Mass							
1.11	Silver, total (7440-22-4)	☑	☐	☐	Concentration	ug/L						
					Mass							

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410		TVA Browns Ferry Nuclear Plant	0011

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TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
1.12	Thallium, total (7440-28-0)	☐	☐	☐	Concentration							
					Mass							
1.13	Zinc, total (7440-66-6)	☐	☐	☐	Concentration							
					Mass							
1.14	Cyanide, total (57-12-5)	☐	☐	☐	Concentration							
					Mass							
1.15	Phenols, total	☐	☐	☐	Concentration							
					Mass							
Section 2. Organic Toxic Pollutants (GC/MS Fraction—Volatile Compounds)												
2.1	Acrolein (107-02-8)	☐	☐	☐	Concentration							
					Mass							
2.2	Acrylonitrile (107-13-1)	☐	☐	☐	Concentration							
					Mass							
2.3	Benzene (71-43-2)	☐	☐	☐	Concentration							
					Mass							
2.4	Bromoform (75-25-2)	☐	☐	☐	Concentration							
					Mass							
2.5	Carbon tetrachloride (56-23-5)	☐	☐	☐	Concentration							
					Mass							
2.6	Chlorobenzene (108-90-7)	☐	☐	☐	Concentration							
					Mass							
2.7	Chlorodibromomethane (124-48-1)	☐	☐	☐	Concentration							
					Mass							
2.8	Chloroethane (75-00-3)	☐	☐	☐	Concentration							
					Mass							

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
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TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
2.9	2-chloroethylvinyl ether (110-75-8)	☐	☐	☐	Concentration							
					Mass							
2.10	Chloroform (67-66-3)	☐	☐	☐	Concentration							
					Mass							
2.11	Dichlorobromomethane (75-27-4)	☐	☐	☐	Concentration							
					Mass							
2.12	1,1-dichloroethane (75-34-3)	☐	☐	☐	Concentration							
					Mass							
2.13	1,2-dichloroethane (107-06-2)	☐	☐	☐	Concentration							
					Mass							
2.14	1,1-dichloroethylene (75-35-4)	☐	☐	☐	Concentration							
					Mass							
2.15	1,2-dichloropropane (78-87-5)	☐	☐	☐	Concentration							
					Mass							
2.16	1,3-dichloropropylene (542-75-6)	☐	☐	☐	Concentration							
					Mass							
2.17	Ethylbenzene (100-41-4)	☐	☐	☐	Concentration							
					Mass							
2.18	Methyl bromide (74-83-9)	☐	☐	☐	Concentration							
					Mass							
2.19	Methyl chloride (74-87-3)	☐	☐	☐	Concentration							
					Mass							
2.20	Methylene chloride (75-09-2)	☐	☐	☐	Concentration							
					Mass							
2.21	1,1,2,2- tetrachloroethane (79-34-5)	☐	☐	☐	Concentration							
					Mass							

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
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TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
2.22	Tetrachloroethylene (127-18-4)	☐	☐	☐	Concentration							
					Mass							
2.23	Toluene (108-88-3)	☐	☐	☐	Concentration							
					Mass							
2.24	1,2-trans-dichloroethylene (156-60-5)	☐	☐	☐	Concentration							
					Mass							
2.25	1,1,1-trichloroethane (71-55-6)	☐	☐	☐	Concentration							
					Mass							
2.26	1,1,2-trichloroethane (79-00-5)	☐	☐	☐	Concentration							
					Mass							
2.27	Trichloroethylene (79-01-6)	☐	☐	☐	Concentration							
					Mass							
2.28	Vinyl chloride (75-01-4)	☐	☐	☐	Concentration							
					Mass							
Section 3. Organic Toxic Pollutants (GC/MS Fraction—Acid Compounds)												
3.1	2-chlorophenol (95-57-8)	☐	☐	☐	Concentration							
					Mass							
3.2	2,4-dichlorophenol (120-83-2)	☐	☐	☐	Concentration							
					Mass							
3.3	2,4-dimethylphenol (105-67-9)	☐	☐	☐	Concentration							
					Mass							
3.4	4,6-dinitro-o-cresol (534-52-1)	☐	☐	☐	Concentration							
					Mass							
3.5	2,4-dinitrophenol (51-28-5)	☐	☐	☐	Concentration							
					Mass							

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410		TVA Browns Ferry Nuclear Plant	0011

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TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
3.6	2-nitrophenol (88-75-5)	☐	☐	☐	Concentration							
					Mass							
3.7	4-nitrophenol (100-02-7)	☐	☐	☐	Concentration							
					Mass							
3.8	p-chloro-m-cresol (59-50-7)	☐	☐	☐	Concentration							
					Mass							
3.9	Pentachlorophenol (87-86-5)	☐	☐	☐	Concentration							
					Mass							
3.10	Phenol (108-95-2)	☐	☐	☐	Concentration							
					Mass							
3.11	2,4,6-trichlorophenol (88-05-2)	☐	☐	☐	Concentration							
					Mass							
Section 4. Organic Toxic Pollutants (GC/MS Fraction—Base /Neutral Compounds)												
4.1	Acenaphthene (83-32-9)	☐	☐	☐	Concentration							
					Mass							
4.2	Acenaphthylene (208-96-8)	☐	☐	☐	Concentration							
					Mass							
4.3	Anthracene (120-12-7)	☐	☐	☐	Concentration							
					Mass							
4.4	Benzidine (92-87-5)	☐	☐	☐	Concentration							
					Mass							
4.5	Benzo (a) anthracene (56-55-3)	☐	☐	☐	Concentration							
					Mass							
4.6	Benzo (a) pyrene (50-32-8)	☐	☐	☐	Concentration							
					Mass							

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410		TVA Browns Ferry Nuclear Plant	0011

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TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.7	3,4-benzofluoranthene (205-99-2)	☐	☐	☐	Concentration							
					Mass							
4.8	Benzo (ghi) perylene (191-24-2)	☐	☐	☐	Concentration							
					Mass							
4.9	Benzo (k) fluoranthene (207-08-9)	☐	☐	☐	Concentration							
					Mass							
4.10	Bis (2-chloroethoxy) methane (111-91-1)	☐	☐	☐	Concentration							
					Mass							
4.11	Bis (2-chloroethyl) ether (111-44-4)	☐	☐	☐	Concentration							
					Mass							
4.12	Bis (2-chloroisopropyl) ether (102-80-1)	☐	☐	☐	Concentration							
					Mass							
4.13	Bis (2-ethylhexyl) phthalate (117-81-7)	☐	☐	☐	Concentration							
					Mass							
4.14	4-bromophenyl phenyl ether (101-55-3)	☐	☐	☐	Concentration							
					Mass							
4.15	Butyl benzyl phthalate (85-68-7)	☐	☐	☐	Concentration							
					Mass							
4.16	2-chloronaphthalene (91-58-7)	☐	☐	☐	Concentration							
					Mass							
4.17	4-chlorophenyl phenyl ether (7005-72-3)	☐	☐	☐	Concentration							
					Mass							
4.18	Chrysene (218-01-9)	☐	☐	☐	Concentration							
					Mass							
4.19	Dibenzo (a,h) anthracene (53-70-3)	☐	☐	☐	Concentration							
					Mass							

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
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TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.20	1,2-dichlorobenzene (95-50-1)	☐	☐	☐	Concentration							
					Mass							
4.21	1,3-dichlorobenzene (541-73-1)	☐	☐	☐	Concentration							
					Mass							
4.22	1,4-dichlorobenzene (106-46-7)	☐	☐	☐	Concentration							
					Mass							
4.23	3,3-dichlorobenzidine (91-94-1)	☐	☐	☐	Concentration							
					Mass							
4.24	Diethyl phthalate (84-66-2)	☐	☐	☐	Concentration							
					Mass							
4.25	Dimethyl phthalate (131-11-3)	☐	☐	☐	Concentration							
					Mass							
4.26	Di-n-butyl phthalate (84-74-2)	☐	☐	☐	Concentration							
					Mass							
4.27	2,4-dinitrotoluene (121-14-2)	☐	☐	☐	Concentration							
					Mass							
4.28	2,6-dinitrotoluene (606-20-2)	☐	☐	☐	Concentration							
					Mass							
4.29	Di-n-octyl phthalate (117-84-0)	☐	☐	☐	Concentration							
					Mass							
4.30	1,2-Diphenylhydrazine (as azobenzene) (122-66-7)	☐	☐	☐	Concentration							
					Mass							
4.31	Fluoranthene (206-44-0)	☐	☐	☐	Concentration							
					Mass							
4.32	Fluorene (86-73-7)	☐	☐	☐	Concentration							
					Mass							

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TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.33	Hexachlorobenzene (118-74-1)	☐	☐	☐	Concentration							
					Mass							
4.34	Hexachlorobutadiene (87-68-3)	☐	☐	☐	Concentration							
					Mass							
4.35	Hexachlorocyclopentadiene (77-47-4)	☐	☐	☐	Concentration							
					Mass							
4.36	Hexachloroethane (67-72-1)	☐	☐	☐	Concentration							
					Mass							
4.37	Indeno (1,2,3-cd) pyrene (193-39-5)	☐	☐	☐	Concentration							
					Mass							
4.38	Isophorone (78-59-1)	☐	☐	☐	Concentration							
					Mass							
4.39	Naphthalene (91-20-3)	☐	☐	☐	Concentration							
					Mass							
4.40	Nitrobenzene (98-95-3)	☐	☐	☐	Concentration							
					Mass							
4.41	N-nitrosodimethylamine (62-75-9)	☐	☐	☐	Concentration							
					Mass							
4.42	N-nitrosodi-n-propylamine (621-64-7)	☐	☐	☐	Concentration							
					Mass							
4.43	N-nitrosodiphenylamine (86-30-6)	☐	☐	☐	Concentration							
					Mass							
4.44	Phenanthrene (85-01-8)	☐	☐	☐	Concentration							
					Mass							
4.45	Pyrene (129-00-0)	☐	☐	☐	Concentration							
					Mass							

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TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.46	1,2,4-trichlorobenzene (120-82-1)	☐	☐	☐	Concentration							
					Mass							
Section 5. Organic Toxic Pollutants (GC/MS Fraction—Pesticides)												
5.1	Aldrin (309-00-2)	☐	☐	☐	Concentration							
					Mass							
5.2	α-BHC (319-84-6)	☐	☐	☐	Concentration							
					Mass							
5.3	β-BHC (319-85-7)	☐	☐	☐	Concentration							
					Mass							
5.4	γ-BHC (58-89-9)	☐	☐	☐	Concentration							
					Mass							
5.5	δ-BHC (319-86-8)	☐	☐	☐	Concentration							
					Mass							
5.6	Chlordane (57-74-9)	☐	☐	☐	Concentration							
					Mass							
5.7	4,4'-DDT (50-29-3)	☐	☐	☐	Concentration							
					Mass							
5.8	4,4'-DDE (72-55-9)	☐	☐	☐	Concentration							
					Mass							
5.9	4,4'-DDD (72-54-8)	☐	☐	☐	Concentration							
					Mass							
5.10	Dieldrin (60-57-1)	☐	☐	☐	Concentration							
					Mass							
5.11	α-endosulfan (115-29-7)	☐	☐	☐	Concentration							
					Mass							

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TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
5.12	β-endosulfan (115-29-7)	☐	☐	☐	Concentration							
					Mass							
5.13	Endosulfan sulfate (1031-07-8)	☐	☐	☐	Concentration							
					Mass							
5.14	Endrin (72-20-8)	☐	☐	☐	Concentration							
					Mass							
5.15	Endrin aldehyde (7421-93-4)	☐	☐	☐	Concentration							
					Mass							
5.16	Heptachlor (76-44-8)	☐	☐	☐	Concentration							
					Mass							
5.17	Heptachlor epoxide (1024-57-3)	☐	☐	☐	Concentration							
					Mass							
5.18	PCB-1242 (53469-21-9)	☐	☐	☐	Concentration							
					Mass							
5.19	PCB-1254 (11097-69-1)	☐	☐	☐	Concentration							
					Mass							
5.20	PCB-1221 (11104-28-2)	☐	☐	☐	Concentration							
					Mass							
5.21	PCB-1232 (11141-16-5)	☐	☐	☐	Concentration							
					Mass							
5.22	PCB-1248 (12672-29-6)	☐	☐	☐	Concentration							
					Mass							
5.23	PCB-1260 (11096-82-5)	☐	☐	☐	Concentration							
					Mass							
5.24	PCB-1016 (12674-11-2)	☐	☐	☐	Concentration							
					Mass							

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TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
5.25	Toxaphene (8001-35-2)	☐	☐	☐	Concentration							
					Mass							

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
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TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you believe all pollutants on Table C to be ***present*** in your discharge from the noted outfall. You need *not* complete the "Presence or Absence" column of Table C for *each* pollutant.										
☐	Check here if you believe all pollutants on Table C to be ***absent*** in your discharge from the noted outfall. You need *not* complete the "Presence or Absence" column of Table C for *each* pollutant.										
1.	Bromide (24959-67-9)	☐	☐	Concentration							
				Mass							
2.	Chlorine, total residual	☐	☐	Concentration							
				Mass							
3.	Color	☐	☐	Concentration							
				Mass							
4.	Fecal coliform	☐	☐	Concentration							
				Mass							
5.	Fluoride (16984-48-8)	☐	☐	Concentration							
				Mass							
6	Nitrate-nitrite	☐	☐	Concentration							
				Mass							
7.	Nitrogen, total organic (as N)	☐	☐	Concentration							
				Mass							
8.	Oil and grease	☐	☐	Concentration							
				Mass							
9.	Phosphorus (as P), total (7723-14-0)	☐	☐	Concentration							
				Mass							
10.	Sulfate (as SO_4) (14808-79-8)	☐	☐	Concentration							
				Mass							
11.	Sulfide (as S)	☐	☐	Concentration							
				Mass							

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
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TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
12.	Sulfite (as SO_3) (14265-45-3)	☐	☐	Concentration							
				Mass							
13.	Surfactants	☐	☐	Concentration							
				Mass							
14.	Aluminum, total (7429-90-5)	☐	☐	Concentration							
				Mass							
15.	Barium, total (7440-39-3)	☐	☐	Concentration							
				Mass							
16.	Boron, total (7440-42-8)	☐	☐	Concentration							
				Mass							
17.	Cobalt, total (7440-48-4)	☐	☐	Concentration							
				Mass							
18.	Iron, total (7439-89-6)	☐	☐	Concentration							
				Mass							
19.	Magnesium, total (7439-95-4)	☐	☐	Concentration							
				Mass							
20.	Molybdenum, total (7439-98-7)	☐	☐	Concentration							
				Mass							
21.	Manganese, total (7439-96-5)	☐	☐	Concentration							
				Mass							
22.	Tin, total (7440-31-5)	☐	☐	Concentration							
				Mass							
23.	Titanium, total (7440-32-6)	☐	☐	Concentration							
				Mass							

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
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TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
24.	Radioactivity										
	Alpha, total	☐	☐	Concentration							
				Mass							
	Beta, total	☐	☐	Concentration							
				Mass							
	Radium, total	☐	☐	Concentration							
				Mass							
	Radium 226, total	☐	☐	Concentration							
				Mass							

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
1.	Asbestos	☐	☐		
2.	Acetaldehyde	☐	☐		
3.	Allyl alcohol	☐	☐		
4.	Allyl chloride	☐	☐		
5.	Amyl acetate	☐	☐		
6.	Aniline	☐	☐		
7.	Benzonitrile	☐	☐		
8.	Benzyl chloride	☐	☐		
9.	Butyl acetate	☐	☐		
10.	Butylamine	☐	☐		
11.	Captan	☐	☐		
12.	Carbaryl	☐	☐		
13.	Carbofuran	☐	☐		
14.	Carbon disulfide	☐	☐		
15.	Chlorpyrifos	☐	☐		
16.	Coumaphos	☐	☐		
17.	Cresol	☐	☐		
18.	Crotonaldehyde	☐	☐		
19.	Cyclohexane	☐	☐		

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TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
20.	2,4-D (2,4-dichlorophenoxyacetic acid)	☐	☐		
21.	Diazinon	☐	☐		
22.	Dicamba	☐	☐		
23.	Dichlobenil	☐	☐		
24.	Dichlone	☐	☐		
25.	2,2-dichloropropionic acid	☐	☐		
26.	Dichlorvos	☐	☐		
27.	Diethyl amine	☐	☐		
28.	Dimethyl amine	☐	☐		
29.	Dintrobenzene	☐	☐		
30.	Diquat	☐	☐		
31.	Disulfoton	☐	☐		
32.	Diuron	☐	☐		
33.	Epichlorohydrin	☐	☐		
34.	Ethion	☐	☐		
35.	Ethylene diamine	☐	☐		
36.	Ethylene dibromide	☐	☐		
37.	Formaldehyde	☐	☐		
38.	Furfural	☐	☐		

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TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
39.	Guthion	☐	☐		
40.	Isoprene	☐	☐		
41.	Isopropanolamine	☐	☐		
42.	Kelthane	☐	☐		
43.	Kepone	☐	☐		
44.	Malathion	☐	☐		
45.	Mercaptodimethur	☐	☐		
46.	Methoxychlor	☐	☐		
47.	Methyl mercaptan	☐	☐		
48.	Methyl methacrylate	☐	☐		
49.	Methyl parathion	☐	☐		
50.	Mevinphos	☐	☐		
51.	Mexacarbate	☐	☐		
52.	Monoethyl amine	☐	☐		
53.	Monomethyl amine	☐	☐		
54.	Naled	☐	☐		
55.	Naphthenic acid	☐	☐		
56.	Nitrotoluene	☐	☐		
57.	Parathion	☐	☐		

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TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
58.	Phenolsulfonate	☐	☐		
59.	Phosgene	☐	☐		
60.	Propargite	☐	☐		
61.	Propylene oxide	☐	☐		
62.	Pyrethrins	☐	☐		
63.	Quinoline	☐	☐		
64.	Resorcinol	☐	☐		
65.	Strontium	☐	☐		
66.	Strychnine	☐	☐		
67.	Styrene	☐	☐		
68.	2,4,5-T (2,4,5-trichlorophenoxyacetic acid)	☐	☐		
69.	TDE (tetrachlorodiphenyl ethane)	☐	☐		
70.	2,4,5-TP [2-(2,4,5-trichlorophenoxy) propanoic acid]	☐	☐		
71.	Trichlorofon	☐	☐		
72.	Triethanolamine	☐	☐		
73.	Triethylamine	☐	☐		
74.	Trimethylamine	☐	☐		
75.	Uranium	☐	☐		
76.	Vanadium	☐	☐		

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TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
77.	Vinyl acetate	☐	☐		
78.	Xylene	☐	☐		
79.	Xylenol	☐	☐		
80.	Zirconium	☐	☐		

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE E. 2,3,7,8 TETRACHLORODIBENZO P DIOXIN (2,3,7,8 TCDD) (40 CFR 122.21(g)(7)(viii))

Pollutant	TCDD Congeners Used or Manufactured	Presence or Absence (check one)		Results of Screening Procedure
		Believed Present	Believed Absent	
2,3,7,8-TCDD	☐	☐	☐	

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Average Flows and Treatment Continued

3.1 cont.

Outfall Number 013C1

Operations Contributing to Flow

Operation	Average Flow
Wastewater Lagoon discharge which include sanitary	0.105 mgd
waste; waste from a medical and metals lab, photo	mgd
developers; Standby Liquid Control discharges flushes from	mgd
the cooler air compressor cleaning activities; blowdown fron	mgd

Treatment Units

Description (include size, flow rate through each treatment unit, retention time, etc.)	Code from Table 2C-1	Final Disposal of Solid or Liquid Wastes Other Than by Discharge
Grinding	1-L	
Stabilization Ponds	3-G	
Aerated Lagoons	3-B	
Discharge to surface water	4-A	

Outfall Number _____

Operations Contributing to Flow

Operation	Average Flow
	mgd
	mgd
	mgd
	mgd

Treatment Units

Description (include size, flow rate through each treatment unit, retention time, etc.)	Code from Table 2C-1	Final Disposal of Solid or Liquid Wastes Other Than by Discharge

System Users

3.2 Are you applying for an NPDES permit to operate a privately owned treatment works?

☐ Yes ☑ No ➔ SKIP to Section 4.

3.3 Have you attached a list that identifies each user of the treatment works?

☐ Yes ☐ No

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EPA Form 2C Attachment 1

I. Outfall Location							
For each outfall, list the latitude and longitude of its location to the nearest 15 seconds and the name of the receiving water.							
A. Outfall Number *(list)*	B. Latitude			C. Longitude			D. Receiving Water *(name)*
0011	34	42	15	87	07	15	Tennessee River
0012	34	42	15	87	07	15	Tennessee River
01B1	34	42	15	87	07	15	Tennessee River via DSN001 (internal monitoring point)
0051	34	42	15	87	07	15	Tennessee River
013B1	34	43	00	87	07	00	Tennessee River via DSN013
013C1	34	42	30	87	07	30	Tennessee River via DSN013

ADEM Watermark

Pinson, Theo

From: Phillips, Craig Lee <clphillips@tva.gov>
Sent: Monday, June 23, 2025 11:50 AM
To: Pinson, Theo
Subject: RE: Mercury Units Table Form 2C

Theo,

Outfalls 0011, 013B1, 13C1, 005 and 01B1 lab reports for mercury reported it as ng/L. The unit ug/L would be a typo for these outfalls.

Craig L. Phillips
Specialist, Water Permits, Compliance, & Monitoring
Regulatory Environmental Programs

TVA TENNESSEE VALLEY AUTHORITY

M. 865-599-6183 **E.** clphillips@tva.gov
400 West Summit Hill Drive, Knoxville, TN 37902

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From: Pinson, Theo <tpinson@adem.alabama.gov>
Sent: Monday, June 16, 2025 6:29 PM
To: Phillips, Craig Lee <clphillips@tva.gov>
Subject: Mercury Units Table Form 2C

This is an EXTERNAL EMAIL from outside TVA. THINK BEFORE you CLICK links or OPEN attachments. If suspicious, please click the "Report Phishing" button located on the Outlook Toolbar at the top of your screen.

Craig,

The table for form 2C lists the units for mercury as ug/l for Outfalls 0011, 13B1, and 13C1. The units are listed as ng/l on 0051 and 01B1. Will you check into this and see if they are all listed correctly?

Thank you,

Theo

Theo Pinson
Industrial Section
Water Division
Alabama Department of Environmental Management
(334) 274 – 4202

NEW ADEM ELECTRONIC SYSTEM: Alabama Environmental Permitting and Compliance System (AEPACS)

AEPACS is an electronic system that allows facilities to apply for and maintain permits as well as submit other required applications, registrations, and certifications. In addition, the system allows facilities to submit required compliance reports or other information to the Department. For general information about AEPACS, visit http://adem.alabama.gov/egov/AEPACS.cnt. For NPDES and SID program specific information about AEPACS, visit http://adem.alabama.gov/egov/AEPACSwater.cnt.

If you have questions or need assistance with AEPACS, please contact the ADEM Web Portal/AEPACS Help Desk at ademwebportal@adem.alabama.gov. The email box is monitored Monday through Friday, 7:00 am –5:00 pm.

TABLE A. CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(iii)) [1]

	Pollutant	Waiver Requested (if applicable)	Units (specify)		Effluent				Intake (Optional)	
					Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you have applied to your NPDES permitting authority for a waiver for *all* of the pollutants listed on this table for the noted outfall.									
1.	Biochemical oxygen demand (BOD_5)	☐	Concentration	mg/l	<1.00			1	1.12	1
			Mass							
2.	Chemical oxygen demand (COD)	☐	Concentration	mg/L	237			1	22.3	1
			Mass							
3.	Total organic carbon (TOC)	☐	Concentration	mg/L	<0.330			1	1.76	1
			Mass							
4.	Total suspended solids (TSS)	☐	Concentration	mg/L	<0.57	49.1		28	6.90	1
			Mass							
5.	Ammonia (as N)	☐	Concentration	mg/L	0.0942			1	0.0864	1
			Mass							
6.	Flow	☐	Rate	MGD	0.022	0.2200		28	3044.2	1
7.	Temperature (winter)	☐	°C	°C	23.85			1	11.35	1
	Temperature (summer)	☐	°C	°C						
8.	pH (minimum)	☐	Standard units	s.u.	6.79	7.8		28	7.69	1
	pH (maximum)	☐	Standard units	s.u.	6.79	78		28	7.69	1

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 01B1

Form Approved 03/05/19
OMB No. 2040-0004

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you qualify as a small business per the instructions to Form 2C and, therefore, do not need to submit quantitative data for any of the organic toxic pollutants in Sections 2 through 5 of this table. Note, however, that you must still indicate in the appropriate column of this table if you believe any of the pollutants listed are present in your discharge.											
Section 1. Toxic Metals, Cyanide, and Total Phenols												
1.1	Antimony, total (7440-36-0)	☐	☑	☐	Concentration	ug/L	<1.00			1	<1.00	1
					Mass							
1.2	Arsenic, total (7440-38-2)	☐	☑	☐	Concentration	ug/L	<2.00			1	<2.00	1
					Mass							
1.3	Beryllium, total (7440-41-7)	☐	☑	☐	Concentration	ug/L	<0.200			1	<0.200	1
					Mass							
1.4	Cadmium, total (7440-43-9)	☐	☑	☐	Concentration	ug/L	<0.300			1	<0.300	1
					Mass							
1.5	Chromium, total (7440-47-3)	☐	☑	☐	Concentration	ug/L	<3.00			1	<3.00	1
					Mass							
1.6	Copper, total (7440-50-8)	☐	☑	☐	Concentration	ug/L	<0.300			1	1.28	1
					Mass							
1.7	Lead, total (7439-92-1)	☐	☑	☐	Concentration	ug/L	<0.500			1	<0.500	1
					Mass							
1.8	Mercury, total (7439-97-6)	☐	☑	☐	Concentration	ng/L	<0.500			4	2.04	1
					Mass							
1.9	Nickel, total (7440-02-0)	☐	☑	☐	Concentration	ug/L	<0.600			1	<6.00	1
					Mass							
1.10	Selenium, total (7782-49-2)	☐	☑	☐	Concentration	ug/L	<1.50			1	<1.50	1
					Mass							
1.11	Silver, total (7440-22-4)	☐	☑	☐	Concentration	ug/L	<0.300			1	<0.300	1
					Mass							

EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 01B1

Form Approved 03/05/19
OMB No. 2040-0004

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
1.12	Thallium, total (7440-28-0)	☐	☑	☐	Concentration	ug/L	<0.600			1	<0.600	1
					Mass							
1.13	Zinc, total (7440-66-6)	☐	☑	☐	Concentration	ug/L	<3.30			1	4.25	1
					Mass							
1.14	Cyanide, total (57-12-5)	☐	☑	☐	Concentration	ug/L	<1.67			1	<5.00	1
					Mass							
1.15	Phenols, total	☐	☑	☐	Concentration	ug/L	<1.67			1	<2.82	1
					Mass							
Section 2. Organic Toxic Pollutants (GC/MS Fraction—Volatile Compounds)												
2.1	Acrolein (107-02-8)	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.2	Acrylonitrile (107-13-1)	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.3	Benzene (71-43-2)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.4	Bromoform (75-25-2)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.5	Carbon tetrachloride (56-23-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.6	Chlorobenzene (108-90-7)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.7	Chlorodibromomethane (124-48-1)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.8	Chloroethane (75-00-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
2.9	2-chloroethylvinyl ether (110-75-8)	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.10	Chloroform (67-66-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.11	Dichlorobromomethane (75-27-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.12	1,1-dichloroethane (75-34-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.13	1,2-dichloroethane (107-06-2)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.14	1,1-dichloroethylene (75-35-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.15	1,2-dichloropropane (78-87-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.16	1,3-dichloropropylene (542-75-6)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.17	Ethylbenzene (100-41-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.18	Methyl bromide (74-83-9)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.337	1
					Mass							
2.19	Methyl chloride (74-87-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.20	Methylene chloride (75-09-2)	☐	☑	☐	Concentration	ug/L	<0.500			1	<0.500	1
					Mass							
2.21	1,1,2,2- tetrachloroethane (79-34-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
2.22	Tetrachloroethylene (127-18-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.23	Toluene (108-88-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.24	1,2-trans-dichloroethylene (156-60-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.25	1,1,1-trichloroethane (71-55-6)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.26	1,1,2-trichloroethane (79-00-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.27	Trichloroethylene (79-01-6)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.28	Vinyl chloride (75-01-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
Section 3. Organic Toxic Pollutants (GC/MS Fraction—Acid Compounds)												
3.1	2-chlorophenol (95-57-8)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.2	2,4-dichlorophenol (120-83-2)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.3	2,4-dimethylphenol (105-67-9)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.4	4,6-dinitro-o-cresol (534-52-1)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.5	2,4-dinitrophenol (51-28-5)	☐	☑	☐	Concentration	ug/L	<4.71			1	<4.71	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
3.6	2-nitrophenol (88-75-5)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.7	4-nitrophenol (100-02-7)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.8	p-chloro-m-cresol (59-50-7)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.9	Pentachlorophenol (87-86-5)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.10	Phenol (108-95-2)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.11	2,4,6-trichlorophenol (88-05-2)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
Section 4. Organic Toxic Pollutants (GC/MS Fraction—Base /Neutral Compounds)												
4.1	Acenaphthene (83-32-9)	☐	☐	☑	Concentration							
					Mass							
4.2	Acenaphthylene (208-96-8)	☐	☐	☑	Concentration							
					Mass							
4.3	Anthracene (120-12-7)	☐	☐	☑	Concentration							
					Mass							
4.4	Benzidine (92-87-5)	☐	☐	☑	Concentration							
					Mass							
4.5	Benzo (a) anthracene (56-55-3)	☐	☐	☑	Concentration							
					Mass							
4.6	Benzo (a) pyrene (50-32-8)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.7	3,4-benzofluoranthene (205-99-2)	☐	☐	☑	Concentration							
					Mass							
4.8	Benzo (ghi) perylene (191-24-2)	☐	☐	☑	Concentration							
					Mass							
4.9	Benzo (k) fluoranthene (207-08-9)	☐	☐	☑	Concentration							
					Mass							
4.10	Bis (2-chloroethoxy) methane (111-91-1)	☐	☐	☑	Concentration							
					Mass							
4.11	Bis (2-chloroethyl) ether (111-44-4)	☐	☐	☑	Concentration							
					Mass							
4.12	Bis (2-chloroisopropyl) ether (102-80-1)	☐	☐	☑	Concentration							
					Mass							
4.13	Bis (2-ethylhexyl) phthalate (117-81-7)	☐	☐	☑	Concentration							
					Mass							
4.14	4-bromophenyl phenyl ether (101-55-3)	☐	☐	☑	Concentration							
					Mass							
4.15	Butyl benzyl phthalate (85-68-7)	☐	☐	☑	Concentration							
					Mass							
4.16	2-chloronaphthalene (91-58-7)	☐	☐	☑	Concentration							
					Mass							
4.17	4-chlorophenyl phenyl ether (7005-72-3)	☐	☐	☑	Concentration							
					Mass							
4.18	Chrysene (218-01-9)	☐	☐	☑	Concentration							
					Mass							
4.19	Dibenzo (a,h) anthracene (53-70-3)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.20	1,2-dichlorobenzene (95-50-1)	☐	☐	☑	Concentration							
					Mass							
4.21	1,3-dichlorobenzene (541-73-1)	☐	☐	☑	Concentration							
					Mass							
4.22	1,4-dichlorobenzene (106-46-7)	☐	☐	☑	Concentration							
					Mass							
4.23	3,3-dichlorobenzidine (91-94-1)	☐	☐	☑	Concentration							
					Mass							
4.24	Diethyl phthalate (84-66-2)	☐	☐	☑	Concentration							
					Mass							
4.25	Dimethyl phthalate (131-11-3)	☐	☐	☑	Concentration							
					Mass							
4.26	Di-n-butyl phthalate (84-74-2)	☐	☐	☑	Concentration							
					Mass							
4.27	2,4-dinitrotoluene (121-14-2)	☐	☐	☑	Concentration							
					Mass							
4.28	2,6-dinitrotoluene (606-20-2)	☐	☐	☑	Concentration							
					Mass							
4.29	Di-n-octyl phthalate (117-84-0)	☐	☐	☑	Concentration							
					Mass							
4.30	1,2-Diphenylhydrazine (as azobenzene) (122-66-7)	☐	☐	☑	Concentration							
					Mass							
4.31	Fluoranthene (206-44-0)	☐	☐	☑	Concentration							
					Mass							
4.32	Fluorene (86-73-7)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.33	Hexachlorobenzene (118-74-1)	☐	☐	☑	Concentration							
					Mass							
4.34	Hexachlorobutadiene (87-68-3)	☐	☐	☑	Concentration							
					Mass							
4.35	Hexachlorocyclopentadiene (77-47-4)	☐	☐	☑	Concentration							
					Mass							
4.36	Hexachloroethane (67-72-1)	☐	☐	☑	Concentration							
					Mass							
4.37	Indeno (1,2,3-cd) pyrene (193-39-5)	☐	☐	☑	Concentration							
					Mass							
4.38	Isophorone (78-59-1)	☐	☐	☑	Concentration							
					Mass							
4.39	Naphthalene (91-20-3)	☐	☐	☑	Concentration							
					Mass							
4.40	Nitrobenzene (98-95-3)	☐	☐	☑	Concentration							
					Mass							
4.41	N-nitrosodimethylamine (62-75-9)	☐	☐	☑	Concentration							
					Mass							
4.42	N-nitrosodi-n-propylamine (621-64-7)	☐	☐	☑	Concentration							
					Mass							
4.43	N-nitrosodiphenylamine (86-30-6)	☐	☐	☑	Concentration							
					Mass							
4.44	Phenanthrene (85-01-8)	☐	☐	☑	Concentration							
					Mass							
4.45	Pyrene (129-00-0)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.46	1,2,4-trichlorobenzene (120-82-1)	☐	☐	☑	Concentration							
					Mass							
Section 5. Organic Toxic Pollutants (GC/MS Fraction—Pesticides)												
5.1	Aldrin (309-00-2)	☐	☐	☑	Concentration							
					Mass							
5.2	α-BHC (319-84-6)	☐	☐	☑	Concentration							
					Mass							
5.3	β-BHC (319-85-7)	☐	☐	☑	Concentration							
					Mass							
5.4	γ-BHC (58-89-9)	☐	☐	☑	Concentration							
					Mass							
5.5	δ-BHC (319-86-8)	☐	☐	☑	Concentration							
					Mass							
5.6	Chlordane (57-74-9)	☐	☐	☑	Concentration							
					Mass							
5.7	4,4'-DDT (50-29-3)	☐	☐	☑	Concentration							
					Mass							
5.8	4,4'-DDE (72-55-9)	☐	☐	☑	Concentration							
					Mass							
5.9	4,4'-DDD (72-54-8)	☐	☐	☑	Concentration							
					Mass							
5.10	Dieldrin (60-57-1)	☐	☐	☑	Concentration							
					Mass							
5.11	α-endosulfan (115-29-7)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
5.12	β-endosulfan (115-29-7)	☐	☐	☑	Concentration							
					Mass							
5.13	Endosulfan sulfate (1031-07-8)	☐	☐	☑	Concentration							
					Mass							
5.14	Endrin (72-20-8)	☐	☐	☑	Concentration							
					Mass							
5.15	Endrin aldehyde (7421-93-4)	☐	☐	☑	Concentration							
					Mass							
5.16	Heptachlor (76-44-8)	☐	☐	☑	Concentration							
					Mass							
5.17	Heptachlor epoxide (1024-57-3)	☐	☐	☑	Concentration							
					Mass							
5.18	PCB-1242 (53469-21-9)	☐	☐	☑	Concentration							
					Mass							
5.19	PCB-1254 (11097-69-1)	☐	☐	☑	Concentration							
					Mass							
5.20	PCB-1221 (11104-28-2)	☐	☐	☑	Concentration							
					Mass							
5.21	PCB-1232 (11141-16-5)	☐	☐	☑	Concentration							
					Mass							
5.22	PCB-1248 (12672-29-6)	☐	☐	☑	Concentration							
					Mass							
5.23	PCB-1260 (11096-82-5)	☐	☐	☑	Concentration							
					Mass							
5.24	PCB-1016 (12674-11-2)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
5.25	Toxaphene (8001-35-2)	☐	☐	☑	Concentration							
					Mass							

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you believe all pollutants on Table C to be ***present*** in your discharge from the noted outfall. You need *not* complete the "Presence or Absence" column of Table C for *each* pollutant.										
☐	Check here if you believe all pollutants on Table C to be ***absent*** in your discharge from the noted outfall. You need *not* complete the "Presence or Absence" column of Table C for *each* pollutant.										
1.	Bromide (24959-67-9)	☐	☑	Concentration							
				Mass							
2.	Chlorine, total residual	☐	☑	Concentration							
				Mass							
3.	Color	☑	☐	Concentration	PSU	<5.00			1	15.0	1
				Mass							
4.	Fecal coliform	☐	☑	Concentration							
				Mass							
5.	Fluoride (16984-48-8)	☐	☑	Concentration							
				Mass							
6	Nitrate-nitrite	☑	☐	Concentration	mg/L	<0.007			1	0.154	1
				Mass							
7.	Nitrogen, total organic (as N)	☑	☐	Concentration	ug/L	<33.0			1	157	1
				Mass							
8.	Oil and grease	☑	☐	Concentration	mg/L	<1.71	11.0		28	<2.095	4
				Mass							
9.	Phosphorus (as P), total (7723-14-0)	☑	☐	Concentration	mg/L	0.0598			1	0.345	1
				Mass							
10.	Sulfate (as SO_4) (14808-79-8)	☑	☐	Concentration	mg/L	<0.133			1	9.38	1
				Mass							
11.	Sulfide (as S)	☑	☐	Concentration	mg/L	<0.033			1	<0.033	1
				Mass							

EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	01B1

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TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
12.	Sulfite (as SO_3) (14265-45-3)	☐	☑	Concentration							
				Mass							
13.	Surfactants	☑	☐	Concentration	mg/L	0.0270			1	0.0175	1
				Mass							
14.	Aluminum, total (7429-90-5)	☑	☐	Concentration	ug/L	<19.3			1	201	1
				Mass							
15.	Barium, total (7440-39-3)	☑	☐	Concentration	ug/L	<0.670			1	23.6	1
				Mass							
16.	Boron, total (7440-42-8)	☑	☐	Concentration	ug/L	<5.20			1	17.9	1
				Mass							
17.	Cobalt, total (7440-48-4)	☑	☐	Concentration	ug/L	<0.300			1	0.334	1
				Mass							
18.	Iron, total (7439-89-6)	☑	☐	Concentration	ug/L	<33.0			1	248	1
				Mass							
19.	Magnesium, total (7439-95-4)	☑	☐	Concentration	ug/L	<10.0			1	5270	1
				Mass							
20.	Molybdenum, total (7439-98-7)	☑	☐	Concentration	ug/L	<0.200			1	0.377	1
				Mass							
21.	Manganese, total (7439-96-5)	☑	☐	Concentration	ug/L	<1.00			1	37.7	1
				Mass							
22.	Tin, total (7440-31-5)	☑	☐	Concentration	ug/L	<1.00			1	<1.00	1
				Mass							
23.	Titanium, total (7440-32-6)	☑	☐	Concentration	ug/L	<2.00			1	3.55	1
				Mass							

TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
24.	**Radioactivity**										
	Alpha, total	☑	☐	Concentration		-0.929			1	2.17	1
				Mass							
	Beta, total	☑	☐	Concentration		1630			1	2.19	1
				Mass							
	Radium, total	☑	☐	Concentration		0.265			1	0.182	1
				Mass							
	Radium 226, total	☑	☐	Concentration		0.164			1	0.199	1
				Mass							

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
1.	Asbestos	☐	☑		
2.	Acetaldehyde	☐	☑		
3.	Allyl alcohol	☐	☑		
4.	Allyl chloride	☐	☑		
5.	Amyl acetate	☐	☑		
6.	Aniline	☐	☑		
7.	Benzonitrile	☐	☑		
8.	Benzyl chloride	☐	☑		
9.	Butyl acetate	☐	☑		
10.	Butylamine	☐	☑		
11.	Captan	☐	☑		
12.	Carbaryl	☐	☑		
13.	Carbofuran	☐	☑		
14.	Carbon disulfide	☐	☑		
15.	Chlorpyrifos	☐	☑		
16.	Coumaphos	☐	☑		
17.	Cresol	☐	☑		
18.	Crotonaldehyde	☐	☑		
19.	Cyclohexane	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
20.	2,4-D (2,4-dichlorophenoxyacetic acid)	☐	☑		
21.	Diazinon	☐	☑		
22.	Dicamba	☐	☑		
23.	Dichlobenil	☐	☑		
24.	Dichlone	☐	☑		
25.	2,2-dichloropropionic acid	☐	☑		
26.	Dichlorvos	☐	☑		
27.	Diethyl amine	☐	☑		
28.	Dimethyl amine	☐	☑		
29.	Dintrobenzene	☐	☑		
30.	Diquat	☐	☑		
31.	Disulfoton	☐	☑		
32.	Diuron	☐	☑		
33.	Epichlorohydrin	☐	☑		
34.	Ethion	☐	☑		
35.	Ethylene diamine	☐	☑		
36.	Ethylene dibromide	☐	☑		
37.	Formaldehyde	☐	☑		
38.	Furfural	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
39.	Guthion	☐	☑		
40.	Isoprene	☐	☑		
41.	Isopropanolamine	☐	☑		
42.	Kelthane	☐	☑		
43.	Kepone	☐	☑		
44.	Malathion	☐	☑		
45.	Mercaptodimethur	☐	☑		
46.	Methoxychlor	☐	☑		
47.	Methyl mercaptan	☐	☑		
48.	Methyl methacrylate	☐	☑		
49.	Methyl parathion	☐	☑		
50.	Mevinphos	☐	☑		
51.	Mexacarbate	☐	☑		
52.	Monoethyl amine	☐	☑		
53.	Monomethyl amine	☐	☑		
54.	Naled	☐	☑		
55.	Naphthenic acid	☐	☑		
56.	Nitrotoluene	☐	☑		
57.	Parathion	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
58.	Phenolsulfonate	☐	☑		
59.	Phosgene	☐	☑		
60.	Propargite	☐	☑		
61.	Propylene oxide	☐	☑		
62.	Pyrethrins	☐	☑		
63.	Quinoline	☐	☑		
64.	Resorcinol	☐	☑		
65.	Strontium	☐	☑		
66.	Strychnine	☐	☑		
67.	Styrene	☐	☑		
68.	2,4,5-T (2,4,5-trichlorophenoxyacetic acid)	☐	☑		
69.	TDE (tetrachlorodiphenyl ethane)	☐	☑		
70.	2,4,5-TP [2-(2,4,5-trichlorophenoxy) propanoic acid]	☐	☑		
71.	Trichlorofon	☐	☑		
72.	Triethanolamine	☐	☑		
73.	Triethylamine	☐	☑		
74.	Trimethylamine	☐	☑		
75.	Uranium	☐	☑		
76.	Vanadium	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
77.	Vinyl acetate	☐	☑		
78.	Xylene	☐	☑		
79.	Xylenol	☐	☑		
80.	Zirconium	☐	☑		

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE E. 2,3,7,8 TETRACHLORODIBENZO P DIOXIN (2,3,7,8 TCDD) (40 CFR 122.21(g)(7)(viii))

Pollutant	TCDD Congeners Used or Manufactured	Presence or Absence (check one)		Results of Screening Procedure
		Believed Present	Believed Absent	
2,3,7,8-TCDD	☐	☐	☑	

TABLE A. CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(iii)) [1]

	Pollutant	Waiver Requested (if applicable)	Units (specify)		Effluent				Intake (Optional)	
					Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you have applied to your NPDES permitting authority for a waiver for *all* of the pollutants listed on this table for the noted outfall.									
1.	Biochemical oxygen demand (BOD_5)	☐	Concentration	mg/L	<1.00			1	1.12	1
			Mass							
2.	Chemical oxygen demand (COD)	☐	Concentration	mg/L	26.0			1	22.3	1
			Mass							
3.	Total organic carbon (TOC)	☐	Concentration	mg/L	2.45			1	1.76	1
			Mass							
4.	Total suspended solids (TSS)	☐	Concentration	mg/L	7.60			1	6.90	1
			Mass							
5.	Ammonia (as N)	☐	Concentration	mg/L	0.0734			1	0.0864	1
			Mass							
6.	Flow	☐	Rate	MGD	3044.2			1	3044.2	1
7.	Temperature (winter)	☐	°C	°C	21.4			2	11.35	2
	Temperature (summer)	☐	°C	°C						
8.	pH (minimum)	☐	Standard units	s.u.	7.08			1	7.69	1
	pH (maximum)	☐	Standard units	s.u.	7.09			1	7.69	1

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 0011

Form Approved 03/05/19
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TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you qualify as a small business per the instructions to Form 2C and, therefore, do not need to submit quantitative data for any of the organic toxic pollutants in Sections 2 through 5 of this table. Note, however, that you must still indicate in the appropriate column of this table if you believe any of the pollutants listed are present in your discharge.											
Section 1. Toxic Metals, Cyanide, and Total Phenols												
1.1	Antimony, total (7440-36-0)	☐	☑	☐	Concentration	ug/L	<1.00			1	<1.00	1
					Mass							
1.2	Arsenic, total (7440-38-2)	☐	☑	☐	Concentration	ug/L	<2.00			1	<2.00	1
					Mass							
1.3	Beryllium, total (7440-41-7)	☐	☑	☐	Concentration	ug/L	<0.200			1	<0.200	1
					Mass							
1.4	Cadmium, total (7440-43-9)	☐	☑	☐	Concentration	ug/L	<0.300			1	<0.300	1
					Mass							
1.5	Chromium, total (7440-47-3)	☐	☑	☐	Concentration	ug/L	<3.00			1	<3.00	1
					Mass							
1.6	Copper, total (7440-50-8)	☐	☑	☐	Concentration	ug/L	1.54			1	1.28	1
					Mass							
1.7	Lead, total (7439-92-1)	☐	☑	☐	Concentration	ug/L	<0.500			1	<0.500	1
					Mass							
1.8	Mercury, total (7439-97-6)	☐	☑	☐	Concentration	ug/L	0.90			4	2.04	4
					Mass							
1.9	Nickel, total (7440-02-0)	☐	☑	☐	Concentration	ug/L	<6.00			1	<6.00	1
					Mass							
1.10	Selenium, total (7782-49-2)	☐	☑	☐	Concentration	ug/L	<1.50			1	<1.50	1
					Mass							
1.11	Silver, total (7440-22-4)	☐	☑	☐	Concentration	ug/L	<0.300			1	<0.300	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
1.12	Thallium, total (7440-28-0)	☐	☑	☐	Concentration	ug/L	<0.600			1	<0.600	1
					Mass							
1.13	Zinc, total (7440-66-6)	☐	☑	☐	Concentration	ug/L	4.57			1	4.25	1
					Mass							
1.14	Cyanide, total (57-12-5)	☐	☑	☐	Concentration	ug/L	<5.00			1	<5.00	1
					Mass							
1.15	Phenols, total	☐	☑	☐	Concentration	ug/L	<2.82			1	<2.82	1
					Mass							
Section 2. Organic Toxic Pollutants (GC/MS Fraction—Volatile Compounds)												
2.1	Acrolein (107-02-8)	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.2	Acrylonitrile (107-13-1)	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.3	Benzene (71-43-2)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.4	Bromoform (75-25-2)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.5	Carbon tetrachloride (56-23-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.6	Chlorobenzene (108-90-7)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.7	Chlorodibromomethane (124-48-1)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.8	Chloroethane (75-00-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							

EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 0011

Form Approved 03/05/19
OMB No. 2040-0004

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
2.9	2-chloroethylvinyl ether (110-75-8)	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.10	Chloroform (67-66-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.11	Dichlorobromomethane (75-27-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.12	1,1-dichloroethane (75-34-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.13	1,2-dichloroethane (107-06-2)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.14	1,1-dichloroethylene (75-35-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.15	1,2-dichloropropane (78-87-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.16	1,3-dichloropropylene (542-75-6)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.17	Ethylbenzene (100-41-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.18	Methyl bromide (74-83-9)	☐	☑	☐	Concentration	ug/L	<0.337			1	<0.337	1
					Mass							
2.19	Methyl chloride (74-87-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.20	Methylene chloride (75-09-2)	☐	☑	☐	Concentration	ug/L	<0.500			1	<0.500	1
					Mass							
2.21	1,1,2,2- tetrachloroethane (79-34-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
2.22	Tetrachloroethylene (127-18-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.23	Toluene (108-88-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.24	1,2-trans-dichloroethylene (156-60-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.25	1,1,1-trichloroethane (71-55-6)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.26	1,1,2-trichloroethane (79-00-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	
					Mass							
2.27	Trichloroethylene (79-01-6)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.28	Vinyl chloride (75-01-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
Section 3. Organic Toxic Pollutants (GC/MS Fraction—Acid Compounds)												
3.1	2-chlorophenol (95-57-8)	☐	☑	☐	Concentration	ug/L	<2.82			1	<2.83	1
					Mass							
3.2	2,4-dichlorophenol (120-83-2)	☐	☑	☐	Concentration	ug/L	<2.82			1	<2.83	1
					Mass							
3.3	2,4-dimethylphenol (105-67-9)	☐	☑	☐	Concentration	ug/L	<2.82			1	<2.83	1
					Mass							
3.4	4,6-dinitro-o-cresol (534-52-1)	☐	☑	☐	Concentration	ug/L	<2.72			1	<2.83	1
					Mass							
3.5	2,4-dinitrophenol (51-28-5)	☐	☑	☐	Concentration	ug/L	<4.70			1	<4.71	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
3.6	2-nitrophenol (88-75-5)	☐	☑	☐	Concentration	ug/L	<2.82			1	<2.83	1
					Mass							
3.7	4-nitrophenol (100-02-7)	☐	☑	☐	Concentration	ug/L	<2.82			1	<2.83	1
					Mass							
3.8	p-chloro-m-cresol (59-50-7)	☐	☑	☐	Concentration	ug/L	<2.82			1	<2.83	1
					Mass							
3.9	Pentachlorophenol (87-86-5)	☐	☑	☐	Concentration	ug/L	<2.82			1	<2.83	1
					Mass							
3.10	Phenol (108-95-2)	☐	☑	☐	Concentration	ug/L	<2.82			1	<2.83	1
					Mass							
3.11	2,4,6-trichlorophenol (88-05-2)	☐	☑	☐	Concentration	ug/L	<2.82			1	<2.83	1
					Mass							
Section 4. Organic Toxic Pollutants (GC/MS Fraction—Base /Neutral Compounds)												
4.1	Acenaphthene (83-32-9)	☐	☐	☑	Concentration							
					Mass							
4.2	Acenaphthylene (208-96-8)	☐	☐	☑	Concentration							
					Mass							
4.3	Anthracene (120-12-7)	☐	☐	☑	Concentration							
					Mass							
4.4	Benzidine (92-87-5)	☐	☐	☑	Concentration							
					Mass							
4.5	Benzo (a) anthracene (56-55-3)	☐	☐	☑	Concentration							
					Mass							
4.6	Benzo (a) pyrene (50-32-8)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.7	3,4-benzofluoranthene (205-99-2)	☐	☐	☑	Concentration							
					Mass							
4.8	Benzo (ghi) perylene (191-24-2)	☐	☐	☑	Concentration							
					Mass							
4.9	Benzo (k) fluoranthene (207-08-9)	☐	☐	☑	Concentration							
					Mass							
4.10	Bis (2-chloroethoxy) methane (111-91-1)	☐	☐	☑	Concentration							
					Mass							
4.11	Bis (2-chloroethyl) ether (111-44-4)	☐	☐	☑	Concentration							
					Mass							
4.12	Bis (2-chloroisopropyl) ether (102-80-1)	☐	☐	☑	Concentration							
					Mass							
4.13	Bis (2-ethylhexyl) phthalate (117-81-7)	☐	☐	☑	Concentration							
					Mass							
4.14	4-bromophenyl phenyl ether (101-55-3)	☐	☐	☑	Concentration							
					Mass							
4.15	Butyl benzyl phthalate (85-68-7)	☐	☐	☑	Concentration							
					Mass							
4.16	2-chloronaphthalene (91-58-7)	☐	☐	☑	Concentration							
					Mass							
4.17	4-chlorophenyl phenyl ether (7005-72-3)	☐	☐	☑	Concentration							
					Mass							
4.18	Chrysene (218-01-9)	☐	☐	☑	Concentration							
					Mass							
4.19	Dibenzo (a,h) anthracene (53-70-3)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.20	1,2-dichlorobenzene (95-50-1)	☐	☐	☑	Concentration							
					Mass							
4.21	1,3-dichlorobenzene (541-73-1)	☐	☐	☑	Concentration							
					Mass							
4.22	1,4-dichlorobenzene (106-46-7)	☐	☐	☑	Concentration							
					Mass							
4.23	3,3-dichlorobenzidine (91-94-1)	☐	☐	☑	Concentration							
					Mass							
4.24	Diethyl phthalate (84-66-2)	☐	☐	☑	Concentration							
					Mass							
4.25	Dimethyl phthalate (131-11-3)	☐	☐	☑	Concentration							
					Mass							
4.26	Di-n-butyl phthalate (84-74-2)	☐	☐	☑	Concentration							
					Mass							
4.27	2,4-dinitrotoluene (121-14-2)	☐	☐	☑	Concentration							
					Mass							
4.28	2,6-dinitrotoluene (606-20-2)	☐	☐	☑	Concentration							
					Mass							
4.29	Di-n-octyl phthalate (117-84-0)	☐	☐	☑	Concentration							
					Mass							
4.30	1,2-Diphenylhydrazine (as azobenzene) (122-66-7)	☐	☐	☑	Concentration							
					Mass							
4.31	Fluoranthene (206-44-0)	☐	☐	☑	Concentration							
					Mass							
4.32	Fluorene (86-73-7)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.33	Hexachlorobenzene (118-74-1)	☐	☐	☑	Concentration							
					Mass							
4.34	Hexachlorobutadiene (87-68-3)	☐	☐	☑	Concentration							
					Mass							
4.35	Hexachlorocyclopentadiene (77-47-4)	☐	☐	☑	Concentration							
					Mass							
4.36	Hexachloroethane (67-72-1)	☐	☐	☑	Concentration							
					Mass							
4.37	Indeno (1,2,3-cd) pyrene (193-39-5)	☐	☐	☑	Concentration							
					Mass							
4.38	Isophorone (78-59-1)	☐	☐	☑	Concentration							
					Mass							
4.39	Naphthalene (91-20-3)	☐	☐	☑	Concentration							
					Mass							
4.40	Nitrobenzene (98-95-3)	☐	☐	☑	Concentration							
					Mass							
4.41	N-nitrosodimethylamine (62-75-9)	☐	☐	☑	Concentration							
					Mass							
4.42	N-nitrosodi-n-propylamine (621-64-7)	☐	☐	☑	Concentration							
					Mass							
4.43	N-nitrosodiphenylamine (86-30-6)	☐	☐	☑	Concentration							
					Mass							
4.44	Phenanthrene (85-01-8)	☐	☐	☑	Concentration							
					Mass							
4.45	Pyrene (129-00-0)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.46	1,2,4-trichlorobenzene (120-82-1)	☐	☐	☑	Concentration							
					Mass							
Section 5. Organic Toxic Pollutants (GC/MS Fraction—Pesticides)												
5.1	Aldrin (309-00-2)	☐	☐	☑	Concentration							
					Mass							
5.2	α-BHC (319-84-6)	☐	☐	☑	Concentration							
					Mass							
5.3	β-BHC (319-85-7)	☐	☐	☑	Concentration							
					Mass							
5.4	γ-BHC (58-89-9)	☐	☐	☑	Concentration							
					Mass							
5.5	δ-BHC (319-86-8)	☐	☐	☑	Concentration							
					Mass							
5.6	Chlordane (57-74-9)	☐	☐	☑	Concentration							
					Mass							
5.7	4,4'-DDT (50-29-3)	☐	☐	☑	Concentration							
					Mass							
5.8	4,4'-DDE (72-55-9)	☐	☐	☑	Concentration							
					Mass							
5.9	4,4'-DDD (72-54-8)	☐	☐	☑	Concentration							
					Mass							
5.10	Dieldrin (60-57-1)	☐	☐	☑	Concentration							
					Mass							
5.11	α-endosulfan (115-29-7)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
5.12	β-endosulfan (115-29-7)	☐	☐	☑	Concentration							
					Mass							
5.13	Endosulfan sulfate (1031-07-8)	☐	☐	☑	Concentration							
					Mass							
5.14	Endrin (72-20-8)	☐	☐	☑	Concentration							
					Mass							
5.15	Endrin aldehyde (7421-93-4)	☐	☐	☑	Concentration							
					Mass							
5.16	Heptachlor (76-44-8)	☐	☐	☑	Concentration							
					Mass							
5.17	Heptachlor epoxide (1024-57-3)	☐	☐	☑	Concentration							
					Mass							
5.18	PCB-1242 (53469-21-9)	☐	☐	☑	Concentration							
					Mass							
5.19	PCB-1254 (11097-69-1)	☐	☐	☑	Concentration							
					Mass							
5.20	PCB-1221 (11104-28-2)	☐	☐	☑	Concentration							
					Mass							
5.21	PCB-1232 (11141-16-5)	☐	☐	☑	Concentration							
					Mass							
5.22	PCB-1248 (12672-29-6)	☐	☐	☑	Concentration							
					Mass							
5.23	PCB-1260 (11096-82-5)	☐	☐	☑	Concentration							
					Mass							
5.24	PCB-1016 (12674-11-2)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
5.25	Toxaphene (8001-35-2)	☐	☐	☑	Concentration							
					Mass							

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you believe all pollutants on Table C to be ***present*** in your discharge from the noted outfall. You need *not* complete the "Presence or Absence" column of Table C for *each* pollutant.										
☐	Check here if you believe all pollutants on Table C to be ***absent*** in your discharge from the noted outfall. You need *not* complete the "Presence or Absence" column of Table C for *each* pollutant.										
1.	Bromide (24959-67-9)	☐	☑	Concentration							
				Mass							
2.	Chlorine, total residual	☐	☑	Concentration							
				Mass							
3.	Color	☑	☐	Concentration	PSU	10.0			1	15.0	1
				Mass							
4.	Fecal coliform	☐	☑	Concentration							
				Mass							
5.	Fluoride (16984-48-8)	☐	☑	Concentration							
				Mass							
6	Nitrate-nitrite	☑	☐	Concentration	mg/L	0.153			1	0.154	1
				Mass							
7.	Nitrogen, total organic (as N)	☑	☐	Concentration	ug/L	119			1	157	1
				Mass							
8.	Oil and grease	☑	☐	Concentration	mg/L	<2.25			4	<2.095	4
				Mass							
9.	Phosphorus (as P), total (7723-14-0)	☑	☐	Concentration	mg/L	0.374			1	0.345	1
				Mass							
10.	Sulfate (as SO_4) (14808-79-8)	☑	☐	Concentration	mg/L	9.35			1	9.38	1
				Mass							
11.	Sulfide (as S)	☑	☐	Concentration	mg/L	<0.033			1	<0.033	1
				Mass							

TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
12.	Sulfite (as SO_3) (14265-45-3)	☐	☑	Concentration							
				Mass							
13.	Surfactants	☑	☐	Concentration	mg/L	0.0270			1	0.0175	1
				Mass							
14.	Aluminum, total (7429-90-5)	☑	☐	Concentration	ug/L	163			1	201	1
				Mass							
15.	Barium, total (7440-39-3)	☑	☐	Concentration	ug/L	23.2			1	23.6	1
				Mass							
16.	Boron, total (7440-42-8)	☑	☐	Concentration	ug/L	17.5			1	17.9	1
				Mass							
17.	Cobalt, total (7440-48-4)	☑	☐	Concentration	ug/L	<0.300			1	0.334	1
				Mass							
18.	Iron, total (7439-89-6)	☑	☐	Concentration	ug/L	206			1	248	1
				Mass							
19.	Magnesium, total (7439-95-4)	☑	☐	Concentration	ug/L	5230			1	5270	1
				Mass							
20.	Molybdenum, total (7439-98-7)	☑	☐	Concentration	ug/L	0.379			1	0.377	1
				Mass							
21.	Manganese, total (7439-96-5)	☑	☐	Concentration	ug/L	36.7			1	37.7	1
				Mass							
22.	Tin, total (7440-31-5)	☑	☐	Concentration	ug/L	<1.00			1	<1.00	1
				Mass							
23.	Titanium, total (7440-32-6)	☑	☐	Concentration	ug/L	2.72			1	3.55	1
				Mass							

TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
24.	**Radioactivity**										
	Alpha, total	☑	☐	Concentration	pCi/L	0.736			1	2.17	1
				Mass							
	Beta, total	☑	☐	Concentration	pCi/L	1.85			1	2.19	1
				Mass							
	Radium, total	☑	☐	Concentration	pCi/L	0.537			1	0.182	1
				Mass							
	Radium 226, total	☑	☐	Concentration	pCi/L	0.345			1	0.199	1
				Mass							

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
1.	Asbestos	☐	☑		
2.	Acetaldehyde	☐	☑		
3.	Allyl alcohol	☐	☑		
4.	Allyl chloride	☐	☑		
5.	Amyl acetate	☐	☑		
6.	Aniline	☐	☑		
7.	Benzonitrile	☐	☑		
8.	Benzyl chloride	☐	☑		
9.	Butyl acetate	☐	☑		
10.	Butylamine	☐	☑		
11.	Captan	☐	☑		
12.	Carbaryl	☐	☑		
13.	Carbofuran	☐	☑		
14.	Carbon disulfide	☐	☑		
15.	Chlorpyrifos	☐	☑		
16.	Coumaphos	☐	☑		
17.	Cresol	☐	☑		
18.	Crotonaldehyde	☐	☑		
19.	Cyclohexane	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
20.	2,4-D (2,4-dichlorophenoxyacetic acid)	☐	☑		
21.	Diazinon	☐	☑		
22.	Dicamba	☐	☑		
23.	Dichlobenil	☐	☑		
24.	Dichlone	☐	☑		
25.	2,2-dichloropropionic acid	☐	☑		
26.	Dichlorvos	☐	☑		
27.	Diethyl amine	☐	☑		
28.	Dimethyl amine	☐	☑		
29.	Dintrobenzene	☐	☑		
30.	Diquat	☐	☑		
31.	Disulfoton	☐	☑		
32.	Diuron	☐	☑		
33.	Epichlorohydrin	☐	☑		
34.	Ethion	☐	☑		
35.	Ethylene diamine	☐	☑		
36.	Ethylene dibromide	☐	☑		
37.	Formaldehyde	☐	☑		
38.	Furfural	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
39.	Guthion	☐	☑		
40.	Isoprene	☐	☑		
41.	Isopropanolamine	☐	☑		
42.	Kelthane	☐	☑		
43.	Kepone	☐	☑		
44.	Malathion	☐	☑		
45.	Mercaptodimethur	☐	☑		
46.	Methoxychlor	☐	☑		
47.	Methyl mercaptan	☐	☑		
48.	Methyl methacrylate	☐	☑		
49.	Methyl parathion	☐	☑		
50.	Mevinphos	☐	☑		
51.	Mexacarbate	☐	☑		
52.	Monoethyl amine	☐	☑		
53.	Monomethyl amine	☐	☑		
54.	Naled	☐	☑		
55.	Naphthenic acid	☐	☑		
56.	Nitrotoluene	☐	☑		
57.	Parathion	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
58.	Phenolsulfonate	☐	☑		
59.	Phosgene	☐	☑		
60.	Propargite	☐	☑		
61.	Propylene oxide	☐	☑		
62.	Pyrethrins	☐	☑		
63.	Quinoline	☐	☑		
64.	Resorcinol	☐	☑		
65.	Strontium	☐	☑		
66.	Strychnine	☐	☑		
67.	Styrene	☐	☑		
68.	2,4,5-T (2,4,5-trichlorophenoxyacetic acid)	☐	☑		
69.	TDE (tetrachlorodiphenyl ethane)	☐	☑		
70.	2,4,5-TP [2-(2,4,5-trichlorophenoxy) propanoic acid]	☐	☑		
71.	Trichlorofon	☐	☑		
72.	Triethanolamine	☐	☑		
73.	Triethylamine	☐	☑		
74.	Trimethylamine	☐	☑		
75.	Uranium	☐	☑		
76.	Vanadium	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
77.	Vinyl acetate	☐	☑		
78.	Xylene	☐	☑		
79.	Xylenol	☐	☑		
80.	Zirconium	☐	☑		

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE E. 2,3,7,8 TETRACHLORODIBENZO P DIOXIN (2,3,7,8 TCDD) (40 CFR 122.21(g)(7)(viii))

Pollutant	TCDD Congeners Used or Manufactured	Presence or Absence (check one)		Results of Screening Procedure
		Believed Present	Believed Absent	
2,3,7,8-TCDD	☐	☐	☑	

TABLE A. CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(iii)) [1]

	Pollutant	Waiver Requested (if applicable)	Units (specify)		Effluent				Intake (Optional)	
					Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you have applied to your NPDES permitting authority for a waiver for *all* of the pollutants listed on this table for the noted outfall.									
1.	Biochemical oxygen demand (BOD_5)	☐	Concentration	mg/l	<1.00			1	1.12	1
			Mass							
2.	Chemical oxygen demand (COD)	☐	Concentration	mg/L	11.2			1	22.3	1
			Mass							
3.	Total organic carbon (TOC)	☐	Concentration	mg/L	3.35			1	1.76	1
			Mass							
4.	Total suspended solids (TSS)	☐	Concentration	mg/L	2.10	52.5		38	6.90	1
			Mass							
5.	Ammonia (as N)	☐	Concentration	mg/L	0.0628			1	0.0864	1
			Mass							
6.	Flow	☐	Rate	mgd		0.5040		38	3044.2	1
7.	Temperature (winter)	☐	°C	°C	10.5			1	11.35	2
	Temperature (summer)	☐	°C	°C						
8.	pH (minimum)	☐	Standard units	s.u.	8.31	9.0	8.5974	38	7.69	1
	pH (maximum)	☐	Standard units	s.u.	8.31	9.0	8.5974	38	7.69	1

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 13B1

Form Approved 03/05/19
OMB No. 2040-0004

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you qualify as a small business per the instructions to Form 2C and, therefore, do not need to submit quantitative data for any of the organic toxic pollutants in Sections 2 through 5 of this table. Note, however, that you must still indicate in the appropriate column of this table if you believe any of the pollutants listed are present in your discharge.											
Section 1. Toxic Metals, Cyanide, and Total Phenols												
1.1	Antimony, total (7440-36-0)	☐	☑	☐	Concentration	ug/L	<1.00			1	<1.00	1
					Mass							
1.2	Arsenic, total (7440-38-2)	☐	☑	☐	Concentration	ug/L	<2.00			1	<2.00	1
					Mass							
1.3	Beryllium, total (7440-41-7)	☐	☑	☐	Concentration	ug/L	<0.200			1	<0.200	1
					Mass							
1.4	Cadmium, total (7440-43-9)	☐	☑	☐	Concentration	ug/L	<0.300			1	<0.300	1
					Mass							
1.5	Chromium, total (7440-47-3)	☐	☑	☐	Concentration	ug/L	<3.00			1	<3.00	1
					Mass							
1.6	Copper, total (7440-50-8)	☐	☑	☐	Concentration	ug/L	0.963			1	1.28	1
					Mass							
1.7	Lead, total (7439-92-1)	☐	☑	☐	Concentration	ug/L	<0.500			1	<0.500	1
					Mass							
1.8	Mercury, total (7439-97-6)	☐	☑	☐	Concentration	ug/L	<0.200			1	2.04	4
					Mass							
1.9	Nickel, total (7440-02-0)	☐	☑	☐	Concentration	ug/L	<0.600			1	<0.600	1
					Mass							
1.10	Selenium, total (7782-49-2)	☐	☑	☐	Concentration	ug/L	<1.50			1	<1.50	1
					Mass							
1.11	Silver, total (7440-22-4)	☐	☑	☐	Concentration	ug/L	<0.300			1	<0.300	1
					Mass							

EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 13B1

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TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
1.12	Thallium, total (7440-28-0)	☐	☑	☐	Concentration	ug/L	<0.600			1	<0.600	1
					Mass							
1.13	Zinc, total (7440-66-6)	☐	☑	☐	Concentration	ug/L	<3.30			1	4.25	1
					Mass							
1.14	Cyanide, total (57-12-5)	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	4
					Mass							
1.15	Phenols, total	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	4
					Mass							
Section 2. Organic Toxic Pollutants (GC/MS Fraction—Volatile Compounds)												
2.1	Acrolein (107-02-8)	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.2	Acrylonitrile (107-13-1)	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.3	Benzene (71-43-2)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.4	Bromoform (75-25-2)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.5	Carbon tetrachloride (56-23-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.6	Chlorobenzene (108-90-7)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.7	Chlorodibromomethane (124-48-1)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.8	Chloroethane (75-00-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							

EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 13B1

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TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
2.9	2-chloroethylvinyl ether (110-75-8)	☐	☑	☐	Concentration	ug/L	<1.67					
					Mass							
2.10	Chloroform (67-66-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.11	Dichlorobromomethane (75-27-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.12	1,1-dichloroethane (75-34-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.13	1,2-dichloroethane (107-06-2)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.14	1,1-dichloroethylene (75-35-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.15	1,2-dichloropropane (78-87-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.16	1,3-dichloropropylene (542-75-6)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.17	Ethylbenzene (100-41-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.18	Methyl bromide (74-83-9)	☐	☑	☐	Concentration	ugl	<0.337			1	<0.337	1
					Mass							
2.19	Methyl chloride (74-87-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.20	Methylene chloride (75-09-2)	☐	☑	☐	Concentration	ug/L	<0.500			1	<0.500	1
					Mass							
2.21	1,1,2,2- tetrachloroethane (79-34-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
2.22	Tetrachloroethylene (127-18-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.23	Toluene (108-88-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.24	1,2-trans-dichloroethylene (156-60-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.25	1,1,1-trichloroethane (71-55-6)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.26	1,1,2-trichloroethane (79-00-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.27	Trichloroethylene (79-01-6)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.28	Vinyl chloride (75-01-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
Section 3. Organic Toxic Pollutants (GC/MS Fraction—Acid Compounds)												
3.1	2-chlorophenol (95-57-8)	☐	☑	☐	Concentration	ug/L	<2.72			1	<2.83	1
					Mass							
3.2	2,4-dichlorophenol (120-83-2)	☐	☑	☐	Concentration	ug/L	<2.72			1	<2.83	1
					Mass							
3.3	2,4-dimethylphenol (105-67-9)	☐	☑	☐	Concentration	ug/L	<2.72			1	<2.83	1
					Mass							
3.4	4,6-dinitro-o-cresol (534-52-1)	☐	☑	☐	Concentration	ug/L	<2.72			1	<2.83	1
					Mass							
3.5	2,4-dinitrophenol (51-28-5)	☐	☑	☐	Concentration	ug/L	<4.53			1	<4.71	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
3.6	2-nitrophenol (88-75-5)	☐	☑	☐	Concentration		<2.72			1	<2.83	1
					Mass							
3.7	4-nitrophenol (100-02-7)	☐	☑	☐	Concentration		<2.72			1	<2.83	1
					Mass							
3.8	p-chloro-m-cresol (59-50-7)	☐	☑	☐	Concentration		<2.72			1	<2.83	1
					Mass							
3.9	Pentachlorophenol (87-86-5)	☐	☑	☐	Concentration		<2.72			1	<2.83	1
					Mass							
3.10	Phenol (108-95-2)	☐	☑	☐	Concentration		<2.72			1	<2.83	1
					Mass							
3.11	2,4,6-trichlorophenol (88-05-2)	☐	☑	☐	Concentration		<2.72			1	<2.83	1
					Mass							
Section 4. Organic Toxic Pollutants (GC/MS Fraction—Base /Neutral Compounds)												
4.1	Acenaphthene (83-32-9)	☐	☐	☑	Concentration							
					Mass							
4.2	Acenaphthylene (208-96-8)	☐	☐	☑	Concentration							
					Mass							
4.3	Anthracene (120-12-7)	☐	☐	☑	Concentration							
					Mass							
4.4	Benzidine (92-87-5)	☐	☐	☑	Concentration							
					Mass							
4.5	Benzo (a) anthracene (56-55-3)	☐	☐	☑	Concentration							
					Mass							
4.6	Benzo (a) pyrene (50-32-8)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.7	3,4-benzofluoranthene (205-99-2)	☐	☐	☑	Concentration							
					Mass							
4.8	Benzo (ghi) perylene (191-24-2)	☐	☐	☑	Concentration							
					Mass							
4.9	Benzo (k) fluoranthene (207-08-9)	☐	☐	☑	Concentration							
					Mass							
4.10	Bis (2-chloroethoxy) methane (111-91-1)	☐	☐	☑	Concentration							
					Mass							
4.11	Bis (2-chloroethyl) ether (111-44-4)	☐	☐	☑	Concentration							
					Mass							
4.12	Bis (2-chloroisopropyl) ether (102-80-1)	☐	☐	☑	Concentration							
					Mass							
4.13	Bis (2-ethylhexyl) phthalate (117-81-7)	☐	☐	☑	Concentration							
					Mass							
4.14	4-bromophenyl phenyl ether (101-55-3)	☐	☐	☑	Concentration							
					Mass							
4.15	Butyl benzyl phthalate (85-68-7)	☐	☐	☑	Concentration							
					Mass							
4.16	2-chloronaphthalene (91-58-7)	☐	☐	☑	Concentration							
					Mass							
4.17	4-chlorophenyl phenyl ether (7005-72-3)	☐	☐	☑	Concentration							
					Mass							
4.18	Chrysene (218-01-9)	☐	☐	☑	Concentration							
					Mass							
4.19	Dibenzo (a,h) anthracene (53-70-3)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.20	1,2-dichlorobenzene (95-50-1)	☐	☐	☑	Concentration							
					Mass							
4.21	1,3-dichlorobenzene (541-73-1)	☐	☐	☑	Concentration							
					Mass							
4.22	1,4-dichlorobenzene (106-46-7)	☐	☐	☑	Concentration							
					Mass							
4.23	3,3-dichlorobenzidine (91-94-1)	☐	☐	☑	Concentration							
					Mass							
4.24	Diethyl phthalate (84-66-2)	☐	☐	☑	Concentration							
					Mass							
4.25	Dimethyl phthalate (131-11-3)	☐	☐	☑	Concentration							
					Mass							
4.26	Di-n-butyl phthalate (84-74-2)	☐	☐	☑	Concentration							
					Mass							
4.27	2,4-dinitrotoluene (121-14-2)	☐	☐	☑	Concentration							
					Mass							
4.28	2,6-dinitrotoluene (606-20-2)	☐	☐	☑	Concentration							
					Mass							
4.29	Di-n-octyl phthalate (117-84-0)	☐	☐	☑	Concentration							
					Mass							
4.30	1,2-Diphenylhydrazine (as azobenzene) (122-66-7)	☐	☐	☑	Concentration							
					Mass							
4.31	Fluoranthene (206-44-0)	☐	☐	☑	Concentration							
					Mass							
4.32	Fluorene (86-73-7)	☐	☐	☑	Concentration							
					Mass							

EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 13B1

Form Approved 03/05/19
OMB No. 2040-0004

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.33	Hexachlorobenzene (118-74-1)	☐	☐	☑	Concentration							
					Mass							
4.34	Hexachlorobutadiene (87-68-3)	☐	☐	☑	Concentration							
					Mass							
4.35	Hexachlorocyclopentadiene (77-47-4)	☐	☐	☑	Concentration							
					Mass							
4.36	Hexachloroethane (67-72-1)	☐	☐	☑	Concentration							
					Mass							
4.37	Indeno (1,2,3-cd) pyrene (193-39-5)	☐	☐	☑	Concentration							
					Mass							
4.38	Isophorone (78-59-1)	☐	☐	☑	Concentration							
					Mass							
4.39	Naphthalene (91-20-3)	☐	☐	☑	Concentration							
					Mass							
4.40	Nitrobenzene (98-95-3)	☐	☐	☑	Concentration							
					Mass							
4.41	N-nitrosodimethylamine (62-75-9)	☐	☐	☑	Concentration							
					Mass							
4.42	N-nitrosodi-n-propylamine (621-64-7)	☐	☐	☑	Concentration							
					Mass							
4.43	N-nitrosodiphenylamine (86-30-6)	☐	☐	☑	Concentration							
					Mass							
4.44	Phenanthrene (85-01-8)	☐	☐	☑	Concentration							
					Mass							
4.45	Pyrene (129-00-0)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.46	1,2,4-trichlorobenzene (120-82-1)	☐	☐	☑	Concentration							
					Mass							
Section 5. Organic Toxic Pollutants (GC/MS Fraction—Pesticides)												
5.1	Aldrin (309-00-2)	☐	☐	☑	Concentration							
					Mass							
5.2	α-BHC (319-84-6)	☐	☐	☑	Concentration							
					Mass							
5.3	β-BHC (319-85-7)	☐	☐	☑	Concentration							
					Mass							
5.4	γ-BHC (58-89-9)	☐	☐	☑	Concentration							
					Mass							
5.5	δ-BHC (319-86-8)	☐	☐	☑	Concentration							
					Mass							
5.6	Chlordane (57-74-9)	☐	☐	☑	Concentration							
					Mass							
5.7	4,4'-DDT (50-29-3)	☐	☐	☑	Concentration							
					Mass							
5.8	4,4'-DDE (72-55-9)	☐	☐	☑	Concentration							
					Mass							
5.9	4,4'-DDD (72-54-8)	☐	☐	☑	Concentration							
					Mass							
5.10	Dieldrin (60-57-1)	☐	☐	☑	Concentration							
					Mass							
5.11	α-endosulfan (115-29-7)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
5.12	β-endosulfan (115-29-7)	☐	☐	☑	Concentration							
					Mass							
5.13	Endosulfan sulfate (1031-07-8)	☐	☐	☑	Concentration							
					Mass							
5.14	Endrin (72-20-8)	☐	☐	☑	Concentration							
					Mass							
5.15	Endrin aldehyde (7421-93-4)	☐	☐	☑	Concentration							
					Mass							
5.16	Heptachlor (76-44-8)	☐	☐	☑	Concentration							
					Mass							
5.17	Heptachlor epoxide (1024-57-3)	☐	☐	☑	Concentration							
					Mass							
5.18	PCB-1242 (53469-21-9)	☐	☐	☑	Concentration							
					Mass							
5.19	PCB-1254 (11097-69-1)	☐	☐	☑	Concentration							
					Mass							
5.20	PCB-1221 (11104-28-2)	☐	☐	☑	Concentration							
					Mass							
5.21	PCB-1232 (11141-16-5)	☐	☐	☑	Concentration							
					Mass							
5.22	PCB-1248 (12672-29-6)	☐	☐	☑	Concentration							
					Mass							
5.23	PCB-1260 (11096-82-5)	☐	☐	☑	Concentration							
					Mass							
5.24	PCB-1016 (12674-11-2)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
5.25	Toxaphene (8001-35-2)	☐	☐	☑	Concentration							
					Mass							

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you believe all pollutants on Table C to be ***present*** in your discharge from the noted outfall. You need *not* complete the "Presence or Absence" column of Table C for *each* pollutant.										
☐	Check here if you believe all pollutants on Table C to be ***absent*** in your discharge from the noted outfall. You need *not* complete the "Presence or Absence" column of Table C for *each* pollutant.										
1.	Bromide (24959-67-9)	☐	☑	Concentration							
				Mass							
2.	Chlorine, total residual	☐	☑	Concentration							
				Mass							
3.	Color	☑	☐	Concentration	PCU	5.00			1	15.0	1
				Mass							
4.	Fecal coliform	☐	☑	Concentration							
				Mass							
5.	Fluoride (16984-48-8)	☐	☑	Concentration							
				Mass							
6	Nitrate-nitrite	☑	☐	Concentration		0.0747			1	0.154	1
				Mass							
7.	Nitrogen, total organic (as N)	☑	☐	Concentration	ug/L	447			1	157	1
				Mass							
8.	Oil and grease	☑	☐	Concentration	mg/L	<1.69	9.0		39	<2.095	4
				Mass							
9.	Phosphorus (as P), total (7723-14-0)	☑	☐	Concentration	mg/L	0.502			1	0.345	1
				Mass							
10.	Sulfate (as SO_4) (14808-79-8)	☑	☐	Concentration	mg/L	21.7			1	9.38	1
				Mass							
11.	Sulfide (as S)	☑	☐	Concentration	mg/L	<0.033			1	<0.033	1
				Mass							

TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
12.	Sulfite (as SO_3) (14265-45-3)	☐	☑	Concentration							
				Mass							
13.	Surfactants	☑	☐	Concentration	mg/L	<0.017			1	0.0175	1
				Mass							
14.	Aluminum, total (7429-90-5)	☑	☐	Concentration	ug/L	432			1	201	1
				Mass							
15.	Barium, total (7440-39-3)	☑	☐	Concentration	ug/L	29.5			1	23.6	1
				Mass							
16.	Boron, total (7440-42-8)	☑	☐	Concentration	ug/L	45.3			1	17.9	1
				Mass							
17.	Cobalt, total (7440-48-4)	☑	☐	Concentration	ug/L	<0.300			1	0.334	1
				Mass							
18.	Iron, total (7439-89-6)	☑	☐	Concentration	ug/L	63.7			1	248	1
				Mass							
19.	Magnesium, total (7439-95-4)	☑	☐	Concentration	ug/L	8820			1	5270	1
				Mass							
20.	Molybdenum, total (7439-98-7)	☑	☐	Concentration	ug/L	3.27			1	0.377	1
				Mass							
21.	Manganese, total (7439-96-5)	☑	☐	Concentration	ug/L	42.2			1	37.7	1
				Mass							
22.	Tin, total (7440-31-5)	☑	☐	Concentration	ug/L	<1.00			1	<1.00	1
				Mass							
23.	Titanium, total (7440-32-6)	☑	☐	Concentration	ug/L	<2.00			1	3.55	1
				Mass							

TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
24.	**Radioactivity**										
	Alpha, total	☑	☐	Concentration	pCi/L	2.21			1	2.17	1
				Mass							
	Beta, total	☑	☐	Concentration	pCi/L	4.83			1	2.19	1
				Mass							
	Radium, total	☑	☐	Concentration	pCi/L	0.154			1	0.182	1
				Mass							
	Radium 226, total	☑	☐	Concentration	pCi/L	0.535			1	0.199	1
				Mass							

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
1.	Asbestos	☐	☑		
2.	Acetaldehyde	☐	☑		
3.	Allyl alcohol	☐	☑		
4.	Allyl chloride	☐	☑		
5.	Amyl acetate	☐	☑		
6.	Aniline	☐	☑		
7.	Benzonitrile	☐	☑		
8.	Benzyl chloride	☐	☑		
9.	Butyl acetate	☐	☑		
10.	Butylamine	☐	☑		
11.	Captan	☐	☑		
12.	Carbaryl	☐	☑		
13.	Carbofuran	☐	☑		
14.	Carbon disulfide	☐	☑		
15.	Chlorpyrifos	☐	☑		
16.	Coumaphos	☐	☑		
17.	Cresol	☐	☑		
18.	Crotonaldehyde	☐	☑		
19.	Cyclohexane	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
20.	2,4-D (2,4-dichlorophenoxyacetic acid)	☐	☑		
21.	Diazinon	☐	☑		
22.	Dicamba	☐	☑		
23.	Dichlobenil	☐	☑		
24.	Dichlone	☐	☑		
25.	2,2-dichloropropionic acid	☐	☑		
26.	Dichlorvos	☐	☑		
27.	Diethyl amine	☐	☑		
28.	Dimethyl amine	☐	☑		
29.	Dintrobenzene	☐	☑		
30.	Diquat	☐	☑		
31.	Disulfoton	☐	☑		
32.	Diuron	☐	☑		
33.	Epichlorohydrin	☐	☑		
34.	Ethion	☐	☑		
35.	Ethylene diamine	☐	☑		
36.	Ethylene dibromide	☐	☑		
37.	Formaldehyde	☐	☑		
38.	Furfural	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
39.	Guthion	☐	☑		
40.	Isoprene	☐	☑		
41.	Isopropanolamine	☐	☑		
42.	Kelthane	☐	☑		
43.	Kepone	☐	☑		
44.	Malathion	☐	☑		
45.	Mercaptodimethur	☐	☑		
46.	Methoxychlor	☐	☑		
47.	Methyl mercaptan	☐	☑		
48.	Methyl methacrylate	☐	☑		
49.	Methyl parathion	☐	☑		
50.	Mevinphos	☐	☑		
51.	Mexacarbate	☐	☑		
52.	Monoethyl amine	☐	☑		
53.	Monomethyl amine	☐	☑		
54.	Naled	☐	☑		
55.	Naphthenic acid	☐	☑		
56.	Nitrotoluene	☐	☑		
57.	Parathion	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
58.	Phenolsulfonate	☐	☑		
59.	Phosgene	☐	☑		
60.	Propargite	☐	☑		
61.	Propylene oxide	☐	☑		
62.	Pyrethrins	☐	☑		
63.	Quinoline	☐	☑		
64.	Resorcinol	☐	☑		
65.	Strontium	☐	☑		
66.	Strychnine	☐	☑		
67.	Styrene	☐	☑		
68.	2,4,5-T (2,4,5-trichlorophenoxyacetic acid)	☐	☑		
69.	TDE (tetrachlorodiphenyl ethane)	☐	☑		
70.	2,4,5-TP [2-(2,4,5-trichlorophenoxy) propanoic acid]	☐	☑		
71.	Trichlorofon	☐	☑		
72.	Triethanolamine	☐	☑		
73.	Triethylamine	☐	☑		
74.	Trimethylamine	☐	☑		
75.	Uranium	☐	☑		
76.	Vanadium	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
77.	Vinyl acetate	☐	☑		
78.	Xylene	☐	☑		
79.	Xylenol	☐	☑		
80.	Zirconium	☐	☑		

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE E. 2,3,7,8 TETRACHLORODIBENZO P DIOXIN (2,3,7,8 TCDD) (40 CFR 122.21(g)(7)(viii))

Pollutant	TCDD Congeners Used or Manufactured	Presence or Absence (check one)		Results of Screening Procedure
		Believed Present	Believed Absent	
2,3,7,8-TCDD	☐	☐	☑	

TABLE A. CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(iii)) [1]

	Pollutant	Waiver Requested (if applicable)	Units (specify)		Effluent				Intake (Optional)	
					Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you have applied to your NPDES permitting authority for a waiver for *all* of the pollutants listed on this table for the noted outfall.									
1.	Biochemical oxygen demand (BOD_5)	☐	Concentration	mg/l	1.75	14.9		37	1.12	1
			Mass							
2.	Chemical oxygen demand (COD)	☐	Concentration	mg/L	18.6			1	22.3	1
			Mass							
3.	Total organic carbon (TOC)	☐	Concentration	mg/L	4.37			1	1.76	1
			Mass							
4.	Total suspended solids (TSS)	☐	Concentration	mg/L	6.50	28		37	6.90	1
			Mass							
5.	Ammonia (as N)	☐	Concentration	mg/L	0.109			1	0.0864	1
			Mass							
6.	Flow	☐	Rate	mgd		0.4920		37	3044.2	1
7.	Temperature (winter)	☐	°C	°C	10.7			2	11.35	2
	Temperature (summer)	☐	°C	°C						
8.	pH (minimum)	☐	Standard units	s.u.	7.69	7.3		37	7.69	1
	pH (maximum)	☐	Standard units	s.u.	7.71	8.8		37	7.69	1

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 13C1

Form Approved 03/05/19
OMB No. 2040-0004

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you qualify as a small business per the instructions to Form 2C and, therefore, do not need to submit quantitative data for any of the organic toxic pollutants in Sections 2 through 5 of this table. Note, however, that you must still indicate in the appropriate column of this table if you believe any of the pollutants listed are present in your discharge.											
Section 1. Toxic Metals, Cyanide, and Total Phenols												
1.1	Antimony, total (7440-36-0)	☑	☐	☐	Concentration	ug/L	<1.00			1	<1.00	1
					Mass							
1.2	Arsenic, total (7440-38-2)	☑	☐	☐	Concentration	ug/L	<2.00			1	<2.00	1
					Mass							
1.3	Beryllium, total (7440-41-7)	☑	☐	☐	Concentration	ug/L	<0.200			1	<0.200	1
					Mass							
1.4	Cadmium, total (7440-43-9)	☑	☐	☐	Concentration	ug/L	<0.300			1	<0.300	1
					Mass							
1.5	Chromium, total (7440-47-3)	☑	☐	☐	Concentration	ug/L	<3.00			1	<3.00	1
					Mass							
1.6	Copper, total (7440-50-8)	☑	☐	☐	Concentration	ug/L	0.721			1	1.28	1
					Mass							
1.7	Lead, total (7439-92-1)	☑	☐	☐	Concentration	ug/L	<0.500			1	<0.500	1
					Mass							
1.8	Mercury, total (7439-97-6)	☑	☐	☐	Concentration	ug/L	1.42			1	2.04	2
					Mass							
1.9	Nickel, total (7440-02-0)	☑	☐	☐	Concentration	ug/L	0.615			1	<0.600	1
					Mass							
1.10	Selenium, total (7782-49-2)	☑	☐	☐	Concentration	ug/L	<1.50			1	<1.50	1
					Mass							
1.11	Silver, total (7440-22-4)	☑	☐	☐	Concentration	ug/L	<0.300			1	<0.300	1
					Mass							

EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 13C1

Form Approved 03/05/19
OMB No. 2040-0004

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
1.12	Thallium, total (7440-28-0)	☑	☐	☐	Concentration	ug/L	<0.600			1	<0.600	1
					Mass							
1.13	Zinc, total (7440-66-6)	☑	☐	☐	Concentration	ug/L	3.98			1	4.25	1
					Mass							
1.14	Cyanide, total (57-12-5)	☑	☐	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
1.15	Phenols, total	☑	☐	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
Section 2. Organic Toxic Pollutants (GC/MS Fraction—Volatile Compounds)												
2.1	Acrolein (107-02-8)	☑	☐	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.2	Acrylonitrile (107-13-1)	☑	☐	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.3	Benzene (71-43-2)	☑	☐	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.4	Bromoform (75-25-2)	☑	☐	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.5	Carbon tetrachloride (56-23-5)	☑	☐	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.6	Chlorobenzene (108-90-7)	☑	☐	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.7	Chlorodibromomethane (124-48-1)	☑	☐	☐	Concentration	ug/L	0.64			1	<0.333	1
					Mass							
2.8	Chloroethane (75-00-3)	☑	☐	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
2.9	2-chloroethylvinyl ether (110-75-8)	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.10	Chloroform (67-66-3)	☐	☑	☐	Concentration	ug/L	13.4			1	<0.333	1
					Mass							
2.11	Dichlorobromomethane (75-27-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.12	1,1-dichloroethane (75-34-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.13	1,2-dichloroethane (107-06-2)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.14	1,1-dichloroethylene (75-35-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.15	1,2-dichloropropane (78-87-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.16	1,3-dichloropropylene (542-75-6)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.17	Ethylbenzene (100-41-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.18	Methyl bromide (74-83-9)	☐	☑	☐	Concentration	ug/L	<0.337			1	<0.337	1
					Mass							
2.19	Methyl chloride (74-87-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.20	Methylene chloride (75-09-2)	☐	☑	☐	Concentration	ug/L	<0.500			1	<0.500	1
					Mass							
2.21	1,1,2,2- tetrachloroethane (79-34-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
2.22	Tetrachloroethylene (127-18-4)	☐	☑	☐	Concentration	ug/L	<0.333			1		1
					Mass							
2.23	Toluene (108-88-3)	☐	☑	☐	Concentration	ug/L	<0.333			1		1
					Mass							
2.24	1,2-trans-dichloroethylene (156-60-5)	☐	☑	☐	Concentration	ug/L	<0.333			1		1
					Mass							
2.25	1,1,1-trichloroethane (71-55-6)	☐	☑	☐	Concentration	ug/L	<0.333			1		1
					Mass							
2.26	1,1,2-trichloroethane (79-00-5)	☐	☑	☐	Concentration	ug/L	<0.333			1		1
					Mass							
2.27	Trichloroethylene (79-01-6)	☐	☑	☐	Concentration	ug/L	<0.333			1		1
					Mass							
2.28	Vinyl chloride (75-01-4)	☐	☑	☐	Concentration	ug/L	<0.333			1		1
					Mass							
Section 3. Organic Toxic Pollutants (GC/MS Fraction—Acid Compounds)												
3.1	2-chlorophenol (95-57-8)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.2	2,4-dichlorophenol (120-83-2)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.3	2,4-dimethylphenol (105-67-9)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.4	4,6-dinitro-o-cresol (534-52-1)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.5	2,4-dinitrophenol (51-28-5)	☐	☑	☐	Concentration	ug/L	<4.72			1	<4.71	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
3.6	2-nitrophenol (88-75-5)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.7	4-nitrophenol (100-02-7)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.8	p-chloro-m-cresol (59-50-7)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.9	Pentachlorophenol (87-86-5)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.10	Phenol (108-95-2)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
3.11	2,4,6-trichlorophenol (88-05-2)	☐	☑	☐	Concentration	ug/L	<2.83			1	<2.83	1
					Mass							
Section 4. Organic Toxic Pollutants (GC/MS Fraction—Base /Neutral Compounds)												
4.1	Acenaphthene (83-32-9)	☐	☐	☑	Concentration							
					Mass							
4.2	Acenaphthylene (208-96-8)	☐	☐	☑	Concentration							
					Mass							
4.3	Anthracene (120-12-7)	☐	☐	☑	Concentration							
					Mass							
4.4	Benzidine (92-87-5)	☐	☐	☑	Concentration							
					Mass							
4.5	Benzo (a) anthracene (56-55-3)	☐	☐	☑	Concentration							
					Mass							
4.6	Benzo (a) pyrene (50-32-8)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.7	3,4-benzofluoranthene (205-99-2)	☐	☐	☑	Concentration							
					Mass							
4.8	Benzo (ghi) perylene (191-24-2)	☐	☐	☑	Concentration							
					Mass							
4.9	Benzo (k) fluoranthene (207-08-9)	☐	☐	☑	Concentration							
					Mass							
4.10	Bis (2-chloroethoxy) methane (111-91-1)	☐	☐	☑	Concentration							
					Mass							
4.11	Bis (2-chloroethyl) ether (111-44-4)	☐	☐	☑	Concentration							
					Mass							
4.12	Bis (2-chloroisopropyl) ether (102-80-1)	☐	☐	☑	Concentration							
					Mass							
4.13	Bis (2-ethylhexyl) phthalate (117-81-7)	☐	☐	☑	Concentration							
					Mass							
4.14	4-bromophenyl phenyl ether (101-55-3)	☐	☐	☑	Concentration							
					Mass							
4.15	Butyl benzyl phthalate (85-68-7)	☐	☐	☑	Concentration							
					Mass							
4.16	2-chloronaphthalene (91-58-7)	☐	☐	☑	Concentration							
					Mass							
4.17	4-chlorophenyl phenyl ether (7005-72-3)	☐	☐	☑	Concentration							
					Mass							
4.18	Chrysene (218-01-9)	☐	☐	☑	Concentration							
					Mass							
4.19	Dibenzo (a,h) anthracene (53-70-3)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.20	1,2-dichlorobenzene (95-50-1)	☐	☐	☑	Concentration							
					Mass							
4.21	1,3-dichlorobenzene (541-73-1)	☐	☐	☑	Concentration							
					Mass							
4.22	1,4-dichlorobenzene (106-46-7)	☐	☐	☑	Concentration							
					Mass							
4.23	3,3-dichlorobenzidine (91-94-1)	☐	☐	☑	Concentration							
					Mass							
4.24	Diethyl phthalate (84-66-2)	☐	☐	☑	Concentration							
					Mass							
4.25	Dimethyl phthalate (131-11-3)	☐	☐	☑	Concentration							
					Mass							
4.26	Di-n-butyl phthalate (84-74-2)	☐	☐	☑	Concentration							
					Mass							
4.27	2,4-dinitrotoluene (121-14-2)	☐	☐	☑	Concentration							
					Mass							
4.28	2,6-dinitrotoluene (606-20-2)	☐	☐	☑	Concentration							
					Mass							
4.29	Di-n-octyl phthalate (117-84-0)	☐	☐	☑	Concentration							
					Mass							
4.30	1,2-Diphenylhydrazine (as azobenzene) (122-66-7)	☐	☐	☑	Concentration							
					Mass							
4.31	Fluoranthene (206-44-0)	☐	☐	☑	Concentration							
					Mass							
4.32	Fluorene (86-73-7)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.33	Hexachlorobenzene (118-74-1)	☐	☐	☑	Concentration							
					Mass							
4.34	Hexachlorobutadiene (87-68-3)	☐	☐	☑	Concentration							
					Mass							
4.35	Hexachlorocyclopentadiene (77-47-4)	☐	☐	☑	Concentration							
					Mass							
4.36	Hexachloroethane (67-72-1)	☐	☐	☑	Concentration							
					Mass							
4.37	Indeno (1,2,3-cd) pyrene (193-39-5)	☐	☐	☑	Concentration							
					Mass							
4.38	Isophorone (78-59-1)	☐	☐	☑	Concentration							
					Mass							
4.39	Naphthalene (91-20-3)	☐	☐	☑	Concentration							
					Mass							
4.40	Nitrobenzene (98-95-3)	☐	☐	☑	Concentration							
					Mass							
4.41	N-nitrosodimethylamine (62-75-9)	☐	☐	☑	Concentration							
					Mass							
4.42	N-nitrosodi-n-propylamine (621-64-7)	☐	☐	☑	Concentration							
					Mass							
4.43	N-nitrosodiphenylamine (86-30-6)	☐	☐	☑	Concentration							
					Mass							
4.44	Phenanthrene (85-01-8)	☐	☐	☑	Concentration							
					Mass							
4.45	Pyrene (129-00-0)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.46	1,2,4-trichlorobenzene (120-82-1)	☐	☐	☑	Concentration							
					Mass							
Section 5. Organic Toxic Pollutants (GC/MS Fraction—Pesticides)												
5.1	Aldrin (309-00-2)	☐	☐	☑	Concentration							
					Mass							
5.2	α-BHC (319-84-6)	☐	☐	☑	Concentration							
					Mass							
5.3	β-BHC (319-85-7)	☐	☐	☑	Concentration							
					Mass							
5.4	γ-BHC (58-89-9)	☐	☐	☑	Concentration							
					Mass							
5.5	δ-BHC (319-86-8)	☐	☐	☑	Concentration							
					Mass							
5.6	Chlordane (57-74-9)	☐	☐	☑	Concentration							
					Mass							
5.7	4,4'-DDT (50-29-3)	☐	☐	☑	Concentration							
					Mass							
5.8	4,4'-DDE (72-55-9)	☐	☐	☑	Concentration							
					Mass							
5.9	4,4'-DDD (72-54-8)	☐	☐	☑	Concentration							
					Mass							
5.10	Dieldrin (60-57-1)	☐	☐	☑	Concentration							
					Mass							
5.11	α-endosulfan (115-29-7)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
5.12	β-endosulfan (115-29-7)	☐	☐	☑	Concentration							
					Mass							
5.13	Endosulfan sulfate (1031-07-8)	☐	☐	☑	Concentration							
					Mass							
5.14	Endrin (72-20-8)	☐	☐	☑	Concentration							
					Mass							
5.15	Endrin aldehyde (7421-93-4)	☐	☐	☑	Concentration							
					Mass							
5.16	Heptachlor (76-44-8)	☐	☐	☑	Concentration							
					Mass							
5.17	Heptachlor epoxide (1024-57-3)	☐	☐	☑	Concentration							
					Mass							
5.18	PCB-1242 (53469-21-9)	☐	☐	☑	Concentration							
					Mass							
5.19	PCB-1254 (11097-69-1)	☐	☐	☑	Concentration							
					Mass							
5.20	PCB-1221 (11104-28-2)	☐	☐	☑	Concentration							
					Mass							
5.21	PCB-1232 (11141-16-5)	☐	☐	☑	Concentration							
					Mass							
5.22	PCB-1248 (12672-29-6)	☐	☐	☑	Concentration							
					Mass							
5.23	PCB-1260 (11096-82-5)	☐	☐	☑	Concentration							
					Mass							
5.24	PCB-1016 (12674-11-2)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
5.25	Toxaphene (8001-35-2)	☐	☐	☑	Concentration							
					Mass							

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you believe all pollutants on Table C to be ***present*** in your discharge from the noted outfall. You need *not* complete the "Presence or Absence" column of Table C for *each* pollutant.										
☐	Check here if you believe all pollutants on Table C to be ***absent*** in your discharge from the noted outfall. You need *not* complete the "Presence or Absence" column of Table C for *each* pollutant.										
1.	Bromide (24959-67-9)	☐	☑	Concentration							
				Mass							
2.	Chlorine, total residual	☐	☑	Concentration							
				Mass							
3.	Color	☑	☐	Concentration	PCU	30.0			1	15.0	1
				Mass							
4.	Fecal coliform	☐	☑	Concentration							
				Mass							
5.	Fluoride (16984-48-8)	☐	☑	Concentration							
				Mass							
6	Nitrate-nitrite	☑	☐	Concentration	mg/L	0.493			1	0.154	1
				Mass							
7.	Nitrogen, total organic (as N)	☑	☐	Concentration	ug/L	519			1	157	1
				Mass							
8.	Oil and grease	☑	☐	Concentration	mg/L	2.77			4	<2.095	4
				Mass							
9.	Phosphorus (as P), total (7723-14-0)	☑	☐	Concentration	mg/L	0.447			1	0.345	1
				Mass							
10.	Sulfate (as SO_4) (14808-79-8)	☑	☐	Concentration	mg/L	9.51			1	9.38	1
				Mass							
11.	Sulfide (as S)	☑	☐	Concentration	mg/L	<0.033			1	<0.033	1
				Mass							

EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 013C1

Form Approved 03/05/19
OMB No. 2040-0004

TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
12.	Sulfite (as SO_3) (14265-45-3)	☐	☑	Concentration							
				Mass							
13.	Surfactants	☑	☐	Concentration	mg/L	0.0175			1	0.0175	1
				Mass							
14.	Aluminum, total (7429-90-5)	☑	☐	Concentration	ug/L	166			1	201	1
				Mass							
15.	Barium, total (7440-39-3)	☑	☐	Concentration	ug/L	16.0			1	23.6	1
				Mass							
16.	Boron, total (7440-42-8)	☑	☐	Concentration	ug/L	13.4			1	17.9	1
				Mass							
17.	Cobalt, total (7440-48-4)	☑	☐	Concentration	ug/L	<0.300			1	0.334	1
				Mass							
18.	Iron, total (7439-89-6)	☑	☐	Concentration	ug/L	233			1	248	1
				Mass							
19.	Magnesium, total (7439-95-4)	☑	☐	Concentration	ug/L	4120			1	5270	1
				Mass							
20.	Molybdenum, total (7439-98-7)	☑	☐	Concentration	ug/L	2.52			1	0.377	1
				Mass							
21.	Manganese, total (7439-96-5)	☑	☐	Concentration	ug/L	19.8			1	37.7	1
				Mass							
22.	Tin, total (7440-31-5)	☑	☐	Concentration	ug/L	<1.00			1	<1.00	1
				Mass							
23.	Titanium, total (7440-32-6)	☑	☐	Concentration	ug/L	3.53			1	3.55	1
				Mass							

TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
24.	**Radioactivity**										
	Alpha, total	☑	☐	Concentration	pCi/L	-0.0531			1	2.17	1
				Mass							
	Beta, total	☑	☐	Concentration	pCi/L	2.97			1	2.19	1
				Mass							
	Radium, total	☑	☐	Concentration	pCi/L	0.146			1	0.182	1
				Mass							
	Radium 226, total	☑	☐	Concentration	pCi/L	0.734			1	0.169	1
				Mass							

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
1.	Asbestos	☐	☑		
2.	Acetaldehyde	☐	☑		
3.	Allyl alcohol	☐	☑		
4.	Allyl chloride	☐	☑		
5.	Amyl acetate	☐	☑		
6.	Aniline	☐	☑		
7.	Benzonitrile	☐	☑		
8.	Benzyl chloride	☐	☑		
9.	Butyl acetate	☐	☑		
10.	Butylamine	☐	☑		
11.	Captan	☐	☑		
12.	Carbaryl	☐	☑		
13.	Carbofuran	☐	☑		
14.	Carbon disulfide	☐	☑		
15.	Chlorpyrifos	☐	☑		
16.	Coumaphos	☐	☑		
17.	Cresol	☐	☑		
18.	Crotonaldehyde	☐	☑		
19.	Cyclohexane	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
20.	2,4-D (2,4-dichlorophenoxyacetic acid)	☐	☑		
21.	Diazinon	☐	☑		
22.	Dicamba	☐	☑		
23.	Dichlobenil	☐	☑		
24.	Dichlone	☐	☑		
25.	2,2-dichloropropionic acid	☐	☑		
26.	Dichlorvos	☐	☑		
27.	Diethyl amine	☐	☑		
28.	Dimethyl amine	☐	☑		
29.	Dintrobenzene	☐	☑		
30.	Diquat	☐	☑		
31.	Disulfoton	☐	☑		
32.	Diuron	☐	☑		
33.	Epichlorohydrin	☐	☑		
34.	Ethion	☐	☑		
35.	Ethylene diamine	☐	☑		
36.	Ethylene dibromide	☐	☑		
37.	Formaldehyde	☐	☑		
38.	Furfural	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
39.	Guthion	☐	☑		
40.	Isoprene	☐	☑		
41.	Isopropanolamine	☐	☑		
42.	Kelthane	☐	☑		
43.	Kepone	☐	☑		
44.	Malathion	☐	☑		
45.	Mercaptodimethur	☐	☑		
46.	Methoxychlor	☐	☑		
47.	Methyl mercaptan	☐	☑		
48.	Methyl methacrylate	☐	☑		
49.	Methyl parathion	☐	☑		
50.	Mevinphos	☐	☑		
51.	Mexacarbate	☐	☑		
52.	Monoethyl amine	☐	☑		
53.	Monomethyl amine	☐	☑		
54.	Naled	☐	☑		
55.	Naphthenic acid	☐	☑		
56.	Nitrotoluene	☐	☑		
57.	Parathion	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
58.	Phenolsulfonate	☐	☑		
59.	Phosgene	☐	☑		
60.	Propargite	☐	☑		
61.	Propylene oxide	☐	☑		
62.	Pyrethrins	☐	☑		
63.	Quinoline	☐	☑		
64.	Resorcinol	☐	☑		
65.	Strontium	☐	☑		
66.	Strychnine	☐	☑		
67.	Styrene	☐	☑		
68.	2,4,5-T (2,4,5-trichlorophenoxyacetic acid)	☐	☑		
69.	TDE (tetrachlorodiphenyl ethane)	☐	☑		
70.	2,4,5-TP [2-(2,4,5-trichlorophenoxy) propanoic acid]	☐	☑		
71.	Trichlorofon	☐	☑		
72.	Triethanolamine	☐	☑		
73.	Triethylamine	☐	☑		
74.	Trimethylamine	☐	☑		
75.	Uranium	☐	☑		
76.	Vanadium	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
77.	Vinyl acetate	☐	☑		
78.	Xylene	☐	☑		
79.	Xylenol	☐	☑		
80.	Zirconium	☐	☑		

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE E. 2,3,7,8 TETRACHLORODIBENZO P DIOXIN (2,3,7,8 TCDD) (40 CFR 122.21(g)(7)(viii))

Pollutant	TCDD Congeners Used or Manufactured	Presence or Absence (check one)		Results of Screening Procedure
		Believed Present	Believed Absent	
2,3,7,8-TCDD	☐	☐	☑	

TABLE A. CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(iii)) [1]

	Pollutant	Waiver Requested (if applicable)	Units (specify)		Effluent				Intake (Optional)	
					Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you have applied to your NPDES permitting authority for a waiver for *all* of the pollutants listed on this table for the noted outfall.									
1.	Biochemical oxygen demand (BOD_5)	☐	Concentration	mg/L	<1.00			1	1.12	1
			Mass							
2.	Chemical oxygen demand (COD)	☐	Concentration	mg/L	<8.95			1	22.3	1
			Mass							
3.	Total organic carbon (TOC)	☐	Concentration	mg/L	2.37			1	1.76	1
			Mass							
4.	Total suspended solids (TSS)	☐	Concentration	mg/L	13.3			1	6.90	1
			Mass							
5.	Ammonia (as N)	☐	Concentration	mg/L	0.155			1	0.0864	1
			Mass							
6.	Flow	☐	Rate	mgd	0.144			1	3044.2	1
7.	Temperature (winter)	☐	°C	°C	21.4			1	11.35	2
	Temperature (summer)	☐	°C	°C						
8.	pH (minimum)	☐	Standard units	s.u.	6.83			1	7.69	1
	pH (maximum)	☐	Standard units	s.u.	6.84			1	7.69	1

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 0051

Form Approved 03/05/19
OMB No. 2040-0004

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you qualify as a small business per the instructions to Form 2C and, therefore, do not need to submit quantitative data for any of the organic toxic pollutants in Sections 2 through 5 of this table. Note, however, that you must still indicate in the appropriate column of this table if you believe any of the pollutants listed are present in your discharge.											
Section 1. Toxic Metals, Cyanide, and Total Phenols												
1.1	Antimony, total (7440-36-0)	☐	☑	☐	Concentration	ug/L	<1.00			1	<1.00	1
					Mass							
1.2	Arsenic, total (7440-38-2)	☐	☑	☐	Concentration	ug/L	<2.00			1	<2.00	1
					Mass							
1.3	Beryllium, total (7440-41-7)	☐	☑	☐	Concentration	ug/L	<0.200			1	<0.200	1
					Mass							
1.4	Cadmium, total (7440-43-9)	☐	☑	☐	Concentration	ug/L	<0.300			1	<0.300	1
					Mass							
1.5	Chromium, total (7440-47-3)	☐	☑	☐	Concentration	ug/L	<3.00			1	<3.00	1
					Mass							
1.6	Copper, total (7440-50-8)	☐	☑	☐	Concentration	ug/L	2.85			1	1.28	1
					Mass							
1.7	Lead, total (7439-92-1)	☐	☑	☐	Concentration	ug/L	0.872			1	<0.500	1
					Mass							
1.8	Mercury, total (7439-97-6)	☐	☑	☐	Concentration	ng/L	1.88			1	2.04	4
					Mass							
1.9	Nickel, total (7440-02-0)	☐	☑	☐	Concentration	ug/L	0.901			1	<6.00	1
					Mass							
1.10	Selenium, total (7782-49-2)	☐	☑	☐	Concentration	ug/L	<1.50			1	<1.50	1
					Mass							
1.11	Silver, total (7440-22-4)	☐	☑	☐	Concentration	ug/L	<0.300			1	<0.300	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
1.12	Thallium, total (7440-28-0)	☐	☑	☐	Concentration	ug/L	<0.600			1	<0.600	1
					Mass							
1.13	Zinc, total (7440-66-6)	☐	☑	☐	Concentration	ug/L	176			1	4.25	1
					Mass							
1.14	Cyanide, total (57-12-5)	☐	☑	☐	Concentration	ug/L	<1.67			1	<5.00	1
					Mass							
1.15	Phenols, total	☐	☑	☐	Concentration	ug/L	2.02			1	<2.82	1
					Mass							
Section 2. Organic Toxic Pollutants (GC/MS Fraction—Volatile Compounds)												
2.1	Acrolein (107-02-8)	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.2	Acrylonitrile (107-13-1)	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.3	Benzene (71-43-2)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.4	Bromoform (75-25-2)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.5	Carbon tetrachloride (56-23-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.6	Chlorobenzene (108-90-7)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.7	Chlorodibromomethane (124-48-1)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.8	Chloroethane (75-00-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
2.9	2-chloroethylvinyl ether (110-75-8)	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.10	Chloroform (67-66-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.11	Dichlorobromomethane (75-27-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.12	1,1-dichloroethane (75-34-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.13	1,2-dichloroethane (107-06-2)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.14	1,1-dichloroethylene (75-35-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.15	1,2-dichloropropane (78-87-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.16	1,3-dichloropropylene (542-75-6)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.17	Ethylbenzene (100-41-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.18	Methyl bromide (74-83-9)	☐	☑	☐	Concentration	ug/L	<0.337			1	<0.337	1
					Mass							
2.19	Methyl chloride (74-87-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.20	Methylene chloride (75-09-2)	☐	☑	☐	Concentration	ug/L	<0.500			1	<0.500	1
					Mass							
2.21	1,1,2,2- tetrachloroethane (79-34-5)	☐	☑	☐	Concentration	ug/L	<0.500			1	<0.333	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
2.22	Tetrachloroethylene (127-18-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.23	Toluene (108-88-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.24	1,2-trans-dichloroethylene (156-60-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.25	1,1,1-trichloroethane (71-55-6)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.26	1,1,2-trichloroethane (79-00-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.27	Trichloroethylene (79-01-6)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.28	Vinyl chloride (75-01-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
Section 3. Organic Toxic Pollutants (GC/MS Fraction—Acid Compounds)												
3.1	2-chlorophenol (95-57-8)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.2	2,4-dichlorophenol (120-83-2)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.3	2,4-dimethylphenol (105-67-9)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.4	4,6-dinitro-o-cresol (534-52-1)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.5	2,4-dinitrophenol (51-28-5)	☐	☑	☐	Concentration	ug/L	<4.67			1	<4.71	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
3.6	2-nitrophenol (88-75-5)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.7	4-nitrophenol (100-02-7)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.8	p-chloro-m-cresol (59-50-7)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.9	Pentachlorophenol (87-86-5)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.10	Phenol (108-95-2)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.11	2,4,6-trichlorophenol (88-05-2)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
Section 4. Organic Toxic Pollutants (GC/MS Fraction—Base /Neutral Compounds)												
4.1	Acenaphthene (83-32-9)	☐	☐	☑	Concentration							
					Mass							
4.2	Acenaphthylene (208-96-8)	☐	☐	☑	Concentration							
					Mass							
4.3	Anthracene (120-12-7)	☐	☐	☑	Concentration							
					Mass							
4.4	Benzidine (92-87-5)	☐	☐	☑	Concentration							
					Mass							
4.5	Benzo (a) anthracene (56-55-3)	☐	☐	☑	Concentration							
					Mass							
4.6	Benzo (a) pyrene (50-32-8)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.7	3,4-benzofluoranthene (205-99-2)	☐	☐	☑	Concentration							
					Mass							
4.8	Benzo (ghi) perylene (191-24-2)	☐	☐	☑	Concentration							
					Mass							
4.9	Benzo (k) fluoranthene (207-08-9)	☐	☐	☑	Concentration							
					Mass							
4.10	Bis (2-chloroethoxy) methane (111-91-1)	☐	☐	☑	Concentration							
					Mass							
4.11	Bis (2-chloroethyl) ether (111-44-4)	☐	☐	☑	Concentration							
					Mass							
4.12	Bis (2-chloroisopropyl) ether (102-80-1)	☐	☐	☑	Concentration							
					Mass							
4.13	Bis (2-ethylhexyl) phthalate (117-81-7)	☐	☐	☑	Concentration							
					Mass							
4.14	4-bromophenyl phenyl ether (101-55-3)	☐	☐	☑	Concentration							
					Mass							
4.15	Butyl benzyl phthalate (85-68-7)	☐	☐	☑	Concentration							
					Mass							
4.16	2-chloronaphthalene (91-58-7)	☐	☐	☑	Concentration							
					Mass							
4.17	4-chlorophenyl phenyl ether (7005-72-3)	☐	☐	☑	Concentration							
					Mass							
4.18	Chrysene (218-01-9)	☐	☐	☑	Concentration							
					Mass							
4.19	Dibenzo (a,h) anthracene (53-70-3)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.20	1,2-dichlorobenzene (95-50-1)	☐	☐	☑	Concentration							
					Mass							
4.21	1,3-dichlorobenzene (541-73-1)	☐	☐	☑	Concentration							
					Mass							
4.22	1,4-dichlorobenzene (106-46-7)	☐	☐	☑	Concentration							
					Mass							
4.23	3,3-dichlorobenzidine (91-94-1)	☐	☐	☑	Concentration							
					Mass							
4.24	Diethyl phthalate (84-66-2)	☐	☐	☑	Concentration							
					Mass							
4.25	Dimethyl phthalate (131-11-3)	☐	☐	☑	Concentration							
					Mass							
4.26	Di-n-butyl phthalate (84-74-2)	☐	☐	☑	Concentration							
					Mass							
4.27	2,4-dinitrotoluene (121-14-2)	☐	☐	☑	Concentration							
					Mass							
4.28	2,6-dinitrotoluene (606-20-2)	☐	☐	☑	Concentration							
					Mass							
4.29	Di-n-octyl phthalate (117-84-0)	☐	☐	☑	Concentration							
					Mass							
4.30	1,2-Diphenylhydrazine (as azobenzene) (122-66-7)	☐	☐	☑	Concentration							
					Mass							
4.31	Fluoranthene (206-44-0)	☐	☐	☑	Concentration							
					Mass							
4.32	Fluorene (86-73-7)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.33	Hexachlorobenzene (118-74-1)	☐	☐	☑	Concentration							
					Mass							
4.34	Hexachlorobutadiene (87-68-3)	☐	☐	☑	Concentration							
					Mass							
4.35	Hexachlorocyclopentadiene (77-47-4)	☐	☐	☑	Concentration							
					Mass							
4.36	Hexachloroethane (67-72-1)	☐	☐	☑	Concentration							
					Mass							
4.37	Indeno (1,2,3-cd) pyrene (193-39-5)	☐	☐	☑	Concentration							
					Mass							
4.38	Isophorone (78-59-1)	☐	☐	☑	Concentration							
					Mass							
4.39	Naphthalene (91-20-3)	☐	☐	☑	Concentration							
					Mass							
4.40	Nitrobenzene (98-95-3)	☐	☐	☑	Concentration							
					Mass							
4.41	N-nitrosodimethylamine (62-75-9)	☐	☐	☑	Concentration							
					Mass							
4.42	N-nitrosodi-n-propylamine (621-64-7)	☐	☐	☑	Concentration							
					Mass							
4.43	N-nitrosodiphenylamine (86-30-6)	☐	☐	☑	Concentration							
					Mass							
4.44	Phenanthrene (85-01-8)	☐	☐	☑	Concentration							
					Mass							
4.45	Pyrene (129-00-0)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.46	1,2,4-trichlorobenzene (120-82-1)	☐	☐	☑	Concentration							
					Mass							
Section 5. Organic Toxic Pollutants (GC/MS Fraction—Pesticides)												
5.1	Aldrin (309-00-2)	☐	☐	☑	Concentration							
					Mass							
5.2	α-BHC (319-84-6)	☐	☐	☑	Concentration							
					Mass							
5.3	β-BHC (319-85-7)	☐	☐	☑	Concentration							
					Mass							
5.4	γ-BHC (58-89-9)	☐	☐	☑	Concentration							
					Mass							
5.5	δ-BHC (319-86-8)	☐	☐	☑	Concentration							
					Mass							
5.6	Chlordane (57-74-9)	☐	☐	☑	Concentration							
					Mass							
5.7	4,4'-DDT (50-29-3)	☐	☐	☑	Concentration							
					Mass							
5.8	4,4'-DDE (72-55-9)	☐	☐	☑	Concentration							
					Mass							
5.9	4,4'-DDD (72-54-8)	☐	☐	☑	Concentration							
					Mass							
5.10	Dieldrin (60-57-1)	☐	☐	☑	Concentration							
					Mass							
5.11	α-endosulfan (115-29-7)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
5.12	β-endosulfan (115-29-7)	☐	☐	☑	Concentration							
					Mass							
5.13	Endosulfan sulfate (1031-07-8)	☐	☐	☑	Concentration							
					Mass							
5.14	Endrin (72-20-8)	☐	☐	☑	Concentration							
					Mass							
5.15	Endrin aldehyde (7421-93-4)	☐	☐	☑	Concentration							
					Mass							
5.16	Heptachlor (76-44-8)	☐	☐	☑	Concentration							
					Mass							
5.17	Heptachlor epoxide (1024-57-3)	☐	☐	☑	Concentration							
					Mass							
5.18	PCB-1242 (53469-21-9)	☐	☐	☑	Concentration							
					Mass							
5.19	PCB-1254 (11097-69-1)	☐	☐	☑	Concentration							
					Mass							
5.20	PCB-1221 (11104-28-2)	☐	☐	☑	Concentration							
					Mass							
5.21	PCB-1232 (11141-16-5)	☐	☐	☑	Concentration							
					Mass							
5.22	PCB-1248 (12672-29-6)	☐	☐	☑	Concentration							
					Mass							
5.23	PCB-1260 (11096-82-5)	☐	☐	☑	Concentration							
					Mass							
5.24	PCB-1016 (12674-11-2)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
5.25	Toxaphene (8001-35-2)	☐	☐	☑	Concentration							
					Mass							

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 0051

Form Approved 03/05/19
OMB No. 2040-0004

TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you believe all pollutants on Table C to be ***present*** in your discharge from the noted outfall. You need *not* complete the "Presence or Absence" column of Table C for *each* pollutant.										
☐	Check here if you believe all pollutants on Table C to be ***absent*** in your discharge from the noted outfall. You need *not* complete the "Presence or Absence" column of Table C for *each* pollutant.										
1.	Bromide (24959-67-9)	☐	☑	Concentration							
				Mass							
2.	Chlorine, total residual	☐	☑	Concentration							
				Mass							
3.	Color	☑	☐	Concentration	PSU				1	15.0	1
				Mass							
4.	Fecal coliform	☐	☑	Concentration							
				Mass							
5.	Fluoride (16984-48-8)	☐	☑	Concentration							
				Mass							
6	Nitrate-nitrite	☑	☐	Concentration	mg/L				1	0.154	1
				Mass							
7.	Nitrogen, total organic (as N)	☑	☐	Concentration	ug/L				1	157	1
				Mass							
8.	Oil and grease	☑	☐	Concentration	mg/L				4	<2.095	4
				Mass							
9.	Phosphorus (as P), total (7723-14-0)	☑	☐	Concentration	mg/L				1	0.345	1
				Mass							
10.	Sulfate (as SO_4) (14808-79-8)	☑	☐	Concentration	mg/L				1	9.38	1
				Mass							
11.	Sulfide (as S)	☑	☐	Concentration	mg/L				1	<0.033	1
				Mass							

TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
12.	Sulfite (as SO_3) (14265-45-3)	☐	☑	Concentration							
				Mass							
13.	Surfactants	☑	☐	Concentration					1	0.0175	1
				Mass							
14.	Aluminum, total (7429-90-5)	☑	☐	Concentration					1	201	1
				Mass							
15.	Barium, total (7440-39-3)	☑	☐	Concentration					1	23.6	1
				Mass							
16.	Boron, total (7440-42-8)	☑	☐	Concentration					1	17.9	1
				Mass							
17.	Cobalt, total (7440-48-4)	☑	☐	Concentration					1	0.334	1
				Mass							
18.	Iron, total (7439-89-6)	☑	☐	Concentration					1	248	1
				Mass							
19.	Magnesium, total (7439-95-4)	☑	☐	Concentration					1	5270	1
				Mass							
20.	Molybdenum, total (7439-98-7)	☑	☐	Concentration					1	0.377	1
				Mass							
21.	Manganese, total (7439-96-5)	☑	☐	Concentration					1	37.7	1
				Mass							
22.	Tin, total (7440-31-5)	☑	☐	Concentration					1	<1.00	1
				Mass							
23.	Titanium, total (7440-32-6)	☑	☐	Concentration					1	3.55	1
				Mass							

TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
24.	**Radioactivity**										
	Alpha, total	☑	☐	Concentration	pCi/L	1.53			1	2.17	1
				Mass							
	Beta, total	☑	☐	Concentration	pCi/L	3.20			1	2.19	1
				Mass							
	Radium, total	☑	☐	Concentration	pCi/L	0.284			1	0.182	1
				Mass							
	Radium 226, total	☑	☐	Concentration	pCi/L	0.335			1	0.199	1
				Mass							

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
1.	Asbestos	☐	☑		
2.	Acetaldehyde	☐	☑		
3.	Allyl alcohol	☐	☑		
4.	Allyl chloride	☐	☑		
5.	Amyl acetate	☐	☑		
6.	Aniline	☐	☑		
7.	Benzonitrile	☐	☑		
8.	Benzyl chloride	☐	☑		
9.	Butyl acetate	☐	☑		
10.	Butylamine	☐	☑		
11.	Captan	☐	☑		
12.	Carbaryl	☐	☑		
13.	Carbofuran	☐	☑		
14.	Carbon disulfide	☐	☑		
15.	Chlorpyrifos	☐	☑		
16.	Coumaphos	☐	☑		
17.	Cresol	☐	☑		
18.	Crotonaldehyde	☐	☑		
19.	Cyclohexane	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
20.	2,4-D (2,4-dichlorophenoxyacetic acid)	☐	☑		
21.	Diazinon	☐	☑		
22.	Dicamba	☐	☑		
23.	Dichlobenil	☐	☑		
24.	Dichlone	☐	☑		
25.	2,2-dichloropropionic acid	☐	☑		
26.	Dichlorvos	☐	☑		
27.	Diethyl amine	☐	☑		
28.	Dimethyl amine	☐	☑		
29.	Dintrobenzene	☐	☑		
30.	Diquat	☐	☑		
31.	Disulfoton	☐	☑		
32.	Diuron	☐	☑		
33.	Epichlorohydrin	☐	☑		
34.	Ethion	☐	☑		
35.	Ethylene diamine	☐	☑		
36.	Ethylene dibromide	☐	☑		
37.	Formaldehyde	☐	☑		
38.	Furfural	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
39.	Guthion	☐	☑		
40.	Isoprene	☐	☑		
41.	Isopropanolamine	☐	☑		
42.	Kelthane	☐	☑		
43.	Kepone	☐	☑		
44.	Malathion	☐	☑		
45.	Mercaptodimethur	☐	☑		
46.	Methoxychlor	☐	☑		
47.	Methyl mercaptan	☐	☑		
48.	Methyl methacrylate	☐	☑		
49.	Methyl parathion	☐	☑		
50.	Mevinphos	☐	☑		
51.	Mexacarbate	☐	☑		
52.	Monoethyl amine	☐	☑		
53.	Monomethyl amine	☐	☑		
54.	Naled	☐	☑		
55.	Naphthenic acid	☐	☑		
56.	Nitrotoluene	☐	☑		
57.	Parathion	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
58.	Phenolsulfonate	☐	☑		
59.	Phosgene	☐	☑		
60.	Propargite	☐	☑		
61.	Propylene oxide	☐	☑		
62.	Pyrethrins	☐	☑		
63.	Quinoline	☐	☑		
64.	Resorcinol	☐	☑		
65.	Strontium	☐	☑		
66.	Strychnine	☐	☑		
67.	Styrene	☐	☑		
68.	2,4,5-T (2,4,5-trichlorophenoxyacetic acid)	☐	☑		
69.	TDE (tetrachlorodiphenyl ethane)	☐	☑		
70.	2,4,5-TP [2-(2,4,5-trichlorophenoxy) propanoic acid]	☐	☑		
71.	Trichlorofon	☐	☑		
72.	Triethanolamine	☐	☑		
73.	Triethylamine	☐	☑		
74.	Trimethylamine	☐	☑		
75.	Uranium	☐	☑		
76.	Vanadium	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
77.	Vinyl acetate	☐	☑		
78.	Xylene	☐	☑		
79.	Xylenol	☐	☑		
80.	Zirconium	☐	☑		

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE E. 2,3,7,8 TETRACHLORODIBENZO P DIOXIN (2,3,7,8 TCDD) (40 CFR 122.21(g)(7)(viii))

Pollutant	TCDD Congeners Used or Manufactured	Presence or Absence (check one)		Results of Screening Procedure
		Believed Present	Believed Absent	
2,3,7,8-TCDD	☐	☐	☑	

Pinson, Theo

From: Phillips, Craig Lee <clphillips@tva.gov>
Sent: Thursday, October 12, 2023 9:29 AM
To: Pinson, Theo
Subject: BFN TRC follow-up

Mr. Pinson,

I apologize for the delay but it has took longer than I had hoped to get information back from the chemistry folks. Our current treatment strategy is the best strategy they have to control microbial growth while ensuring that no chlorine is being released into the river.

BACKGROUND

The Condenser Circulating Water (CCW) System provides the ultimate heat sink for the thermodynamic cycle at BFN. Waste heat is rejected to the CCW system via the main condensers, and subsequently to the environment. The CCW System also provides the source of water to auxiliary cooling water systems such as Residual Heat Removal Water(RHRSW), Emergency Equipment Cooling Water (EECW), Raw Cooling Water (RCW), and dilution of low-level rad waste. The CCW System is designed to provide a flow of approximately 675,000 gpm per unit to the Main Condenser during normal CCW operation (open mode- no cooling towers in-service). An additional flow of approximately 25,000 gpm is supplied to the Raw Cooling Water Systems. Therefore, at the BFN Intake Pumping Station, the three CCW pumps supply a combined flow of approximately 700,000 gpm.

During summer periods, the increasing ambient temperature results in the CCW System inlet temperature increasing which reduces the differential temperature between the Main Turbine exhaust steam and the CCW cooling water. The effect is an increased backpressure with each of the Main Condenser zones.

Microbiological growth rates increase during the summer months as ambient temperature increases. The microbiological organisms attach and grow on plant equipment surfaces which are exposed to raw water, such as the Main Condenser tubes. The microbiological growth produces a surface coating (fouling) on the Main Condenser tubes reducing effective heat from the tube surface to the raw water (CCW). The CCW system is treated at a minimum, Weekly for Microbiological growth once river temperatures are greater than 60°F to combat the microbial growth and reduce backpressure. Treatment can continue at
temperatures below 60°F if needed, to increase thermal performance of a Units Condenser.

TREATMENT STRATEGY

Chemistry treats the CCW system with sodium hypochlorite and a surfactant. Sodium bisulfite is used to detox the CCW system before it returns to the river. A sample is taken at the outfall every hour during treatment to ensure no chlorine is being released into the river.
Monochloramine is an alternate chemical that BFN has been approved to use for the treating of the CCW system.

Thanks,

Craig L. Phillips
Specialist, Water Permits, Compliance, & Monitoring
Regulatory Environmental Programs

TENNESSEE VALLEY AUTHORITY

M. 865-599-6183 **E.** clphillips@tva.gov
400 West Summit Hill Drive, Knoxville, TN 37902

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TABLE A. CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(iii)) [1]

	Pollutant	Waiver Requested (if applicable)	Units (specify)		Effluent				Intake (Optional)	
					Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you have applied to your NPDES permitting authority for a waiver for *all* of the pollutants listed on this table for the noted outfall.									
1.	Biochemical oxygen demand (BOD_5)	☐	Concentration	mg/L	<1.00			1	1.12	1
			Mass							
2.	Chemical oxygen demand (COD)	☐	Concentration	mg/L	<8.95			1	22.3	1
			Mass							
3.	Total organic carbon (TOC)	☐	Concentration	mg/L	2.37			1	1.76	1
			Mass							
4.	Total suspended solids (TSS)	☐	Concentration	mg/L	13.3			1	6.90	1
			Mass							
5.	Ammonia (as N)	☐	Concentration	mg/L	0.155			1	0.0864	1
			Mass							
6.	Flow	☐	Rate	mgd	0.144			1	3044.2	1
7.	Temperature (winter)	☐	°C	°C	21.4			1	11.35	2
	Temperature (summer)	☐	°C	°C						
8.	pH (minimum)	☐	Standard units	s.u.	6.83			1	7.69	1
	pH (maximum)	☐	Standard units	s.u.	6.84			1	7.69	1

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 0051

Form Approved 03/05/19
OMB No. 2040-0004

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you qualify as a small business per the instructions to Form 2C and, therefore, do not need to submit quantitative data for any of the organic toxic pollutants in Sections 2 through 5 of this table. Note, however, that you must still indicate in the appropriate column of this table if you believe any of the pollutants listed are present in your discharge.											
Section 1. Toxic Metals, Cyanide, and Total Phenols												
1.1	Antimony, total (7440-36-0)	☐	☑	☐	Concentration	ug/L	<1.00			1	<1.00	1
					Mass							
1.2	Arsenic, total (7440-38-2)	☐	☑	☐	Concentration	ug/L	<2.00			1	<2.00	1
					Mass							
1.3	Beryllium, total (7440-41-7)	☐	☑	☐	Concentration	ug/L	<0.200			1	<0.200	1
					Mass							
1.4	Cadmium, total (7440-43-9)	☐	☑	☐	Concentration	ug/L	<0.300			1	<0.300	1
					Mass							
1.5	Chromium, total (7440-47-3)	☐	☑	☐	Concentration	ug/L	<3.00			1	<3.00	1
					Mass							
1.6	Copper, total (7440-50-8)	☐	☑	☐	Concentration	ug/L	2.85			1	1.28	1
					Mass							
1.7	Lead, total (7439-92-1)	☐	☑	☐	Concentration	ug/L	0.872			1	<0.500	1
					Mass							
1.8	Mercury, total (7439-97-6)	☐	☑	☐	Concentration	ng/L	1.88			1	2.04	4
					Mass							
1.9	Nickel, total (7440-02-0)	☐	☑	☐	Concentration	ug/L	0.901			1	<6.00	1
					Mass							
1.10	Selenium, total (7782-49-2)	☐	☑	☐	Concentration	ug/L	<1.50			1	<1.50	1
					Mass							
1.11	Silver, total (7440-22-4)	☐	☑	☐	Concentration	ug/L	<0.300			1	<0.300	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
1.12	Thallium, total (7440-28-0)	☐	☑	☐	Concentration	ug/L	<0.600			1	<0.600	1
					Mass							
1.13	Zinc, total (7440-66-6)	☐	☑	☐	Concentration	ug/L	176			1	4.25	1
					Mass							
1.14	Cyanide, total (57-12-5)	☐	☑	☐	Concentration	ug/L	<1.67			1	<5.00	1
					Mass							
1.15	Phenols, total	☐	☑	☐	Concentration	ug/L	2.02			1	<2.82	1
					Mass							
Section 2. Organic Toxic Pollutants (GC/MS Fraction—Volatile Compounds)												
2.1	Acrolein (107-02-8)	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.2	Acrylonitrile (107-13-1)	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.3	Benzene (71-43-2)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.4	Bromoform (75-25-2)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.5	Carbon tetrachloride (56-23-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.6	Chlorobenzene (108-90-7)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.7	Chlorodibromomethane (124-48-1)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.8	Chloroethane (75-00-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
2.9	2-chloroethylvinyl ether (110-75-8)	☐	☑	☐	Concentration	ug/L	<1.67			1	<1.67	1
					Mass							
2.10	Chloroform (67-66-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.11	Dichlorobromomethane (75-27-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.12	1,1-dichloroethane (75-34-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.13	1,2-dichloroethane (107-06-2)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.14	1,1-dichloroethylene (75-35-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.15	1,2-dichloropropane (78-87-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.16	1,3-dichloropropylene (542-75-6)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.17	Ethylbenzene (100-41-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.18	Methyl bromide (74-83-9)	☐	☑	☐	Concentration	ug/L	<0.337			1	<0.337	1
					Mass							
2.19	Methyl chloride (74-87-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.20	Methylene chloride (75-09-2)	☐	☑	☐	Concentration	ug/L	<0.500			1	<0.500	1
					Mass							
2.21	1,1,2,2- tetrachloroethane (79-34-5)	☐	☑	☐	Concentration	ug/L	<0.500			1	<0.333	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
2.22	Tetrachloroethylene (127-18-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.23	Toluene (108-88-3)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.24	1,2-trans-dichloroethylene (156-60-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.25	1,1,1-trichloroethane (71-55-6)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.26	1,1,2-trichloroethane (79-00-5)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.27	Trichloroethylene (79-01-6)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
2.28	Vinyl chloride (75-01-4)	☐	☑	☐	Concentration	ug/L	<0.333			1	<0.333	1
					Mass							
Section 3. Organic Toxic Pollutants (GC/MS Fraction—Acid Compounds)												
3.1	2-chlorophenol (95-57-8)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.2	2,4-dichlorophenol (120-83-2)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.3	2,4-dimethylphenol (105-67-9)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.4	4,6-dinitro-o-cresol (534-52-1)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.5	2,4-dinitrophenol (51-28-5)	☐	☑	☐	Concentration	ug/L	<4.67			1	<4.71	1
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
3.6	2-nitrophenol (88-75-5)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.7	4-nitrophenol (100-02-7)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.8	p-chloro-m-cresol (59-50-7)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.9	Pentachlorophenol (87-86-5)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.10	Phenol (108-95-2)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
3.11	2,4,6-trichlorophenol (88-05-2)	☐	☑	☐	Concentration	ug/L	<2.80			1	<2.83	1
					Mass							
Section 4. Organic Toxic Pollutants (GC/MS Fraction—Base /Neutral Compounds)												
4.1	Acenaphthene (83-32-9)	☐	☐	☑	Concentration							
					Mass							
4.2	Acenaphthylene (208-96-8)	☐	☐	☑	Concentration							
					Mass							
4.3	Anthracene (120-12-7)	☐	☐	☑	Concentration							
					Mass							
4.4	Benzidine (92-87-5)	☐	☐	☑	Concentration							
					Mass							
4.5	Benzo (a) anthracene (56-55-3)	☐	☐	☑	Concentration							
					Mass							
4.6	Benzo (a) pyrene (50-32-8)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.7	3,4-benzofluoranthene (205-99-2)	☐	☐	☑	Concentration							
					Mass							
4.8	Benzo (ghi) perylene (191-24-2)	☐	☐	☑	Concentration							
					Mass							
4.9	Benzo (k) fluoranthene (207-08-9)	☐	☐	☑	Concentration							
					Mass							
4.10	Bis (2-chloroethoxy) methane (111-91-1)	☐	☐	☑	Concentration							
					Mass							
4.11	Bis (2-chloroethyl) ether (111-44-4)	☐	☐	☑	Concentration							
					Mass							
4.12	Bis (2-chloroisopropyl) ether (102-80-1)	☐	☐	☑	Concentration							
					Mass							
4.13	Bis (2-ethylhexyl) phthalate (117-81-7)	☐	☐	☑	Concentration							
					Mass							
4.14	4-bromophenyl phenyl ether (101-55-3)	☐	☐	☑	Concentration							
					Mass							
4.15	Butyl benzyl phthalate (85-68-7)	☐	☐	☑	Concentration							
					Mass							
4.16	2-chloronaphthalene (91-58-7)	☐	☐	☑	Concentration							
					Mass							
4.17	4-chlorophenyl phenyl ether (7005-72-3)	☐	☐	☑	Concentration							
					Mass							
4.18	Chrysene (218-01-9)	☐	☐	☑	Concentration							
					Mass							
4.19	Dibenzo (a,h) anthracene (53-70-3)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.20	1,2-dichlorobenzene (95-50-1)	☐	☐	☑	Concentration							
					Mass							
4.21	1,3-dichlorobenzene (541-73-1)	☐	☐	☑	Concentration							
					Mass							
4.22	1,4-dichlorobenzene (106-46-7)	☐	☐	☑	Concentration							
					Mass							
4.23	3,3-dichlorobenzidine (91-94-1)	☐	☐	☑	Concentration							
					Mass							
4.24	Diethyl phthalate (84-66-2)	☐	☐	☑	Concentration							
					Mass							
4.25	Dimethyl phthalate (131-11-3)	☐	☐	☑	Concentration							
					Mass							
4.26	Di-n-butyl phthalate (84-74-2)	☐	☐	☑	Concentration							
					Mass							
4.27	2,4-dinitrotoluene (121-14-2)	☐	☐	☑	Concentration							
					Mass							
4.28	2,6-dinitrotoluene (606-20-2)	☐	☐	☑	Concentration							
					Mass							
4.29	Di-n-octyl phthalate (117-84-0)	☐	☐	☑	Concentration							
					Mass							
4.30	1,2-Diphenylhydrazine (as azobenzene) (122-66-7)	☐	☐	☑	Concentration							
					Mass							
4.31	Fluoranthene (206-44-0)	☐	☐	☑	Concentration							
					Mass							
4.32	Fluorene (86-73-7)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.33	Hexachlorobenzene (118-74-1)	☐	☐	☑	Concentration							
					Mass							
4.34	Hexachlorobutadiene (87-68-3)	☐	☐	☑	Concentration							
					Mass							
4.35	Hexachlorocyclopentadiene (77-47-4)	☐	☐	☑	Concentration							
					Mass							
4.36	Hexachloroethane (67-72-1)	☐	☐	☑	Concentration							
					Mass							
4.37	Indeno (1,2,3-cd) pyrene (193-39-5)	☐	☐	☑	Concentration							
					Mass							
4.38	Isophorone (78-59-1)	☐	☐	☑	Concentration							
					Mass							
4.39	Naphthalene (91-20-3)	☐	☐	☑	Concentration							
					Mass							
4.40	Nitrobenzene (98-95-3)	☐	☐	☑	Concentration							
					Mass							
4.41	N-nitrosodimethylamine (62-75-9)	☐	☐	☑	Concentration							
					Mass							
4.42	N-nitrosodi-n-propylamine (621-64-7)	☐	☐	☑	Concentration							
					Mass							
4.43	N-nitrosodiphenylamine (86-30-6)	☐	☐	☑	Concentration							
					Mass							
4.44	Phenanthrene (85-01-8)	☐	☐	☑	Concentration							
					Mass							
4.45	Pyrene (129-00-0)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
4.46	1,2,4-trichlorobenzene (120-82-1)	☐	☐	☑	Concentration							
					Mass							
Section 5. Organic Toxic Pollutants (GC/MS Fraction—Pesticides)												
5.1	Aldrin (309-00-2)	☐	☐	☑	Concentration							
					Mass							
5.2	α-BHC (319-84-6)	☐	☐	☑	Concentration							
					Mass							
5.3	β-BHC (319-85-7)	☐	☐	☑	Concentration							
					Mass							
5.4	γ-BHC (58-89-9)	☐	☐	☑	Concentration							
					Mass							
5.5	δ-BHC (319-86-8)	☐	☐	☑	Concentration							
					Mass							
5.6	Chlordane (57-74-9)	☐	☐	☑	Concentration							
					Mass							
5.7	4,4'-DDT (50-29-3)	☐	☐	☑	Concentration							
					Mass							
5.8	4,4'-DDE (72-55-9)	☐	☐	☑	Concentration							
					Mass							
5.9	4,4'-DDD (72-54-8)	☐	☐	☑	Concentration							
					Mass							
5.10	Dieldrin (60-57-1)	☐	☐	☑	Concentration							
					Mass							
5.11	α-endosulfan (115-29-7)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
5.12	β-endosulfan (115-29-7)	☐	☐	☑	Concentration							
					Mass							
5.13	Endosulfan sulfate (1031-07-8)	☐	☐	☑	Concentration							
					Mass							
5.14	Endrin (72-20-8)	☐	☐	☑	Concentration							
					Mass							
5.15	Endrin aldehyde (7421-93-4)	☐	☐	☑	Concentration							
					Mass							
5.16	Heptachlor (76-44-8)	☐	☐	☑	Concentration							
					Mass							
5.17	Heptachlor epoxide (1024-57-3)	☐	☐	☑	Concentration							
					Mass							
5.18	PCB-1242 (53469-21-9)	☐	☐	☑	Concentration							
					Mass							
5.19	PCB-1254 (11097-69-1)	☐	☐	☑	Concentration							
					Mass							
5.20	PCB-1221 (11104-28-2)	☐	☐	☑	Concentration							
					Mass							
5.21	PCB-1232 (11141-16-5)	☐	☐	☑	Concentration							
					Mass							
5.22	PCB-1248 (12672-29-6)	☐	☐	☑	Concentration							
					Mass							
5.23	PCB-1260 (11096-82-5)	☐	☐	☑	Concentration							
					Mass							
5.24	PCB-1016 (12674-11-2)	☐	☐	☑	Concentration							
					Mass							

TABLE B. TOXIC METALS, CYANIDE, TOTAL PHENOLS, AND ORGANIC TOXIC POLLUTANTS (40 CFR 122.21(g)(7)(v))[1]

	Pollutant/Parameter (and CAS Number, if available)	Testing Required	Presence or Absence (check one)		Units (specify)		Effluent				Intake (optional)	
			Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
5.25	Toxaphene (8001-35-2)	☐	☐	☑	Concentration							
					Mass							

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 0051

Form Approved 03/05/19
OMB No. 2040-0004

TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
☐	Check here if you believe all pollutants on Table C to be ***present*** in your discharge from the noted outfall. You need *not* complete the "Presence or Absence" column of Table C for *each* pollutant.										
☐	Check here if you believe all pollutants on Table C to be ***absent*** in your discharge from the noted outfall. You need *not* complete the "Presence or Absence" column of Table C for *each* pollutant.										
1.	Bromide (24959-67-9)	☐	☑	Concentration							
				Mass							
2.	Chlorine, total residual	☐	☑	Concentration							
				Mass							
3.	Color	☑	☐	Concentration	PSU				1	15.0	1
				Mass							
4.	Fecal coliform	☐	☑	Concentration							
				Mass							
5.	Fluoride (16984-48-8)	☐	☑	Concentration							
				Mass							
6	Nitrate-nitrite	☑	☐	Concentration	mg/L				1	0.154	1
				Mass							
7.	Nitrogen, total organic (as N)	☑	☐	Concentration	ug/L				1	157	1
				Mass							
8.	Oil and grease	☑	☐	Concentration	mg/L				4	<2.095	4
				Mass							
9.	Phosphorus (as P), total (7723-14-0)	☑	☐	Concentration	mg/L				1	0.345	1
				Mass							
10.	Sulfate (as SO_4) (14808-79-8)	☑	☐	Concentration	mg/L				1	9.38	1
				Mass							
11.	Sulfide (as S)	☑	☐	Concentration	mg/L				1	<0.033	1
				Mass							

TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
12.	Sulfite (as SO_3) (14265-45-3)	☐	☑	Concentration							
				Mass							
13.	Surfactants	☑	☐	Concentration					1	0.0175	1
				Mass							
14.	Aluminum, total (7429-90-5)	☑	☐	Concentration					1	201	1
				Mass							
15.	Barium, total (7440-39-3)	☑	☐	Concentration					1	23.6	1
				Mass							
16.	Boron, total (7440-42-8)	☑	☐	Concentration					1	17.9	1
				Mass							
17.	Cobalt, total (7440-48-4)	☑	☐	Concentration					1	0.334	1
				Mass							
18.	Iron, total (7439-89-6)	☑	☐	Concentration					1	248	1
				Mass							
19.	Magnesium, total (7439-95-4)	☑	☐	Concentration					1	5270	1
				Mass							
20.	Molybdenum, total (7439-98-7)	☑	☐	Concentration					1	0.377	1
				Mass							
21.	Manganese, total (7439-96-5)	☑	☐	Concentration					1	37.7	1
				Mass							
22.	Tin, total (7440-31-5)	☑	☐	Concentration					1	<1.00	1
				Mass							
23.	Titanium, total (7440-32-6)	☑	☐	Concentration					1	3.55	1
				Mass							

TABLE C. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.21(g)(7)(vi))[1]

	Pollutant	Presence or Absence (check one)		Units (specify)		Effluent				Intake (Optional)	
		Believed Present	Believed Absent			Maximum Daily Discharge (required)	Maximum Monthly Discharge (if available)	Long-Term Average Daily Discharge (if available)	Number of Analyses	Long-Term Average Value	Number of Analyses
24.	**Radioactivity**										
	Alpha, total	☑	☐	Concentration	pCi/L	1.53			1	2.17	1
				Mass							
	Beta, total	☑	☐	Concentration	pCi/L	3.20			1	2.19	1
				Mass							
	Radium, total	☑	☐	Concentration	pCi/L	0.284			1	0.182	1
				Mass							
	Radium 226, total	☑	☐	Concentration	pCi/L	0.335			1	0.199	1
				Mass							

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
1.	Asbestos	☐	☑		
2.	Acetaldehyde	☐	☑		
3.	Allyl alcohol	☐	☑		
4.	Allyl chloride	☐	☑		
5.	Amyl acetate	☐	☑		
6.	Aniline	☐	☑		
7.	Benzonitrile	☐	☑		
8.	Benzyl chloride	☐	☑		
9.	Butyl acetate	☐	☑		
10.	Butylamine	☐	☑		
11.	Captan	☐	☑		
12.	Carbaryl	☐	☑		
13.	Carbofuran	☐	☑		
14.	Carbon disulfide	☐	☑		
15.	Chlorpyrifos	☐	☑		
16.	Coumaphos	☐	☑		
17.	Cresol	☐	☑		
18.	Crotonaldehyde	☐	☑		
19.	Cyclohexane	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
20.	2,4-D (2,4-dichlorophenoxyacetic acid)	☐	☑		
21.	Diazinon	☐	☑		
22.	Dicamba	☐	☑		
23.	Dichlobenil	☐	☑		
24.	Dichlone	☐	☑		
25.	2,2-dichloropropionic acid	☐	☑		
26.	Dichlorvos	☐	☑		
27.	Diethyl amine	☐	☑		
28.	Dimethyl amine	☐	☑		
29.	Dintrobenzene	☐	☑		
30.	Diquat	☐	☑		
31.	Disulfoton	☐	☑		
32.	Diuron	☐	☑		
33.	Epichlorohydrin	☐	☑		
34.	Ethion	☐	☑		
35.	Ethylene diamine	☐	☑		
36.	Ethylene dibromide	☐	☑		
37.	Formaldehyde	☐	☑		
38.	Furfural	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
39.	Guthion	☐	☑		
40.	Isoprene	☐	☑		
41.	Isopropanolamine	☐	☑		
42.	Kelthane	☐	☑		
43.	Kepone	☐	☑		
44.	Malathion	☐	☑		
45.	Mercaptodimethur	☐	☑		
46.	Methoxychlor	☐	☑		
47.	Methyl mercaptan	☐	☑		
48.	Methyl methacrylate	☐	☑		
49.	Methyl parathion	☐	☑		
50.	Mevinphos	☐	☑		
51.	Mexacarbate	☐	☑		
52.	Monoethyl amine	☐	☑		
53.	Monomethyl amine	☐	☑		
54.	Naled	☐	☑		
55.	Naphthenic acid	☐	☑		
56.	Nitrotoluene	☐	☑		
57.	Parathion	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
58.	Phenolsulfonate	☐	☑		
59.	Phosgene	☐	☑		
60.	Propargite	☐	☑		
61.	Propylene oxide	☐	☑		
62.	Pyrethrins	☐	☑		
63.	Quinoline	☐	☑		
64.	Resorcinol	☐	☑		
65.	Strontium	☐	☑		
66.	Strychnine	☐	☑		
67.	Styrene	☐	☑		
68.	2,4,5-T (2,4,5-trichlorophenoxyacetic acid)	☐	☑		
69.	TDE (tetrachlorodiphenyl ethane)	☐	☑		
70.	2,4,5-TP [2-(2,4,5-trichlorophenoxy) propanoic acid]	☐	☑		
71.	Trichlorofon	☐	☑		
72.	Triethanolamine	☐	☑		
73.	Triethylamine	☐	☑		
74.	Trimethylamine	☐	☑		
75.	Uranium	☐	☑		
76.	Vanadium	☐	☑		

TABLE D. CERTAIN HAZARDOUS SUBSTANCES AND ASBESTOS (40 CFR 122.21(g)(7)(vii))[1]

	Pollutant	Presence or Absence (check one)		Reason Pollutant Believed Present in Discharge	Available Quantitative Data (specify units)
		Believed Present	Believed Absent		
77.	Vinyl acetate	☐	☑		
78.	Xylene	☐	☑		
79.	Xylenol	☐	☑		
80.	Zirconium	☐	☑		

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE E. 2,3,7,8 TETRACHLORODIBENZO P DIOXIN (2,3,7,8 TCDD) (40 CFR 122.21(g)(7)(viii))

Pollutant	TCDD Congeners Used or Manufactured	Presence or Absence (check one)		Results of Screening Procedure
		Believed Present	Believed Absent	
2,3,7,8-TCDD	☐	☐	☑	

FORM **2C** NPDES

EPA

U. S. ENVIRONMENTAL PROTECTION AGENCY

APPLICATION FOR PERMIT TO DISCHARGE WASTEWATER

EXISTING MANUFACTURING, COMMERCIAL, MINING AND SILVICULTURAL OPERATIONS

Consolidated Permits Program

I. OUTFALL LOCATION

For each outfall, list the latitude and longitude of its location to the nearest 15 seconds and the name of the receiving water.

A. OUTFALL NUMBER *(list)*	B. LATITUDE			C. LONGITUDE			D. RECEIVING WATER *(name)*
	1. DEG.	2. MIN	3. SEC.	1. DEG.	2. MIN.	3. SEC.	
0011	34	42	15	87	07	15	Tennessee River
0012	34	42	15	87	07	15	Tennessee River
01B1	34	42	15	87	07	15	Tennessee River via DSN001 (internal monitoring point)
0051	34	42	15	87	07	15	Tennessee River
0013AY	34	42	6	87	6	59	Tennessee River via DSN013Y
013B1	34	43	00	87	07	00	Tennessee River via DSN013Y
013C1	34	42	30	87	07	00	Tennessee River via DSN013Y
013Y	34	42	3	87	6	58	Tennessee River
014	34	42	22	87	6	12	Tennessee River
017Y	34	41	57	87	6	45	Tennessee River
018Y	34	41	58	87	6	38	Tennessee River
019Y	34	42	3	87	6	16	Tennessee River
024Y	34	42	22	87	6	12	Tennessee River via unnamed tributary

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EPA Identification Number	NPDES Permit Number	Facility Name	Form Approved 03/05/19 OMB No. 2040-0004
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	

Form 2F NPDES

U.S Environmental Protection Agency
Application for NPDES Permit to Discharge Wastewater

STORMWATER DISCHARGES ASSOCIATED WITH INDUSTRIAL ACTIVITY

SECTION 1. OUTFALL LOCATION (40 CFR 122.21(g)(1))

Outfall Location

1.1 Provide information on each of the facility's outfalls in the table below

Outfall Number	Receiving Water Name	Latitude	Longitude
	See attachment	° ' "	° ' "
		° ' "	° ' "
		° ' "	° ' "
		° ' "	° ' "
		° ' "	° ' "
		° ' "	° ' "

SECTION 2. IMPROVEMENTS (40 CFR 122.21(g)(6))

Improvements

2.1 Are you presently required by any federal, state, or local authority to meet an implementation schedule for constructing, upgrading, or operating wastewater treatment equipment or practices or any other environmental programs that could affect the discharges described in this application?

☐ Yes ☑ No ➔ SKIP to Section 3.

2.2 Briefly identify each applicable project in the table below.

Brief Identification and Description of Project	Affected Outfalls (list outfall numbers)	Source(s) of Discharge	Final Compliance Dates	
			Required	Projected

2.3 Have you attached sheets describing any additional water pollution control programs (or other environmental projects that may affect your discharges) that you now have underway or planned? (Optional Item)

☐ Yes ☐ No

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SECTION 3. SITE DRAINAGE MAP (40 CFR 122.26(c)(1)(i)(A))

Site Drainage Map

3.1 Have you attached a site drainage map containing all required information to this application? (See instructions for specific guidance.)

☑ Yes ☐ No

SECTION 4. POLLUTANT SOURCES (40 CFR 122.26(c)(1)(i)(B))

Pollutant Sources

4.1 Provide information on the facility's pollutant sources in the table below.

Outfall Number	Impervious Surface Area (within a mile radius of the facility)		Total Surface Area Drained (within a mile radius of the facility)	
	See Attachment	*specify units*		*specify units*
		specify units		*specify units*
		specify units		*specify units*
		specify units		*specify units*
		specify units		*specify units*
		specify units		*specify units*

4.2 Provide a narrative description of the facility's significant material in the space below. (See instructions for content requirements.)

See EPA Form 2F Attachment 1

4.3 Provide the location and a description of existing structural and non-structural control measures to reduce pollutants in stormwater runoff. (See instructions for specific guidance.)

Stormwater Treatment		
Outfall Number	Control Measures and Treatment	Codes from Exhibit 2F–1 (list)
	See EPA Form 2F Attachment 1	

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SECTION 5. NON STORMWATER DISCHARGES (40 CFR 122.26(c)(1)(i)(C))

Non-Stormwater Discharges

5.1 *I certify under penalty of law that the outfall(s) covered by this application have been tested or evaluated for the presence of non-stormwater discharges. Moreover, I certify that the outfalls identified as having non-stormwater discharges are described in either an accompanying NPDES Form 2C, 2D, or 2E application.*

Name (print or type first and last name)	Official title
Manu Sivaraman	Site Vice President
Signature	**Date signed**
	12/19/2022

5.2 Provide the testing information requested in the table below.

Outfall Number	Description of Testing Method Used	Date(s) of Testing	Onsite Drainage Points Directly Observed During Test
	See EPA Form 2F Attachment 1		

SECTION 6. SIGNIFICANT LEAKS OR SPILLS (40 CFR 122.26(c)(1)(i)(D))

Significant Leaks or Spills

6.1 Describe any significant leaks or spills of toxic or hazardous pollutants in the last three years.

There have been no significant leaks or spills of toxic or hazardous pollutants at the facility during the last three years.

SECTION 7. DISCHARGE INFORMATION (40 CFR 122.26(c)(1)(i)(E))

Discharge Information

See the instructions to determine the pollutants and parameters you are required to monitor and, in turn, the tables you must complete. Not all applicants need to complete each table.

7.1 Is this a new source or new discharge?

☐ Yes ➔ See instructions regarding submission of *estimated* data.

☑ No ➔ See instructions regarding submission of *actual* data.

Tables A, B, C, and D

7.2 Have you completed Table A for each outfall?

☑ Yes ☐ No

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Discharge Information Continued		
	7.3	Is the facility subject to an effluent limitation guideline (ELG) or effluent limitations in an NPDES permit for its process wastewater? ☑ Yes ☐ No ➔ SKIP to Item 7.5.
	7.4	Have you completed Table B by providing quantitative data for those pollutants that are (1) limited either directly or indirectly in an ELG and/or (2) subject to effluent limitations in an NPDES permit for the facility's process wastewater? ☑ Yes ☐ No
	7.5	Do you know or have reason to believe any pollutants in Exhibit 2F–2 are present in the discharge? ☐ Yes ☑ No ➔ SKIP to Item 7.7.
	7.6	Have you listed all pollutants in Exhibit 2F–2 that you know or have reason to believe are present in the discharge and provided quantitative data or an explanation for those pollutants in Table C? ☐ Yes ☐ No
	7.7	Do you qualify for a small business exemption under the criteria specified in the Instructions? ☐ Yes ➔SKIP to Item 7.18. ☑ No
	7.8	Do you know or have reason to believe any pollutants in Exhibit 2F–3 are present in the discharge? ☑ Yes ☐ No ➔ SKIP to Item 7.10.
	7.9	Have you listed all pollutants in Exhibit 2F–3 that you know or have reason to believe are present in the discharge in Table C? ☑ Yes ☐ No
	7.10	Do you expect any of the pollutants in Exhibit 2F–3 to be discharged in concentrations of 10 ppb or greater? ☐ Yes ☑ No ➔ SKIP to Item 7.12.
	7.11	Have you provided quantitative data in Table C for those pollutants in Exhibit 2F–3 that you expect to be discharged in concentrations of 10 ppb or greater? ☐ Yes ☐ No
	7.12	Do you expect acrolein, acrylonitrile, 2,4-dinitrophenol, or 2-methyl-4,6-dinitrophenol to be discharged in concentrations of 100 ppb or greater? ☐ Yes ☑ No ➔ SKIP to Item 7.14.
	7.13	Have you provided quantitative data in Table C for the pollutants identified in Item 7.12 that you expect to be discharged in concentrations of 100 ppb or greater? ☐ Yes ☐ No
	7.14	Have you provided quantitative data or an explanation in Table C for pollutants you expect to be present in the discharge at concentrations less than 10 ppb (or less than 100 ppb for the pollutants identified in Item 7.12)? ☑ Yes ☐ No
	7.15	Do you know or have reason to believe any pollutants in Exhibit 2F–4 are present in the discharge? ☐ Yes ☑ No ➔ SKIP to Item 7.17.
	7.16	Have you listed pollutants in Exhibit 2F–4 that you know or believe to be present in the discharge and provided an explanation in Table C? ☐ Yes ☐ No
	7.17	Have you provided information for the storm event(s) sampled in Table D? ☑ Yes ☐ No

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Discharge Information Continued

Used or Manufactured Toxics

7.18 Is any pollutant listed on Exhibits 2F–2 through 2F–4 a substance or a component of a substance used or manufactured as an intermediate or final product or byproduct?

☐ Yes ☑ No ➔ SKIP to Section 8.

7.19 List the pollutants below, including TCDD if applicable.

1.	4.	7.
2.	5.	8.
3.	6.	9.

SECTION 8. BIOLOGICAL TOXICITY TESTING DATA (40 CFR 122.21(g)(11))

Biological Toxicity Testing Data

8.1 Do you have any knowledge or reason to believe that any biological test for acute or chronic toxicity has been made on any of your discharges or on a receiving water in relation to your discharge within the last three years?

☑ Yes ☐ No ➔ SKIP to Section 9. 12/19/2022

8.2 Identify the tests and their purposes below.

Test(s)	Purpose of Test(s)	Submitted to NPDES Permitting Authority?	Date Submitted
WET	biomonitoring	☑ Yes ☐ No	01/27/2022
		☐ Yes ☐ No	
		☐ Yes ☐ No	

SECTION 9. CONTRACT ANALYSIS INFORMATION (40 CFR 122.21(g)(12))

Contract Analysis Information

9.1 Were any of the analyses reported in Section 7 (on Tables A through C) performed by a contract laboratory or consulting firm?

☐ Yes ☐ No ➔ SKIP to Section 10.

9.2 Provide information for each contract laboratory or consulting firm below.

	Laboratory Number 1	Laboratory Number 2	Laboratory Number 3
Name of laboratory/firm	GEL Laboratories, LLC		
Laboratory address	2040 Savage Road Charleston, SC 29407		
Phone number	(846) 556-8171		
Pollutant(s) analyzed	All pollutants except field parameters.		

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SECTION 10. CHECKLIST AND CERTIFICATION STATEMENT (40 CFR 122.22(a) and (d))

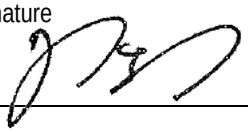
Checklist and Certification Statement

10.1 In Column 1 below, mark the sections of Form 2F that you have completed and are submitting with your application. For each section, specify in Column 2 any attachments that you are enclosing to alert the permitting authority. Note that not all applicants are required to complete all sections or provide attachments.

Column 1	Column 2
☑ Section 1	☐ w/ attachments (e.g., responses for additional outfalls)
☑ Section 2	☐ w/ attachments
☑ Section 3	☐ w/ site drainage map
☑ Section 4	☐ w/ attachments
☑ Section 5	☐ w/ attachments
☑ Section 6	☑ w/ attachments
☑ Section 7	☑ Table A ☐ w/ small business exemption request ☑ Table B ☐ w/ analytical results as an attachment ☑ Table C ☑ Table D
☑ Section 8	☐ w/attachments
☑ Section 9	☐ w/attachments (e.g., responses for additional contact laboratories or firms)
☑ Section 10	☐

10.2 Certification Statement

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name (print or type first and last name)	Official title
Manu Sivaraman	Site Vice President
Signature 	Date signed 12/19/2022

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IV. Narrative Description of Pollutant Sources, B-C

BFN's Spill Prevention Control and Countermeasures (SPCC) Plan is the basic non-structural control for reducing pollutants in storm water runoff. It incorporates best management practices into daily activities conducted on site and is available for review at all times. BFN has instituted a Chemical Traffic Control Plan for the purpose of ensuring that all chemicals brought on site are reviewed are reviewed to prevent the usage of hazardous materials when a non-hazardous material substitute is available. The plan also ensures the proper use, storage, and disposal of all chemicals used at the facility.

DSN 013

DSN 013 receives storm water from the Environmental and Meteorology offices parking lot, the northeast corner of the Training Center parking lot, a storm drain located between the two sedimentation ponds, and from a gravel parking lot and grassy area located south of the Environmental and Meteorology offices (i.e., approximately 1.8 acres of grassed area and 5.0 acres of impervious surfaces). DSN 013 also receives storm water drainage from DSN 013A and process water discharges from DSN 013B prior to discharging to the Tennessee River. DSNs 013A and 013B were sampled at their respective discharge points in accordance with the requirements of the renewal application.

DSN 013A

DSN 013A receives storm water from the 4kV Capacitor Yard, the main plant transformer yard, the switchyard, the parking lot east of and part of the parking lot west of the Wastewater Lagoons, and the grassland north of the east parking lot (i.e., approximately 40.5 acres of impervious area and 54 acres of grassed area). The capacitor yard, the transformer yard, and the switchyard contain only non-PCB, oil-filled equipment. The transformer yard contains two 37,000-gallon mineral oil tanks (abandoned in place) and one 1,500-gallon above-ground diesel storage tank. DSN 013A is provided with secondary containment to prevent oil spills from reaching the river by the presence of a concrete oil skimmer and weir.

DSN 013A also receives wastewater discharged from DSN 013C, the Wastewater Lagoons which includes treated sanitary waste, waste from a photo-processing lab, a metal-processing lab, a medical lab, blowdown from the Training Center's chiller system, flush water from the standby liquid control system and from various cooler and air compressor cleanings, waste from insulator showers used by personnel involved with periodic asbestos stripping and handling operations, and rain water. DSN 013A discharges to DSN 013 which in turn discharges to the Tennessee River.

DSN 014

DSN 014 is located northwest of the cooling towers, and receives drainage from two roads (approximately 5 acres), grassland (approximately 174 acres), and offsite farmland located on the north and northwest sides of the facility. DSN 014 discharges directly to the Tennessee River. Because monitoring is not required for this outfall in the current NPDES permit and because it receives drainage from areas with no industrial activity as defined in 40 CFR122.26(b)(14), it was not monitored for the permit renewal application.

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DSN 017

DSN 017 receives storm water runoff from an approximately 6-acre area (approximately 3 acres of which is impervious area) which includes the Training Center and the Live Well Center parking lots, the Training Center roof, and grassed/wooded land. DSN 017 discharges directly into the Tennessee River. In addition to storm water, DSN 017 receives fire system flush water from a municipal source.

DSN 018

DSN 018 receives storm water from the Materials and Procurement Complex (MPC) parking lot, the firing range parking lot, the Facilities Maintenance area, the vehicle fuel dispensing area, part of the parking lot southwest of the MPC, and from adjacent grassed area (approximately 18.8 acres of impervious drainage and 15.4 acres of grassed land). The MPC includes several enclosed chemical staging areas (e.g., for paints, solvents, oil, and lubricants). DSN 018 discharges directly to the Tennessee River.

DSN 019

DSN 019 receives storm water drainage from the east site drainage area (i.e., 101.1 acres of grassed land, 48 acres of impervious area including a small borrow pit, the Fire Training Area, the Low Level Radwaste Storage Facility, the inert landfill, and the 180-day Hazardous Waste Storage Area. These areas contain kerosene, gasoline, and diesel tanks; a flammable storage area; Facilities Satellite Storage area; a diesel fire pump and fuel tank; oil and used drum storage areas; and hazardous and mixed waste storage area. DSN 019 discharges to the Tennessee River.

DSN 024

DSN 024 is located along the facility's east property boundary and discharges to an adjacent farmland. This outfall receives storm water drainage from offsite grassland, offsite farmland located north of the facility, and from a vehicle servicing and mechanic shop located just south of the northeast corner of the site (approximately 75.9 acres of grassland and 8.4 acres of impervious surfaces). The shop includes a covered storage area for solvents, oils, and lubricants.

ADEM Watermark

EPA Form 2F Attachment 1

I. Outfall Location							
For each outfall, list the latitude and longitude of its location to the nearest 15 seconds and the name of the receiving water.							
A. Outfall Number *(list)*	B. Latitude			C. Longitude			D. Receiving Water *(name)*
013	34	43	00	87	07	00	Tennessee River
013A	34	42	00	87	07	00	Tennessee River via outfall 013
014*	34	43	00	87	07	30	Tennessee River
017	34	42	00	87	07	00	Tennessee River
018	34	42	00	87	06	45	Tennessee River
019	34	42	00	87	06	15	Tennessee River
024	34	42	30	87	06	30	Tennessee River via offsite ditch and farmland
*Because no monitoring is required of 014 and because this outfalls receive only storm water runoff							
from areas with no industrial activity, no sample was collected for this permit renewal application.							

ADEM Watermark

Outfall Number	Area of Impervious Surface (provide units)	Total Area Drained (provide units)	Outfall Number	Area of Impervious Surface (provide units)	Total Area Drained (provide units)
013	5.0 acres	6.8 acres	018	18.8 acres	34.2 acres
013A	40.5 acres	94.5 acres	019	48.0 acres	156.7 acres
014	5.0 acres	174 acres	024	8.4 acres	84.3 acres
017	3.0 acres	6.0 acres			

ADEM Watermark

EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 013

Form Approved 03/05/19
OMB No. 2040-0004

TABLE A. CONVENTIONAL AND NON CONVENTIONAL PARAMETERS (40 CFR 122.26(c)(1)(i)(E)(3))[1]

You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details and requirements.

	Pollutant or Parameter	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
		Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
1.	Oil and grease	<5.88 mg/L		<5.88 mg/L		1	
2.	Biochemical oxygen demand (BOD_5)	NA	4.94 mg/L	NA	4.94 mg/L	1	
3.	Chemical oxygen demand (COD)	<20 mg/L	NA	NA	NA	1	
4.	Total suspended solids (TSS)	NA	124 mg/L	NA	124 mg/L	1	
5.	Total phosphorus	<0.100 mg/L	NA	NA	<0.100 mg/L	1	
6.	Total Kjeldahl nitrogen (TKN)	NA	0.320 mg/L	NA	0.320 mg/L	1	
7.	Total nitrogen (as N)	NA	0.582 mg/L	NA	0.582 mg/L	1	
8.	pH (minimum)	8.10		8.10		1	
	pH (maximum)	8.23		8.23		1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE B. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(A))[1]

List each pollutant that is limited in an effluent limitation guideline (ELG) that the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Napthalene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Cobalt	<0.002 mg/L	<0.002 mg/L	NA	NA	1	
Aluminum	0.377 mg/L	0.463 mg/L	NA	NA	1	
Boron	<0.200 m/L	<0.200 mg/L	NA	NA	1	
Iron	0.284 mg/L	0.325 mg/L	NA	NA	1	
Magnesium	<1.00 mg/L	1.07 mg/L	NA	NA	1	
Manganese	0.111 mg/L	0.0375 mg/L	NA	NA	1	
Molybdenum	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
Tin	<0.004 mg/L	<0.004 mg/L	NA	NA	1	
Titanium	<0.010 mg/L	<0.010 mg/L	NA	NA	1	
Antimony	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
Arsenic	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Barium	0.0132 mg/L	0.00940 mg/L	NA	NA	1	
Beryllium	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Cadmium	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Chromium	<0.020 mg/L	<0.020 mg/L	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE C. TOXIC POLLUTANTS, CERTAIN HAZARDOUS SUBSTANCES, AND ASBESTOS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(B) and (vii))[1]

List each pollutant shown in Exhibits 2F–2, 2F–3, and 2F–4 that you know or have reason to believe is present. Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Acrolein	<0.0500 ug/L	<0.0500 ug/L	NA	NA	1	
Acrylonitrile	<0.0100 ug/L	<0.0100 ug/L	NA	NA	1	
Benzene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Bromoform	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Carbon tetrachloride	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Chlorobenzene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Chlorodibromomethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Chloroethane	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
2-Chloroethyl vinyl ether	<0.0500 mg/L	<0.0500 mg/L	NA	NA	1	
Chloroform	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
1,3-Dichloropropene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Dichlorobromomethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Dichlorodifluoromethane	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
1,1-Dichloroethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
1,2-Dichloroethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
1,1-Dichloroethene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE C. TOXIC POLLUTANTS, CERTAIN HAZARDOUS SUBSTANCES, AND ASBESTOS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(B) and (vii))[1]

List each pollutant shown in Exhibits 2F–2, 2F–3, and 2F–4 that you know or have reason to believe is present. Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
1,2-Dichloropropane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Ethylebenzene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Methyl bromide	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
Methyl chloride	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Methylene chloride	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
1,1,2,2-Tetrachloroethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Tetrachlorethene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Toluene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
trans-1,2-Dichloroethene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
trans-1,3-Dichloropropene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
1,1,1-Trichloroethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
1,1,2-Trichloroethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Trichloroethylene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Trichlorofluoromethane	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
Vinyl chloride	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Color	250 PCU	250 PCU	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 013

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TABLE C. TOXIC POLLUTANTS, CERTAIN HAZARDOUS SUBSTANCES, AND ASBESTOS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(B) and (vii))[1]

List each pollutant shown in Exhibits 2F–2, 2F–3, and 2F–4 that you know or have reason to believe is present. Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Total Residual Chlorine	<0.05 mg/L	NA	NA	NA	1	
Temperature	16.7 C	NA	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE D. STORM EVENT INFORMATION (40 CFR 122.26(c)(1)(i)(E)(6))

Provide data for the storm event(s) that resulted in the maximum daily discharges for the flow-weighted composite sample.

Date of Storm Event	Duration of Storm Event (in hours)	Total Rainfall During Storm Event (in inches)	Number of Hours Between Beginning of Storm Measured and End of Previous Measurable Rain Event	Maximum Flow Rate During Rain Event (in gpm or specify units)	Total Flow from Rain Event (in gallons or specify units)
01/03/2023	14	1.26	80	6.0734 MGD	32.4201 MGD

Provide a description of the method of flow measurement or estimate.

Flow was measured at an existing weir.

Note Fecal coliform was re-sampled 02/09/2023. Duration of the 2/9 storm event was 8 hours. The number of hours between beginning of storm measured and end of previous measurable rain event was 149 hours. The flow at time of collection was 1.4435127 MGD

EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 013A

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TABLE A. CONVENTIONAL AND NON CONVENTIONAL PARAMETERS (40 CFR 122.26(c)(1)(i)(E)(3))[1]

You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details and requirements.

	Pollutant or Parameter	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
		Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
1.	Oil and grease	<5.68 mg/L		NA		1	
2.	Biochemical oxygen demand (BOD_5)	5.20 mg/L	5.54 mg/L	NA	NA	1	
3.	Chemical oxygen demand (COD)	<20.0 mg/L	NA	NA	NA	1	
4.	Total suspended solids (TSS)	23.1 mg/L	25.6 mg/L	NA	NA	1	
5.	Total phosphorus	0.231 mg/L	NA	NA	NA	1	
6.	Total Kjeldahl nitrogen (TKN)	0.646 mg/L	0.648 mg/L	NA	NA	1	
7.	Total nitrogen (as N)	1.26 mg/L	1.16 mg/L	NA	NA	1	
8.	pH (minimum)	7.51 SU		NA		1	
	pH (maximum)	7.53 SU		NA		1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE B. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(A))[1]

List each pollutant that is limited in an effluent limitation guideline (ELG) that the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Napthalene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Sulfate	1.92 mg/L		NA	NA	1	
Aluminum	0.358 mg/L	0.285 mg/L	NA	NA	1	
Boron	<0.200 mg/L	<0.200 mg/L	NA	NA	1	
Iron	0.372 mg/L	0.364 mg/L	NA	NA	1	
Magnesium	3.75 mg/L	2.28 mg/L	NA	NA	1	
Manganese	0.0357 mg/L	0.0556 mg/L	NA	NA	1	
Molybdenum	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
Tin	0.004 mg/L	<0.004 mg/L	NA	NA	1	
Titanium	0.0154 mg/L	<0.010 mg/L	NA	NA	1	
Antimony	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
Arsenic	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Barium	0.0185 mg/L	0.0128 mg/L	NA	NA	1	
Beryllium	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Cadmium	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Chromium	<0.0200 mg/L	<0.020 mg/L	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 013A

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TABLE B. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(A))[1]

List each pollutant that is limited in an effluent limitation guideline (ELG) that the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Cobalt	<0.002 mg/L	<0.001 mg/L	NA	NA	1	
Copper	0.00124 mg/L	0.00168 mg/L	NA	NA	1	
Lead	<0.002 mg/L	0.002 mg/L	NA	NA	1	
Nickel	<0.002 mg/L	<0.002 mg/L	NA	NA	1	
Selenium	<0.002 mg/L	<0.002 mg/L	NA	NA	1	
Silver	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Thallium	<0.001 mg/L	<0.0100 mg/L	NA	NA	1	
Zinc	<0.020 mg/L	0.0201 mg/L	NA	NA	1	
Mercury	<0.0002 mg/L	<0.0002 mg/L	NA	NA	1	
Ammonia (as N)	<0.250 mg/L	<0.250 mg/L	NA	NA	1	
Kjeldahl Nitrogen	0.646 mg/L	0.648 mg/L	NA	NA	1	
Nitrate Nitrite	0.614 mg/L	0.508 mg/L	NA	NA	1	
Total Organic Nitrogen	1.26 mg/L	1.16 mg/L	NA	NA	1	
Surfactants			NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE C. TOXIC POLLUTANTS, CERTAIN HAZARDOUS SUBSTANCES, AND ASBESTOS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(B) and (vii))[1]

List each pollutant shown in Exhibits 2F–2, 2F–3, and 2F–4 that you know or have reason to believe is present. Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Acrolein	<0.05 mg/L	<0.05 mg/L	NA	NA	1	
Acrylonitrile	<0.01 mg/L	<0.01 mg/L	NA	NA	1	
Benzene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Bromoform	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Carbon tetrachloride	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Chlorobenzene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Chlorodibromomethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Chloroethane	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
2-Chloroethyl vinyl ether	<0.05 mg/L	<0.05 mg/L	NA	NA	1	
Chloroform	0.00648 mg/L	<0.005 mg/L	NA	NA	1	
1,3-Dichloropropene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Dichlorobromomethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Dichlorodifluoromethane	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
1,1-Dichloroethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
1,2-Dichloroethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
1,1-Dichloroethene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE C. TOXIC POLLUTANTS, CERTAIN HAZARDOUS SUBSTANCES, AND ASBESTOS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(B) and (vii))[1]

List each pollutant shown in Exhibits 2F–2, 2F–3, and 2F–4 that you know or have reason to believe is present. Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
1,2-Dichloropropane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Ethylebenzene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Methyl bromide	<0.500 mg/L	<0.500 mg/L	NA	NA	1	
Methyl chloride	<0.0025 mg/L	<0.0025 mg/L	NA	NA	1	
Methylene chloride	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
1,1,2,2-Tetrachloroethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Tetrachloroethene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Toluene	<0.001 mg/L	111 mg/L	NA	NA	1	
Trans-1,2-Dichloroethene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Trans-1,3-Dichloropropene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
1,1,1-Trichloroethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
1,1,2-Trichloroethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Trichloroethylene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Trichlorofluoromethane	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
Vinyl chloride	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Total Residual Chlorine	0.04 mg/L	NA	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE C. TOXIC POLLUTANTS, CERTAIN HAZARDOUS SUBSTANCES, AND ASBESTOS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(B) and (vii))[1]

List each pollutant shown in Exhibits 2F–2, 2F–3, and 2F–4 that you know or have reason to believe is present. Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Temperature	17.15 celcius	NA	NA	NA	1	
Fecal Coliform	24200 col/100 mL	NA	25670 col/100 mL	NA	2	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE D. STORM EVENT INFORMATION (40 CFR 122.26(c)(1)(i)(E)(6))

Provide data for the storm event(s) that resulted in the maximum daily discharges for the flow-weighted composite sample.

Date of Storm Event	Duration of Storm Event (in hours)	Total Rainfall During Storm Event (in inches)	Number of Hours Between Beginning of Storm Measured and End of Previous Measurable Rain Event	Maximum Flow Rate During Rain Event (in gpm or specify units)	Total Flow from Rain Event (in gallons or specify units)
01/03/2023	14	1.26	80	6.0734 MGD	32.4201 MGD

Provide a description of the method of flow measurement or estimate.

Flow was measured at an existing weir.

Note Fecal coliform was re-sampled 02/09/2023. Duration of the 2/9 storm event was 8 hours. The number of hours between beginning of storm measured and end of previous measurable rain event was 149 hours. The flow at time of collection was 1.4435127 MGD

EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 018

Form Approved 03/05/19
OMB No. 2040-0004

TABLE A. CONVENTIONAL AND NON CONVENTIONAL PARAMETERS (40 CFR 122.26(c)(1)(i)(E)(3))[1]

You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details and requirements.

	Pollutant or Parameter	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
		Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
1.	Oil and grease	<5.68 mg/L		NA		1	
2.	Biochemical oxygen demand (BOD_5)	7.47 mg/L	7.14 mg/L	NA	NA	1	
3.	Chemical oxygen demand (COD)	<20.0 mg/L	NA	NA	NA	1	
4.	Total suspended solids (TSS)	28.8 mg/L	16.4 mg/L	NA	NA	1	
5.	Total phosphorus	<0.100 mg/L	NA	NA	NA	1	
6.	Total Kjeldahl nitrogen (TKN)	0.503 mg/L	0.812 mg/L	NA	NA	1	
7.	Total nitrogen (as N)	1.10 mg/L	1.52 mg/L	NA	NA	1	
8.	pH (minimum)	7.08		NA		1	
	pH (maximum)	7.21		NA		1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE B. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(A))[1]

List each pollutant that is limited in an effluent limitation guideline (ELG) that the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Napthalene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Aluminum	0.569 mg/L	0.783 mg/L	NA	NA	1	
Boron	<0.200 mg/L	<0.200 mg/L	NA	NA	1	
Iron	0.426 mg/L	0.571 mg/L	NA	NA	1	
Magnesium	<1.00 mg/L	1.22 mg/L	NA	NA	1	
Manganese	0.0269 mg/L	0.0212 mg/L	NA	NA	1	
Molybdenum	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
Tin	<0.004 mg/L	<0.004 mg/L	NA	NA	1	
Titanium	0.0190 mg/L	0.0236 mg/L	NA	NA	1	
Antimony	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
Arsenic	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Barium	0.00649 mg/L	0.00961 mg/L	NA	NA	1	
Beryllium	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Cadmium	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Chromium	<0.02 mg/L	<0.020 mg/L	NA	NA	1	
Cobalt	<0.002 mg/L	<0.002 mg/L	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE B. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(A))[1]

List each pollutant that is limited in an effluent limitation guideline (ELG) that the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Copper	0.00249 mg/L	0.00266 mg/L	NA	NA	1	
Lead	<0.002 mg/L	<0.002 mg/L	NA	NA	1	
Nickel	<0.002 mg/L	<0.002 mg/L	NA	NA	1	
Selenium	<0.002 mg/L	<0.002 mg/L	NA	NA	1	
Silver	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Thallium	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Zinc	0.0212 mg/L	0.0213 mg/L	NA	NA	1	
Ammonia (as N)	<0.250 mg/L	<0.250 mg/L	NA	NA	1	
Kjeldahl Nitrogen	0.503 mg/L	0.812 mg/L	NA	NA	1	
Nitrate Nitrite	0.598 mg/L	0.711 mg/L	NA	NA	1	
Total Organic Nitrogen	1.10 mg/L	1.52 mg/L	NA	NA	1	
Mercury	<0.0002 mg/L	NA	NA	NA	1	
Sulfate	3.20 mg/L	NA	NA	NA	1	
Color	40.0 PCU	250.0 PCU	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE C. TOXIC POLLUTANTS, CERTAIN HAZARDOUS SUBSTANCES, AND ASBESTOS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(B) and (vii))[1]

List each pollutant shown in Exhibits 2F–2, 2F–3, and 2F–4 that you know or have reason to believe is present. Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Acrolein	<0.05 mg/L	<0.05 mg/L	NA	NA	1	
Acrylonitrile	<0.010 mg/L	<0.010 mg/L	NA	NA	1	
Benzene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Bromoform	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Carbon tetrachloride	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Chlorobenzene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Chlorodibromomethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Chloroethane	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
2-Chloroethyl vinyl ether	<0.05 mg/L	<0.05 mg/L	NA	NA	1	
Chloroform	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
1,3-Dichloropropene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Dichlorobromomethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Dichlorodifluoromethane	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
1,1-Dichloroethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
1,2-Dichloroethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
1,1-Dichloroethene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE C. TOXIC POLLUTANTS, CERTAIN HAZARDOUS SUBSTANCES, AND ASBESTOS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(B) and (vii))[1]

List each pollutant shown in Exhibits 2F–2, 2F–3, and 2F–4 that you know or have reason to believe is present. Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
1,2-Dichloropropane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Ethylebenzene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Methyl bromide	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
Methyl chloride	<0.0025 mg/L	<0.0025 mg/L	NA	NA	1	
Methylene chloride	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
1,1,2,2-Tetrachloroethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Tetrachloroethene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Toluene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
trans-1,2-Dichloroethene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
trans-1,3-Dichloropropene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
1,1,1-Trichloroethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
1,1,2-Trichloroethane	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Trichloroethene	<0.001 mg/L	<0.001 mg/L	NA	NA	1	
Trichlorofluoromethane	<0.005 mg/L	<0.005 mg/L	NA	NA	1	
Vinyl chloride	<0.001 mg/L	<0.001 mg/L	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 018

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TABLE C. TOXIC POLLUTANTS, CERTAIN HAZARDOUS SUBSTANCES, AND ASBESTOS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(B) and (vii))[1]

List each pollutant shown in Exhibits 2F–2, 2F–3, and 2F–4 that you know or have reason to believe is present. Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Total Residual Chlorine	0.04 mg/L	NA	NA	NA	1	
Temperature	17.1 celcius	NA	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE D. STORM EVENT INFORMATION (40 CFR 122.26(c)(1)(i)(E)(6))

Provide data for the storm event(s) that resulted in the maximum daily discharges for the flow-weighted composite sample.

Date of Storm Event	Duration of Storm Event (in hours)	Total Rainfall During Storm Event (in inches)	Number of Hours Between Beginning of Storm Measured and End of Previous Measurable Rain Event	Maximum Flow Rate During Rain Event (in gpm or specify units)	Total Flow from Rain Event (in gallons or specify units)
01/03/2023	21	0.91	171	0.6408 MGD	1.958 MGD

Provide a description of the method of flow measurement or estimate.

Flow was measured at an existing weir.

EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 019

Form Approved 03/05/19
OMB No. 2040-0004

TABLE A. CONVENTIONAL AND NON CONVENTIONAL PARAMETERS (40 CFR 122.26(c)(1)(i)(E)(3))[1]

You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details and requirements.

	Pollutant or Parameter	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
		Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
1.	Oil and grease	<1.52 mg/L		NA		1	
2.	Biochemical oxygen demand (BOD_5)	2.92 mg/L	3.11 mg/L	NA	NA	1	
3.	Chemical oxygen demand (COD)	22.1 mg/L	30.5 mg/L	NA	NA	1	
4.	Total suspended solids (TSS)	31.7 mg/L	20.5 mg/L	NA	NA	1	
5.	Total phosphorus	0.319 mg/L	0.311 mg/L	NA	NA	1	
6.	Total Kjeldahl nitrogen (TKN)	0.742 mg/L	0.627 mg/L	NA	NA	1	
7.	Total nitrogen (as N)	639 ug/L	534 ug/L	NA	NA	1	
8.	pH (minimum)	8.16		NA		1	
	pH (maximum)	8.17		NA		1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE B. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(A))[1]

List each pollutant that is limited in an effluent limitation guideline (ELG) that the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Sulfate	4.10 mg/L	4.20 mg/L	NA	NA	1	
Aluminum	950 ug/L	795 ug/L	NA	NA	1	
Boron	12.3 ug/L	10.9 ug/L	NA	NA	1	
Iron	1170 ug/L	1000 ug/L	NA	NA	1	
Magnesium	2010 ug/L	1780 ug/L	NA	NA	1	
Manganese	110 ug/L	48.0 ug/L	NA	NA	1	
Molybdenum	0.662 ug/L	0.660 ug/L	NA	NA	1	
Tin	<1.00 ug/L	<1.00 ug/L	NA	NA	1	
Titanium	17.6 ug/L	17.1 ug/L	NA	NA	1	
Antimony	<1.00 ug/L	<1.00 ug/L	NA	NA	1	
Arsenic	<2.00 ug/L	<2.00 ug/L	NA	NA	1	
Barium	13.4 ug/L	11.4 ug/L	NA	NA	1	
Beryllium	<0.200 ug/L	<0.200 ug/L	NA	NA	1	
Cadmium	<0.300 ug/L	<0.300 ug/L	NA	NA	1	
Chromium	<3.00 ug/L	<3.00 ug/L	NA	NA	1	
Cobalt	0.993 ug/L	0.701 ug/L	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE B. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(A))[1]

List each pollutant that is limited in an effluent limitation guideline (ELG) that the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Copper	3.13 ug/L	2.53 ug/L	NA	NA	1	
Lead	1.41 ug/L	1.15 ug/L	NA	NA	1	
Nickel	3.37 ug/L	2.76 ug/L	NA	NA	1	
Selenium	<1.50 ug/L	<1.50 ug/L	NA	NA	1	
Silver	<0.300 ug/L	<0.300 ug/L	NA	NA	1	
Thallium	<0.600 ug/L	<0.600 ug/L	NA	NA	1	
Zinc	25.8 ug/L	22.8 ug/L	NA	NA	1	
Mercury	<0.0002 mg/L	NA	NA	NA	1	
Ammonia (as N)	0.103 mg/L	0.0935 mg/L	NA	NA	1	
Kjeldahl Nitrogen	0.742 ug/L	0.627 ug/L	NA	NA	1	
Nitrate Nitrite	0.377 ug/L	0.341 ug/L	NA	NA	1	
Total Organic Nitrogen	639 ug/L	534 ug/L	NA	NA	1	
Surfactants	0.0222 mg/L	0.0175 mg/L	NA	NA	1	
Color	60 PCU	80.0 PCU	NA	NA	1	
					1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE C. TOXIC POLLUTANTS, CERTAIN HAZARDOUS SUBSTANCES, AND ASBESTOS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(B) and (vii))[1]

List each pollutant shown in Exhibits 2F–2, 2F–3, and 2F–4 that you know or have reason to believe is present. Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Acrolein	<1.67 ug/L	<1.67 ug/L	NA	NA	1	
Acrylonitrile	<1.67 ug/L	<1.67 ug/L	NA	NA	1	
Benzene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Bromoform	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Carbon tetrachloride	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Chlorobenzene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Chlorodibromomethane	<0.355 ug/L	<0.355 ug/L	NA	NA	1	
Chloroethane	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
2-Chloroethyl vinyl ether	<1.67 ug/L	<1.67 ug/L	NA	NA	1	
Chloroform	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
1,3-Dichloropropene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Dichlorobromomethane	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
1,1-Dichloroethane	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
1,1-Dichloroethene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
1,2-Dichloropropane	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Ethylebenzene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE C. TOXIC POLLUTANTS, CERTAIN HAZARDOUS SUBSTANCES, AND ASBESTOS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(B) and (vii))[1]

List each pollutant shown in Exhibits 2F–2, 2F–3, and 2F–4 that you know or have reason to believe is present. Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Methyl bromide	<0.337ug/L	<1.67 ug/L	NA	NA	1	
Methyl chloride	<0.333 ug/L	<1.67 ug/L	NA	NA	1	
Methylene chloride	<0.500 ug/L	<0.333 ug/L	NA	NA	1	
1,1,2,2-Tetrachloroethane	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Tetrachloroethene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Toluene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
trans-1,2-Dichloroethene	<0.333 ug/L	<0.355 ug/L	NA	NA	1	
trans-1,3-Dichloropropene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Trichloroethylene	<0.333 ug/L	<1.67 ug/L	NA	NA	1	
Trichlorofluoromethane	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Vinyl chloride	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Temperature	13.35 C	NA	NA	NA	1	
Total Residual Chlorine	<0.05 mg/L	NA	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE D. STORM EVENT INFORMATION (40 CFR 122.26(c)(1)(i)(E)(6))

Provide data for the storm event(s) that resulted in the maximum daily discharges for the flow-weighted composite sample.

Date of Storm Event	Duration of Storm Event (in hours)	Total Rainfall During Storm Event (in inches)	Number of Hours Between Beginning of Storm Measured and End of Previous Measurable Rain Event	Maximum Flow Rate During Rain Event (in gpm or specify units)	Total Flow from Rain Event (in gallons or specify units)
11/29/2022	11	2.38	58	1.65 MGD	10.94 MGD

Provide a description of the method of flow measurement or estimate.

Flow was measured at an existing weir

EPA Identification Number	NPDES Permit Number	Facility Name	Outfall Number
AL8640015410	AL0022080	TVA Browns Ferry Nuclear Plant	DSN 024

Form Approved 03/05/19
OMB No. 2040-0004

TABLE A. CONVENTIONAL AND NON CONVENTIONAL PARAMETERS (40 CFR 122.26(c)(1)(i)(E)(3))[1]

You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details and requirements.

	Pollutant or Parameter	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
		Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
1.	Oil and grease	<1.54 mg/L		NA		1	
2.	Biochemical oxygen demand (BOD_5)	9.58 mg/L	12.1 mg/L	NA	NA	1	
3.	Chemical oxygen demand (COD)	72.1 mg/L	76.3 mg/L	NA	NA	1	
4.	Total suspended solids (TSS)	72.0 mg/L	58.0 mg/L	NA	NA	1	
5.	Total phosphorus	1.17 mg/L	1.52 mg/L	NA	NA	1	
6.	Total Kjeldahl nitrogen (TKN)	2.50 mg/L	2.16 mg/L	NA	NA	1	
7.	Total nitrogen (as N)	2260 ug/L	1810 ug/L	NA	NA	1	
8.	pH (minimum)	7.63		NA		1	
	pH (maximum)	7.64		NA		1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

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TABLE B. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(A))[1]

List each pollutant that is limited in an effluent limitation guideline (ELG) that the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Sulfate	1.76 mg/L	2.08 mg/L	NA	NA	1	
Aluminum	3540 ug/L	3040 ug/L	NA	NA	1	
Boron	14.6 ug/L	14.9 ug/L	NA	NA	1	
Iron	4470 ug/L	3740 ug/L	NA	NA	1	
Magnesium	1910 ug/L	2270 ug/L	NA	NA	1	
Manganese	225 ug/L	177 ug/L	NA	NA	1	
Molybdenum	0.869 ug/L	0.943 ug/L	NA	NA	1	
Tin	<1.00 ug/L	<1.00 ug/L	NA	NA	1	
Titanium	73.6 ug/L	60.8 ug/L	NA	NA	1	
Antimony	<1.00 ug/L	<1.00 ug/L	NA	NA	1	
Arsenic	3.23 ug/L	3.45 ug/L	NA	NA	1	
Barium	52.2 ug/L	53.4 ug/L	NA	NA	1	
Beryllium	<0.200 ug/L	<0.200 ug/L	NA	NA	1	
Cadmium	<0.300 ug/L	<0.300 ug/L	NA	NA	1	
Chromium	3.84 ug/L	3.29 ug/L	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE C. TOXIC POLLUTANTS, CERTAIN HAZARDOUS SUBSTANCES, AND ASBESTOS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(B) and (vii))[1]

List each pollutant shown in Exhibits 2F–2, 2F–3, and 2F–4 that you know or have reason to believe is present. Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Temperature	15.4	NA	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE C. TOXIC POLLUTANTS, CERTAIN HAZARDOUS SUBSTANCES, AND ASBESTOS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(B) and (vii))[1]

List each pollutant shown in Exhibits 2F–2, 2F–3, and 2F–4 that you know or have reason to believe is present. Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Acrolein	<1.67 ug/L	<1.67 ug/L	NA	NA	1	
Acrylonitrile	<1.67 ug/L	<1.67 ug/L	NA	NA	1	
Benzene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Bromoform	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Carbon tetrachloride	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Chlorobenzene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Chlorodibromomethane	<0.355 ug/L	<0.355 ug/L	NA	NA	1	
Chloroethane	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
2-Chloroethyl vinyl ether	<1.67 ug/L	<1.67 ug/L	NA	NA	1	
Chloroform	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
1,3-Dichloropropylene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Dichlorobromomethane	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Dichlorodifluoromethane	<0.355 ug/L	<0.355 ug/L	NA	NA	1	
1,1-Dichloroethane	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
1,2-Dichloroethane	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
1,1-Dichloroethene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE B. CERTAIN CONVENTIONAL AND NON CONVENTIONAL POLLUTANTS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(A))[1]

List each pollutant that is limited in an effluent limitation guideline (ELG) that the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
Cobalt	1.73 ug/L	1.40 ug/L	NA	NA	1	
Copper	6.62 ug/L	8.75 ug/L	NA	NA	1	
Lead	7.97 ug/L	6.59 ug/L	NA	NA	1	
Nickel	2.28 ug/L	2.07 ug/L	NA	NA	1	
Selenium	<1.50 ug/L	<1.50 ug/L	NA	NA	1	
Silver	<0.300 ug/L	<0.300 ug/L	NA	NA	1	
Thallium	<0.600 ug/L	<0.600 ug/L	NA	NA	1	
Zinc	26.4 ug/L	27.3 ug/L	NA	NA	1	
Mercury	<0.002 mg/L	NA	NA	NA	1	
Ammonia (as N)	0.245 mg/L	0.355 mg/L	NA	NA	1	
Kjeldahl Nitrogen	2.50 mg/L	2.16 mg/L	NA	NA	1	
Nitrate Nitrite	0.311 mg/L	0.415 mg/L	NA	NA	1	
Total Organic Nitrogen	2260 ug/L	1810 ug/L	NA	NA	1	
Surfactants	0.0317 mg/L	0.0317 mg/L	NA	NA	1	
Color	500 PCU	200 PCU	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE C. TOXIC POLLUTANTS, CERTAIN HAZARDOUS SUBSTANCES, AND ASBESTOS (40 CFR 122.26(c)(1)(i)(E)(4) and 40 CFR 122.21(g)(7)(vi)(B) and (vii))[1]

List each pollutant shown in Exhibits 2F–2, 2F–3, and 2F–4 that you know or have reason to believe is present. Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Number of Storm Events Sampled	Source of Information (new source/new dischargers only; use codes in instructions)
	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-Weighted Composite		
1,2-Dichloropropane	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Ethylebenzene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Methyl bromide	<0.337 ug/L	<0.337 ug/L	NA	NA	1	
Methyl chloride	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Methylene chloride	<0.500 ug/L	<0.500 ug/L	NA	NA	1	
1,1,2,2-Tetrachloroethane	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Tetrachloroethene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Toluene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
trans-1,2-Dichloroethene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
trans-1,3-Dichloropropene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
1,1,1-Trichloroethane	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
1,1,2-Trichloroethane	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Trichloroethylene	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Trichlorofluoromethane	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Vinyl chloride	<0.333 ug/L	<0.333 ug/L	NA	NA	1	
Total Residual Chlorine	0.04 mg/L	NA	NA	NA	1	

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

TABLE D. STORM EVENT INFORMATION (40 CFR 122.26(c)(1)(i)(E)(6))

Provide data for the storm event(s) that resulted in the maximum daily discharges for the flow-weighted composite sample.

Date of Storm Event	Duration of Storm Event (in hours)	Total Rainfall During Storm Event (in inches)	Number of Hours Between Beginning of Storm Measured and End of Previous Measurable Rain Event	Maximum Flow Rate During Rain Event (in gpm or specify units)	Total Flow from Rain Event (in gallons or specify units)
11/29/2022	11	2.38	58	0.7555 MGD	4.3816 MGD

Provide a description of the method of flow measurement or estimate.

Flow was measured at an existing weir.

IV. Narrative Description of Pollutant Sources, B-C

BFN's Spill Prevention Control and Countermeasures (SPCC) Plan is the basic non-structural control for reducing pollutants in storm water runoff. It incorporates best management practices into daily activities conducted on site and is available for review at all times. BFN has instituted a Chemical Traffic Control Plan for the purpose of ensuring that all chemicals brought on site are reviewed are reviewed to prevent the usage of hazardous materials when a non-hazardous material substitute is available. The plan also ensures the proper use, storage, and disposal of all chemicals used at the facility.

DSN 013

DSN 013 receives storm water from the Environmental and Meteorology offices parking lot, the northeast corner of the Training Center parking lot, a storm drain located between the two sedimentation ponds, and from a gravel parking lot and grassy area located south of the Environmental and Meteorology offices (i.e., approximately 1.8 acres of grassed area and 5.0 acres of impervious surfaces). DSN 013 also receives storm water drainage from DSN 013A and process water discharges from DSN 013B prior to discharging to the Tennessee River. DSNs 013A and 013B were sampled at their respective discharge points in accordance with the requirements of the renewal application.

DSN 013A

DSN 013A receives storm water from the 4kV Capacitor Yard, the main plant transformer yard, the switchyard, the parking lot east of and part of the parking lot west of the Wastewater Lagoons, and the grassland north of the east parking lot (i.e., approximately 40.5 acres of impervious area and 54 acres of grassed area). The capacitor yard, the transformer yard, and the switchyard contain only non-PCB, oil-filled equipment. The transformer yard contains two 37,000-gallon mineral oil tanks (abandoned in place) and one 1,500-gallon above-ground diesel storage tank. DSN 013A is provided with secondary containment to prevent oil spills from reaching the river by the presence of a concrete oil skimmer and weir.

DSN 013A also receives wastewater discharged from DSN 013C, the Wastewater Lagoons which includes treated sanitary waste, waste from a photo-processing lab, a metal-processing lab, a medical lab, blowdown from the Training Center's chiller system, flush water from the standby liquid control system and from various cooler and air compressor cleanings, waste from insulator showers used by personnel involved with periodic asbestos stripping and handling operations, and rain water. DSN 013A discharges to DSN 013 which in turn discharges to the Tennessee River.

DSN 014

DSN 014 is located northwest of the cooling towers, and receives drainage from two roads (approximately 5 acres), grassland (approximately 174 acres), and offsite farmland located on the north and northwest sides of the facility. DSN 014 discharges directly to the Tennessee River. Because monitoring is not required for this outfall in the current NPDES permit and because it receives drainage from areas with no industrial activity as defined in 40 CFR122.26(b)(14), it was not monitored for the permit renewal application.

ADEM Watermark

DSN 017

DSN 017 receives storm water runoff from an approximately 6-acre area (approximately 3 acres of which is impervious area) which includes the Training Center and the Live Well Center parking lots, the Training Center roof, and grassed/wooded land. DSN 017 discharges directly into the Tennessee River. In addition to storm water, DSN 017 receives fire system flush water from a municipal source.

DSN 018

DSN 018 receives storm water from the Materials and Procurement Complex (MPC) parking lot, the firing range parking lot, the Facilities Maintenance area, the vehicle fuel dispensing area, part of the parking lot southwest of the MPC, and from adjacent grassed area (approximately 18.8 acres of impervious drainage and 15.4 acres of grassed land). The MPC includes several enclosed chemical staging areas (e.g., for paints, solvents, oil, and lubricants). DSN 018 discharges directly to the Tennessee River.

DSN 019

DSN 019 receives storm water drainage from the east site drainage area (i.e., 101.1 acres of grassed land, 48 acres of impervious area including a small borrow pit, the Fire Training Area, the Low Level Radwaste Storage Facility, the inert landfill, and the 180-day Hazardous Waste Storage Area. These areas contain kerosene, gasoline, and diesel tanks; a flammable storage area; Facilities Satellite Storage area; a diesel fire pump and fuel tank; oil and used drum storage areas; and hazardous and mixed waste storage area. DSN 019 discharges to the Tennessee River.

DSN 024

DSN 024 is located along the facility's east property boundary and discharges to an adjacent farmland. This outfall receives storm water drainage from offsite grassland, offsite farmland located north of the facility, and from a vehicle servicing and mechanic shop located just south of the northeast corner of the site (approximately 75.9 acres of grassland and 8.4 acres of impervious surfaces). The shop includes a covered storage area for solvents, oils, and lubricants.

ADEM Watermark

United States Environmental Protection Agency | Office of Water Washington, D.C. | EPA Form 3510-2E Revised March 2019

Water Permits Division

Application Form 2E

Manufacturing, Commercial, Mining, and Silvicultural Facilities Which Discharge Only Nonprocess Wastewater

NPDES Permitting Program

Note: Complete this form ***and*** Form 1 if your facility is a new or existing manufacturing, commercial, mining, and silvicultural facility that discharges only nonprocess wastewater.

Paperwork Reduction Act Notice

The U.S. Environmental Protection Agency estimates the average burden to collect and complete Form 2E to be 13.5 hours. This estimate includes time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the collection of information. Send comments about the burden estimate or any other aspect of this collection of information to the Chief, Information Policy Branch (PM-223), U.S. Environmental Protection Agency, 1200 Pennsylvania Avenue, NW, Washington, DC 20460, and to the Office of Information and Regulatory Affairs, Office of Management and Budget, 725 17th Street, Washington, DC 20503, marked "Attention: Desk Officer for EPA."

General Instructions

Who Must Complete Form 2E?

You must complete Form 2E if you answered "Yes" to Item 1.2.4 on Form 1—that is, if you are a new or existing facility (including manufacturing, commercial, mining, and silvicultural facilities) that discharges only nonprocess wastewater.

Where to File Your Completed Form

Submit your completed application package (Forms 1 and 2E) to your National Pollutant Discharge Elimination System (NPDES) permitting authority. Consult Exhibit 1–1 of Form 1's "General Instructions" to identify your NPDES permitting authority.

Public Availability of Submitted Information

The U.S. Environmental Protection Agency (EPA) will make information from NPDES permit application forms available to the public for inspection and copying upon request. You may not claim any information on Form 2E (or related attachments) as confidential.

You may make a claim of confidentiality for any information that you submit to EPA that goes beyond the information required by Form 2E. Note that NPDES permitting authorities will deny claims for treating any effluent data as confidential. If you do not assert a claim of confidentiality at the time you submit your information to the NPDES permitting authority, EPA may make the information available to the public without further notice to you. EPA will handle claims of confidentiality in accordance with the Agency's business confidentiality regulations at Part 2 of Title 40 of the *Code of Federal Regulations* (CFR).

Completion of Forms

Print or type in the specified areas only. If you do not have enough space on the form to answer a question, you may continue on additional sheets, as necessary, using a format consistent with the form.

Provide your EPA Identification Number from the Facility Registry Service, NPDES permit number, and facility name at the top of each page of Form 2E and any attachments. If you do not know your EPA Identification Number, contact your NPDES permitting authority. See Exhibit 1–1 of Form 1's "General Instructions" for contact information.

Do not leave any response areas blank unless the form directs you to skip them. If the form directs you to respond to an item that does not apply to your facility or activity, enter "NA" for "not applicable" to demonstrate that you considered the item and determined a response was not necessary for your facility.

The NPDES permitting authority will consider your application complete when it and any supplementary material are received and completed according to the authority's satisfaction. The NPDES permitting authority will judge the completeness of any application independently of the status of any other permit application or permit for the same facility or activity.

Definitions

The legal definitions of all key terms used in these instructions and Form 2E are in the "Glossary" at the end of the "General Instructions" in Form 1.

Follow-up Requirements for New Dischargers

Note that no later than 24 months after commencement of discharge from the proposed facility, you must complete and submit Section 4 of this form. At that time you must test and report *actual* rather than estimated data for the pollutants or parameters listed, unless waived by the NPDES permitting authority.

Line-by-Line Instructions

If you have multiple outfalls, you must submit a separate Form 2E for each (Sections 1, 3, and 4 only).

Section 1. Outfall Location

Item 1.1. Complete sections 1 through 6 for each outfall. Provide the latitude and longitude to the nearest 15 seconds for the outfall. Latitude and longitude coordinates may be obtained in a variety of ways, including use of hand held devices (e.g., a GPS enabled smartphone), internet mapping tools (e.g., https://mynasadata.larc.nasa.gov/latitudelongitude-finder/), geographic information systems (e.g., ArcView), or paper maps from trusted sources (e.g., U.S. Geological Survey or USGS). The location of each outfall (i.e., where the coordinates are collected) shall be the point where the discharge is released into a water of the United States. If you need further guidance in responding to Item 1.1, refer to http://www.epa.gov/geospatial/latitudelongitude-data-standard.

Section 2. Discharge Date

Item 2.1. Indicate whether you are a new or an existing discharger. If you are an existing discharger, skip to Section 3 after completing this item.

Item 2.2. Indicate the date on which the facility will or is estimated to commence discharge.

Section 3. Waste Types

Item 3.1. Indicate the general type(s) of wastes being discharged or to be discharged, depending on whether you are an existing or new discharger. If you mark the response "Other Nonprocess Wastewater," specify the nature of your discharge.

Item 3.2. Indicate if the facility uses cooling water additives. If yes, continue. If no, skip to Section 4.

Item 3.3. List the cooling water additives being used (or to be used) and specify the composition of the additives, if such information is available to you. You can generally find composition information on product labels or from manufacturers' data sheets.

Section 4. Effluent Characteristics

Items 4.1 to 4.8. These items require you to collect and report data for the parameters and pollutants listed in Section 4. The instructions are distinct for applicants with existing discharges versus applicants that are new.

Important note: Read the "General Instructions for Reporting, Sampling, and Analysis" on pages 2E-3 and 2E-4 before completing Section 4.

Item 4.1. Indicate whether you have completed monitoring for all parameters in the table under Item 4.2 and attached it to the application package. If you answer "No" because you have requested a waiver from your NPDES authority, skip to Section 5. If "Yes," continue to Item 4.2.

Item 4.2. Provide the sampling data requested in the table per the "General Instructions for Reporting, Sampling, and Analysis" for biochemical oxygen demand (BOD), total suspended solids (TSS), oil and grease, ammonia (as N), flow, pH, and temperature (winter and summer).

Item 4.3. Answer whether you believe fecal coliform to be present in your discharge or whether sanitary waste is discharged (or will be discharged). If you answer "No," skip to Item 4.5. Otherwise, continue to Item 4.4.

Item 4.4. Provide the sampling data requested in the table per the "General Instructions for Reporting, Sampling, and Analysis" for fecal coliform, *Escherichia coli (E. coli*), and enterococci.

Item 4.5. Indicate whether chlorine is used (or will be used). If no, skip to Item 4.7. Otherwise, continue to Item 4.6.

Item 4.6. Provide the sampling data requested in the table per the "General Instructions for Reporting, Sampling, and Analysis" for total residual chlorine.

Item 4.7. Answer whether non-contact cooling water is (or will be) discharged from your facility. If no, skip to Section 5. If yes, continue to Item 4.8.

Item 4.8. Provide the sampling data requested in the table per the "General Instructions for Reporting, Sampling, and Analysis" for chemical oxygen demand (COD), and total organic carbon (TOC).

Section 5. Flow

Item 5.1. Indicate whether any of the discharges that you described in Sections 1 and 3 (except for stormwater runoff, leaks, or spills) are intermittent or seasonal. If yes, continue to Item 5.2. If no, skip to Section 6.

Item 5.2. Describe the average frequency of flow and duration of any intermittent or seasonal discharge (except for stormwater runoff, leaks, or spills) in gallons or million gallons per day (gpd or mgd), whichever is appropriate. The frequency of flow is the number of days or months per year there is an intermittent discharge. Duration is the number of days or hours per discharge. For new dischargers, report your best estimate.

Section 6. Treatment System

Item 6.1. Briefly describe any treatment system(s) used (or to be used for new dischargers), indicating whether the treatment system is physical, chemical, biological, sludge and disposal, or other. Also give the particular type(s) of process(es) used (or to be used). For example, if a physical treatment system is used (or will be used), specify the processes applied (or to be applied), such as grit removal, ammonia stripping, dialysis, etc.

Section 7. Other Information

Item 7.1. OPTIONAL ITEM. Report any additional information or data (such as sampling results) that you believe the NPDES permitting authority should consider when establishing permit limitations. If you wish to demonstrate your eligibility for a "net" effluent limitation (i.e., an effluent limitation adjusted to provide credit for the pollutant(s) present in your intake water) add a short statement as to why you believe you are eligible. See also 40 CFR 122.45(g). You will be contacted by the NPDES permitting authority with further instructions.

Section 8. Checklist and Certification Statement

Item 8.1. Review the checklist provided on the application. In Column 1, mark the sections of Form 2E that you have completed and are submitting with your application. For each section in Column 2, indicate whether you are submitting attachments.

Item 8.2. The Clean Water Act (CWA) provides for severe penalties for submitting false information on this application form. CWA Section 309(c)(2) provides that "Any person who knowingly makes any false statement, representation, or certification in any application, …shall upon conviction, be punished by a fine of no more than $10,000 or by imprisonment for not more than six months, or both."

FEDERAL REGULATIONS AT 40 CFR 122.22 REQUIRE THIS APPLICATION TO BE SIGNED AS FOLLOWS:

A. For a corporation, by a responsible corporate officer. For the purpose of this section, a responsible corporate officer means: (1) a president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy- or decision-making functions for the corporation, or (2) the manager of one or more manufacturing, production, or operating facilities, provided the manager is authorized to make management decisions which govern the operation of the regulated facility including having the explicit or implicit duty of making major capital investment recommendations, and initiating and directing other comprehensive measures to assure long term environmental compliance with environmental laws and regulations; the manager can ensure that the necessary systems are established or actions taken to gather complete and accurate information for permit application requirements; and where authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.

B. For a partnership or sole proprietorship, by a general partner or the proprietor, respectively.

C. For a municipality, state, federal, or other public facility, by either a principal executive officer or ranking elected official. For purposes of this section, a principal executive officer of a federal agency includes: (1) The chief executive officer of the agency, or (2) a senior executive officer having responsibility for the overall operations of a principal geographic unit of the agency (e.g., Regional Administrators of EPA).

END

Submit your completed Form 1, Form 2E, and all associated attachments (and any other required NPDES application forms) to your NPDES permitting authority.

General Instructions for Reporting, Sampling, and Analysis

Important note: Read these instructions before completing Section 4 of Form 2E.

General Items

Complete the applicable tables for each outfall at your facility. Be sure to note the EPA Identification Number, NPDES permit number, facility name, and applicable outfall number at the top of each page of any associated attachments.

You may report some or all of the required data by attaching separate sheets of paper instead of completing Section 4 for each of your outfalls so long as the sheets contain all of the required information and are similar in format to Section 4.

Reporting of Effluent Data

Report pollutant levels for all pollutants in Section 4 as concentration *and* total mass, with the exception of flow, pH, and temperature. Total mass is the total weight of pollutants discharged over a day.

Flow, temperature, pH, and fecal coliform organisms must be reported as mgd, degrees Celsius (°C), standard units, and most probable number per 100 milliliters (MPN/100 mL), respectively. Use the following abbreviations in the columns requiring "units" in Section 4.

Concentration	Mass
ppm = parts per million	lbs = pounds
mg/L = milligrams per liter	ton = tons (English tons)
ppb = parts per billion	mg = milligrams
µg/L = micrograms per liter	g = grams
MPN = most probable number per 100 milliliters	kg = kilograms
	T = tonnes (metric tons)

Existing Dischargers

You must provide at least one analysis for each parameter or pollutant, including the following: BOD, TSS, oil and grease, ammonia (as N), fecal coliform including *E. coli* and enterococci (if believed present or if sanitary waste is or will be discharged), total residual chlorine (if chlorine is or will be used), COD, and TOC (if non-contact cooling water is or will be discharged), discharge flow, pH, and temperature (winter and summer).

You may report quantitative data that you have collected over the past 365 days if they are representative of your current operations. The data reported must include maximum daily discharge, average daily discharge, and number of analyses. Most existing facilities routinely monitor the pollutants and parameters listed in Section 4 as part of their existing NPDES permit requirements.

You must collect and analyze samples in accordance with 40 CFR 136. Grab samples must be used for analyses of pH, temperature, total residual chlorine, oil and grease, fecal coliform (including *E. coli)*, and enterococci (previously known as fecal streptococcus) and volatile organic compounds. Twenty-four-hour composite samples must be used for all other pollutants, using at least four grab samples unless otherwise specified at 40 CFR 136. For a composite sample, only one analysis of the composite of aliquots is required.

If you have sampling and analysis questions, direct them to your NPDES permitting authority. The authority may request that you do additional testing, if appropriate, on a case-by-case basis under CWA Section 308.

New Dischargers

You must provide maximum daily and average daily discharge *estimates* for the parameters or pollutants listed in Section 4, unless specifically indicated on the form. Note that if you have the results of *actual* analyses for the listed parameters or pollutants, you are required to report those results rather than submit estimates.

Report or estimate all parameter or pollutant levels as concentration *and* as total mass, except for flow, pH, and temperature. Indicate the source of all estimates in the appropriate column in the Section 4 tables using the engineering study codes below. Note that you are required to conduct follow-up testing and reporting no later than two years once your facility commences discharge.

Engineering Report Codes

Actual data from pilot plants 1
Estimates from other engineering reports 2
Data from other similar plants 3
Best professional estimates 4
Others .....*specify on the form*

Base your determination of whether a pollutant will be present in your discharge on your knowledge of the proposed facility's use of maintenance chemicals and any analyses of your effluent or of any similar effluent. You may also provide the estimates based on available in-house or contractor engineering reports or any other studies performed on the proposed facility.

Pollutants Solely in Intake Water

If you expect a pollutant to be present solely because of its presence in your intake water, you must still provide an estimate or analytical result in Section 4; however, you should indicate in Section 7 in Item 7.1 that you believe the pollutant or parameter to be present only due to its presence in your source water. See the instructions under Item 7.1.

Testing Waivers

The NPDES permitting authority may waive the testing and reporting requirements for flow or any of the pollutants listed in Section 4 if you submit a written request for such a waiver before or with your application. Contact your NPDES permitting authority for more information.

Sampling

The collection of samples for the reported analyses should be supervised by a person experienced in performing sampling of industrial wastewater. You may contact your NPDES permitting authority for detailed guidance on sampling techniques and for answers to specific questions. See Exhibit 1–1 of Form 1 for contact information. Any specific requirements in the applicable analytical methods—for example, sample containers, sample preservation, holding times, and the collection of duplicate samples—must be followed.

General Instructions for Reporting, Sampling, and Analysis Continued	
The time when you sample should be representative of your normal operation, to the extent feasible, with all processes that contribute wastewater in normal operation, and with your treatment system operating properly with no system upsets. Collect samples from the center of the flow channel, where turbulence is at a maximum, at a site specified in your present NPDES permit, or at any site adequate for the collection of a representative sample. **Analysis** Except as specified below, all required quantitative data shall be collected in accordance with sufficiently sensitive analytical methods approved under 40 CFR 136 or required under 40 CFR chapter I, subchapter N or O. A method is "sufficiently sensitive" when: • The method minimum level (ML) is at or below the level of the applicable water quality criterion for the measured pollutant or pollutant parameter. • The method ML is above the water quality criterion, but the amount of the pollutant or pollutant parameter in the facility's discharge is high enough that the method detects and quantifies the level of the pollutant or pollutant parameter in the discharge. • The method has the lowest ML of the analytical methods approved under 40 CFR 136 or required under 40 CFR chapter I, subchapter N or O for the measured pollutant or pollutant parameter. Consistent with 40 CFR 136, you may provide matrix- or sample-specific MLs rather than the published levels. Further, where you can demonstrate that, despite a good faith effort to use a method that would otherwise meet the definition of "sufficiently sensitive," the analytical results are not consistent with the quality assurance (QA)/quality control (QC) specifications for that method, then the NPDES permitting authority may determine that the method is not performing adequately and the NPDES permitting authority should select a different method from the remaining EPA-approved methods that is sufficiently sensitive consistent with 40 CFR 122.21(e)(3)(i). Where no other EPA-approved methods exist, you must select a method consistent with 40 CFR 122.21(e)(3)(ii). When there is no analytical method that has been approved under 40 CFR 136; required under 40 CFR chapter I, subchapter N or O, and is not otherwise required by the NPDES permitting authority, you may use any suitable method but shall provide a description of the method. When selecting a suitable method, other factors such as a method's precision, accuracy, or resolution, may be considered when assessing the performance of the method.	

EPA Identification Number	NPDES Permit Number	Facility Name	Form Approved 03/05/19 OMB No. 2040-0004
AL8640015410	AL0022080	Browns Ferry Nuclear Plant	

FORM 2E NPDES

U.S. Environmental Protection Agency
Application for NPDES Permit to Discharge Wastewater

MANUFACTURING, COMMERCIAL, MINING, AND SILVICULTURAL FACILITIES WHICH DISCHARGE ONLY NONPROCESS WASTEWATER

SECTION 1. OUTFALL LOCATION (40 CFR 122.21(h)(1))

Outfall Location

1.1 Provide information on each of the facility's outfalls in the table below.

Outfall Number	Receiving Water Name	Latitude	Longitude
DSN012	Tennessee River	34° 43′ 15″ N	87° 7′ 15″ W
DSN017	Tennessee River	34° 42′ 00″ N	87° 7′ 0″ W
		° ′ ″	° ′ ″

SECTION 2. DISCHARGE DATE (40 CFR 122.21(h)(2))

Discharge Date

2.1 Are you a new or existing discharger? (Check only one response.)

☐ New discharger ☑ Existing discharger ➔ SKIP to Section 3.

2.2 Specify your anticipated discharge date:

SECTION 3. WASTE TYPES (40 CFR 122.21(h)(3))

Waste Types

3.1 What types of wastes are currently being discharged if you are an existing discharger or will be discharged if you are a new discharger? (Check all that apply.)

☐ Sanitary wastes
☐ Restaurant or cafeteria waste
☐ Non-contact cooling water
☑ Other nonprocess wastewater (describe/explain directly below)

DSN012:Backwash from intake screens. DSN017:

3.2 Does the facility use cooling water additives?

☐ Yes ☑ No ➔ SKIP to Section 4.

3.3 List the cooling water additives used and describe their composition.

Cooling Water Additives (list)	Composition of Additives (if available to you)

SECTION 4. EFFLUENT CHARACTERISTICS (40 CFR 122.21(h)(4))

Effluent Characteristics

4.1 Have you completed monitoring for all parameters in the table below at each of your outfalls and attached the results to this application package?

☑ Yes ☐ No; a waiver has been requested from my NPDES permitting authority (attach waiver request and additional information) ➔ SKIP to Section 5.

4.2 Provide data as requested in the table below.[1] (See instructions for specifics.)

Parameter or Pollutant	Number of Analyses (if actual data reported)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Source (use codes per instructions)
		Mass	Conc.	Mass	Conc.	
Biochemical oxygen demand (BOD_5)	1		1.18 mg/L			
Total suspended solids (TSS)	1		<0.570 mg/			
Oil and grease	1		1.65 mg/L			
Ammonia (as N)	1		0.0701 mg/			
Discharge flow	0.0504 MGD					
pH (report as range)	8.16-8.17					
Temperature (winter)	14.7					
Temperature (summer)						

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

Effluent Characteristics Continued

4.3 Is fecal coliform believed present, or is sanitary waste discharged (or will it be discharged)?

☐ Yes ☑ No ➔ SKIP to Item 4.5.

4.4 Provide data as requested in the table below.[1] (See instructions for specifics.)

Parameter or Pollutant	Number of Analyses (if actual data reported)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Source (Use codes per Instructions.)
		Mass	Conc.	Mass	Conc.	
Fecal coliform						
E. coli						
Enterococci						

4.5 Is chlorine used (or will it be used)?

☐ Yes ☑ No ➔ SKIP to Item 4.7.

4.6 Provide data as requested in the table below.[1] (See instructions for specifics.)

Parameter or Pollutant	Number of Analyses (if actual data reported)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Source (use codes per instructions)
		Mass	Conc.	Mass	Conc.	
Total Residual Chlorine						

4.7 Is non-contact cooling water discharged (or will it be discharged)?

☐ Yes ☑ No ➔ SKIP to Section 5.

4.8 Provide data as requested in the table below.[1] (See instructions for specifics.)

Parameter or Pollutant	Number of Analyses (if actual data reported)	Maximum Daily Discharge (specify units)		Average Daily Discharge (specify units)		Source (use codes per instructions)
		Mass	Conc.	Mass	Conc.	
Chemical oxygen demand (COD)						
Total organic carbon (TOC)						

SECTION 5. FLOW (40 CFR 122.21(h)(5))

Flow

5.1 Except for stormwater water runoff, leaks, or spills, are any of the discharges you described in Sections 1 and 3 of this application intermittent or seasonal?

☑ Yes ➔ Complete this section. ☐ No ➔ SKIP to Section 6.

5.2 Briefly describe the frequency and duration of flow.

DSN017: The fire protection system at the Browns Ferry Nuclear Plant Training Center is flushed at least annually. The source of the water used for fire protection is potable water from the local municipality. Flow rates during flushes are approximately 150 gallons per minute and typically last between 15 and 30 minutes for an approximate maximum discharge of 5,000 gallons per day. Lower volume discharges may take place as needed after system operation testing or fire protection system maintenance.

SECTION 6. TREATMENT SYSTEM (40 CFR 122.21(h)(6))

Treatment System

6.1 Briefly describe any treatment system(s) used (or to be used).

DSN012:River water from the intake is used to backwash the intake screens with no chemical treatment provided.
DSN017: The wastewater discharged will not undergo any treatment prior to discharge.

[1] Sampling shall be conducted according to sufficiently sensitive test procedures (i.e., methods) approved under 40 CFR 136 for the analysis of pollutants or pollutant parameters or required under 40 CFR chapter I, subchapter N or O. See instructions and 40 CFR 122.21(e)(3).

SECTION 7. OTHER INFORMATION (40 CFR 122.21(h)(7))

Other Information

7.1 Use the space below to expand upon any of the above items. Use this space to provide any information you believe the reviewer should consider in establishing permit limitations. Attach additional sheets as needed.

DSN012 is primarily comprised of untreated river water from the intake used to wash the intake screens. There may be small quantities (<10% of flow) of treated emergency equipment cooling water which also discharge through this outfall. Because the waste stream is primarily comprised of untreated river water from the intake used to wash the intake screens and the only other contributing source is less than 10% in volume, TVA is requesting a sampling waiver for this outfall which is consistent with previous NPDES permit renewal applications for this source.

SECTION 8. CHECKLIST AND CERTIFICATION STATEMENT (40 CFR 122.22(a) and (d))

Checklist and Certification Statement

8.1 In Column 1 below, mark the sections of Form 2E that you have completed and are submitting with your application. For each section, specify in Column 2 any attachments that you are enclosing to alert the permitting authority. Note that not all applicants are required to provide attachments.

Column 1	Column 2
☑ Section 1: Outfall Location	☐ w/ attachments (e.g., responses for additional outfalls)
☑ Section 2: Discharge Date	☐ w/ attachments
☑ Section 3: Waste Types	☐ w/ attachments
☑ Section 4: Effluent Characteristics	☐ w/ attachments
☑ Section 5: Flow	☐ w/ attachments
☑ Section 6: Treatment System	☐ w/ attachments
☑ Section 7: Other Information	☐ w/ attachments
☑ Section 8: Checklist and Certification Statement	☐ w/ attachments

8.2 **Certification Statement**

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name (print or type first and last name)	Official title
Daniel Komm	Site Vice President
Signature 	Date signed 5-8-2025

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Clean Water Act Section 316(b) § 122.21(r) Compliance Documentation for the Browns Ferry Nuclear Plant

Limestone County, Alabama



April 2021

Tennessee Valley Authority

Knoxville, Tennessee

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1.0 Introduction

The Tennessee Valley Authority (TVA) began commercial operation of the Browns Ferry Nuclear Plant (BFN) Unit 1 August 1, 1974; Unit 2 March 1, 1975; and Unit 3 March 1, 1977. Located approximately eleven miles southwest of Athens, Alabama (Figure 1), BFNs' three units have a total generating capacity of 3,952 megawatts (MW).

Section (§) 316(b) of the Clean Water Act provides that the location, design, construction, and capacity of cooling water intake structures (CWIS) reflect the best technology available (BTA) for minimizing adverse environmental impact (i.e., impingement and entrainment of aquatic species). The U.S. Environmental Protection Agency (EPA) issued a final § 316(b) rule effective October 2014 for existing power generating and industrial facilities.

Under the final rule, an existing facility is defined as "any facility that commenced construction … on or before January 17, 2002 … and any modification of, or any addition of a unit at such a facility." Commercial operation of BFN Units 1, 2, and 3 began in 1974 to 1977; thus, BFN is considered an "existing facility."

Existing facilities are required to meet the BTA standards for impingement via one of seven compliance alternatives provided at § 125.94(c):

1. operate closed-cycle recirculating system,
2. operate CWIS with maximum through-screen design intake velocity of 0.5 feet per second (fps),
3. operate CWIS with maximum through-screen actual intake velocity of 0.5 fps,
4. operate an existing offshore velocity cap,
5. operate a modified traveling screen that Director determines is BTA for impingement reduction,
6. operate a system of technologies, management practices and operational measures that the Director determines is BTA for impingement reduction, or
7. achieve the specified impingement mortality performance standard.

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Existing facilities are also required to meet BTA standards for entrainment for each intake structure as determined on a site-specific basis (§ 125.94(d)) upon review by the permitting authority of supporting documentation conducted and submitted by the facility.

Plant Description

BFN is a three-unit, nuclear-fueled, electricity-generating facility with a total generating capacity of 3,952 MW. The plant is located on Wheeler Reservoir approximately 18 miles upstream of Wheeler Dam at Tennessee River Mile (TRM) 294 in Limestone County, Alabama (Figure 1).

Circulating Cooling Water System

Each of BFN's three nuclear units is a boiling-water reactor that produces steam to turn turbines to generate electricity. Current operation utilizes a once-through condenser circulating water (CCW) system with seven helper cooling towers to dissipate waste heat, withdrawing water from the Tennessee River through an intake structure at TRM 294.3 and discharging through a multi-port diffuser located downstream from the plant at TRM 293.6 (Figure 2). This straight-through flow path is known as "open cycle" or "open mode" operation. Through various gates, some of this cooling water can also be directed through cooling towers to reduce its temperature as necessary to comply with environmental regulations. This flow path is known as the "helper mode." The physical capability also exists to recycle the cooling water from the cooling towers directly back to the intake structure without being discharged to the reservoir; this is known as the "closed mode" of operation. Maximum flow rate of the CCW for all three units is approximately 3,171 million gallons per day (mgd) or 4,915 cubic feet per second (cfs). The BFN plant's total per-unit condenser circulating flow is generally higher than the original design values due to system upgrades, including the refit of the condensers with larger diameter and lower resistance tubes (NRC 2005).

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2.0 Application Requirements of Clean Water Act Section 316(b)

National Pollutant Discharge Elimination System (NPDES) permit application requirements for all existing facilities with CWISs relevant to the new § 316(b) regulations are provided at § 122.21(r) and require the submission of the following information[1]:

- Source Water Physical Data (§ 122.21(r)(2)),
- Cooling Water Intake Structure Data (§ 122.21(r)(3)),
- Source Water Baseline Biological Characterization Data (§ 122.21(r)(4)),
- Cooling Water System Data (§ 122.21(r)(5)),
- Chosen Method For Impingement Compliance (§ 122.21(r)(6)),
- Entrainment Performance (Survival/Mortality) Studies (§ 122.21(r)(7)), and
- Operational Status (§ 122.21(r)(8)).

Unless waived by the permitting authority [Alabama Department of Environmental Management (ADEM)], facilities that withdraw more than 125 million gallons of cooling water per day (actual intake flow) are required to provide this additional information:

- Entrainment Characterization Study (§ 122.21(r)(9)).
- Comprehensive Technical Feasibility And Cost Study (§ 122.21(r)(10)),
- Benefits Valuation Study (§ 122.21(r)(11)),
- Non-Water Quality Impacts Assessment (§ 122.21(r)(12)), and
- Peer Review (§ 122.21(r)(13)).

In the narrative that follows, TVA has compiled the relevant information required of all existing facilities as specified in the § 316(b) rule at § 122.21 under paragraphs (r)(2), (3), (4), (5), (6), (7), and (8).

[1] For § 122.21 paragraphs (r)(4), (5), (6), (7) and (8), only the applicable provisions apply for existing facilities.

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2.1 Source Water Physical Data § 122.21(r)(2)

(i) A narrative description and scaled drawings showing the physical configuration of all source water bodies used by your facility, including areal dimensions, depths, salinity and temperature regimes, and other documentation that supports your determination of the water body type where each cooling water intake structure is located;

Wheeler Reservoir is the cooling water source waterbody for BFN (Figure 2). At normal summer pool elevation of 556 feet (ft) above mean sea level (msl), this reservoir covers a surface area of about 67,070 acres and has a volume of 1,050,000 acre-feet. It extends approximately 74 river miles upstream from Wheeler Dam at Tennessee River mile (TRM) 274.9 to Guntersville Dam at TRM 349 (Figure 1). Water temperature in Wheeler Reservoir naturally varies from around 35 degrees Fahrenheit (°F) in January to 88 to 90°F in July and August, and temperature patterns near BFN are typically well mixed or exhibit weak thermal stratification.

Wheeler Reservoir in the vicinity of BFN is over two miles in width and is relatively shallow, with an average depth of 15 ft and maximum depth of 60 ft. A minimum of 11 ft depth is maintained in a channel for navigation of commercial traffic (NRC 2005). Based on releases from Guntersville and Wheeler dams, average daily flow of the Tennessee River past BFN is approximately 48,300 cfs. TVA believes that the waterbody type (reservoir) is unambiguous.

In association with biological sampling conducted at two locations around BFN during 2010 through 2015, temperature, acidity (pH), conductivity (salinity), and concentration of dissolved oxygen were measured along vertical profiles from surface to depth. At the transect upstream of the BFN discharge (TRM 295.9), measurements were collected April through September from 2010 to 2015 (TVA Data). Water temperatures averaged 62.3°F in April, 72.5°F in May, 81.6°F in June, 84.7°F in July, 85.0°F in August, and 78.6°F in September. pH measurements from April to September were steady, ranging from 7.1 to 7.9 standard units (SU). Conductivity monthly averages were highest in April [182.7 microsiemens per centimeter (µS/cm)] and lowest in May (159.9 µS/cm). With the exception of July, average percent saturation of DO and DO concentration decreased each month from April to September, with percent saturation decreasing from 99.4% to 81.2% and concentration from 9.5 to 6.1 milligrams per liter (mg/L; Table 1).

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Downstream of the BFN discharge (TRM 292.5), measurements were collected in October during 2011, 2013, and 2015 (TVA Data). Water temperatures averaged 70.2°F, conductivity 193.6 µS/cm, pH 7.5 SU, and DO concentration 8.2 mg/L (Table 1).

(ii) Identification and characterization of the source waterbody's hydrological and geomorphological features, as well as the methods you used to conduct any physical studies to determine your intake's area of influence within the waterbody and the results of such studies;

Constructed by TVA from 1933 to 1936 for purposes including electric power generation, flood control, and navigation, Wheeler Dam is one of 49 active dams in the Tennessee River system. The reservoir drains an area of just under 30,000 square miles. During normal operations, the surface elevation of Wheeler Reservoir generally varies between 552 ft msl in winter and 556 feet msl in summer, providing a total fluctuation of 4 ft between normal minimum pool in the winter and maximum pool in the summer (Table 2; NRC 2005). Wheeler Reservoir flow in the vicinity of BFN is controlled primarily by releases from Guntersville and Wheeler dams. Historically, flow in Wheeler Reservoir at BFN is highest during December through February, averaging roughly 72,000 cfs, and lower during April through October at 36,000 cfs. Historical daily flows averaged across all months is roughly 48,000 cfs (Figure 3; Table 2).

The Tennessee River courses through two physiographic provinces that comprise the majority of northern Alabama. Beginning in the northeast corner of the state, the river flows southwest along the Appalachian Plateaus, then turns abruptly at Guntersville and flows to the northwest through the Interior Low Plateaus. The area where BFN is sited exhibits no seismic activity, no faulting or deformation, and the plant is built on massive formations of nearly horizontal bedrock. Due to the proximity of the bedrock formations and their shallow pitch, groundwater moves slowly from the plant area to the Tennessee River. Groundwater movement is further inhibited by thick eluvium deposited on the bedrock.

On annual average, 83% of the total inflow of Wheeler Reservoir originates from discharges from Guntersville Dam, and 17% originates from local tributaries, primarily the Elk River. Guntersville's average contribution to the total inflow of Wheeler varies seasonally from a low

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of 74% in March to a high of 90% in September. The entire volume of Wheeler Reservoir is replaced within an average of nine days (TVA 1990).

TVA has not conducted any physical studies to determine the BFN CWIS's area of hydraulic influence (AHI) within the source waterbody. However, based on three-dimensional computational fluid dynamics (CFD) modeling software (Delft 3D) performed in Wheeler Reservoir associated with BFN permitted discharges, it is expected that the withdrawal zone will vary significantly depending on the flow and the presence of unsteady reservoir sloshing[2] (i.e., on an hourly basis). For a flow rate of 70,000 cfs by the BFN plant, a conservative estimate of the withdrawal zone would be an area of roughly 300 ft by 750 ft (Figure 4) extending out into the reservoir. For a low flow rate of 10,000 cfs, the withdrawal zone would expand to include a larger portion of the reservoir: an area of about 5,000 ft by 9,000 ft. At this flow rate, the AHI could be expected to extend laterally into the river channel (possibly 3/4 of the width of the river) as well as from directions both upstream and downstream of the intake (Figure 4). The withdrawal zone will include regions downstream of the intake during reverse flow/sloshing events. However, releases from Guntersville Dam at this flow rate would be extremely rare (pers. comm. C. Montgomery, TVA Hydrothermal Engineer). The overall long-term average flow past BFN is about 48,400 cfs (Table 2).

(iii) Locational maps

The location of the BFN site is shown in Figures 1 and 2.

2.2 Cooling Water (Service Water) Intake Structure Data § 122.21(r)(3)

(i) A narrative description of the configuration of each of your cooling water intake structures and where it is located in the water body and in the water column;

A cooling water intake structure is defined at § 125.92(f) as:

[2] Reservoir sloshing is an upstream-downstream oscillation that entails periods of reverse flow and changes in reservoir elevation (analogous to tilting a tub of water), generally attributed to rapid water releases at upstream dams.

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"the total physical structure and any associated constructed waterways used to withdraw cooling water from waters of the United States. The cooling water intake structure extends from the point at which water is first withdrawn from waters of the United States up to and including the intake pumps."

BFN operates one intake structure that clearly meet this definition: 1) the Condenser Circulating Water (CCW) system intake.

Condenser Circulating Water (CCW) System

The purpose of the condenser circulating water (CCW) system is to provide cooling water to the condensers of the main steam turbines. This system also provides cooling water for auxiliary equipment and a means of rejecting waste heat from the power generation cycle into the ambient surroundings.

The CCW intake channel extends approximately 500 ft from the intake structure to the Gate Structure No. 3, which acts as a skimmer wall for cooling water drawn from Wheeler Reservoir into the plant, and is a common structure for all three units. It is located at the south-east end of the plant on the reservoir end of the intake channel. The skimmer wall is a 218 ft long concrete and steel structure positioned across the entrance of the intake channel. Water is drawn into the intake channel through the lower portion of the wall through three 40-ft wide by about 24-ft high sections, enabling BFN to withdraw cooler water from the lower stratum. The three open sections have movable, motor-operated wheel gates with bottom elevations that can vary between 527 ft msl and 547 ft msl. Actual water depth in the channel varies based on reservoir elevations: the normal minimum pool elevation is 550 ft msl and normal maximum pool elevation is 556 ft msl (NRC 2005).

The intake pumping station is comprised of a concrete pumping structure 232 ft long by 117 ft wide and 47 ft high, and includes 18 bays, 6 per unit, each having a traveling screen. Each bay will have a net opening of 8 ft 8 inches (in) by 20 ft. The bottom elevation of the pumping station is at 517 ft msl. Each unit has three vertical, nonpullout-type, single-stage, mixed-flow, wet-pit-type circulating water pumps. Suction for these pumps is provided to 532 ft msl. Each pump discharge is equipped with motor-operated butterfly valves. The pumps are installed in

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separate pump bays that are each covered by two trashracks and two traveling screens. The screens are each 7.5 ft wide with mesh openings of 3/8 in (NRC 2005).

Each unit at BFN has one main condenser. Each main condenser has three subsections, one each for each low pressure turbine. Each subsection has two parallel cooling water paths, making a total of six parallel paths for each unit's main condenser. There are twelve 440-revolutions per minute (rpm), mixed-flow, vertical, wet-pit, and non-pullout type cooling tower supply pumps for Cooling Towers 1 through 6 and two 509-rpm, mixed-flow, vertical, wet-pit, pullout-type pumps for Cooling Tower 7. Cooling Towers 1 through 6 are mechanical-induced-draft, cross flow cooling towers consisting of sixteen cells. Cooling Tower 7 is a mechanical-induced-draft, cross flow cooling tower consisting of 28 cells (TVA 2009).

The BFN units are normally cooled by water pumped from Wheeler Reservoir into the turbine-generator condensers and discharging it back to the reservoir via large submerged multiport diffuser pipes that are designed to maximize mixing of the effluent into the receiving water (i.e. open mode). These pipes range in diameter from 17 ft to 20.5 ft. The flow exits each discharge pipe through 7,800 2-in ports. The diffuser pipes have a series of nozzles on the downstream side to inject the condenser discharge water into the main flow of the reservoir (TVA 2009).

(ii) Latitude and longitude in degrees, minutes, and seconds for each of your cooling water intake structures;

Cooling water intake structure for BFN are located at:

Latitude 34° 42' 8.0022"

Longitude -87° 7' 3.8238"

(iii) A narrative description of the operation of each of your cooling water intake structures, including design intake flows, daily hours of operation, number of days of the year in operation and seasonal changes, if applicable;

The BFN intake structure draws water from Wheeler Reservoir at TRM 294.3. The flow velocity through the Gate Structure No. 3 (skimmer wall) openings varies depending on the gate

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position. When the gates are in a full open position and the plant is operating in either open or helper modes, the average flow velocity through the openings is about 0.6 fps for the operation of one unit, 1.1 fps for the operation of two units, and 1.7 fps for the operation of all three units, assuming a water withdrawal rate of approximately 734,000 gallons per minute (gpm) per unit, for a total withdrawal of about 2,202,000 gpm (3,171 mgd; 4,915 cfs) of water for all three units.

The traveling screens and screen wash system can be operated automatically or manually. The design through-screen velocity is 2.1 fps at normal minimum pool and 1.6 fps at normal high pool. Differential pressure across each pair of traveling screens for a given CCW pump is monitored. When operating the system in the automatic mode, the screen wash pump is started when a preset differential pressure of water is reached across any of the three pairs of screens. When a preset pressure is established at the screen wash nozzles, the screen motors are automatically started and the screens are washed. In either manual or automatic mode, the pump and screens run until manually stopped (TVA 2009).

The discharges of the three pumps are brought together in a steel trifurcation transition to a single tunnel. The water is channeled to the condenser by this tunnel. A debris filter is installed in the 78-in inlet pipe of the CCW piping into one condenser water box per condenser. The debris filter is provided with a backwash line that permits manual or automatic operation of the backwash system. The backwash line bypasses the condenser and discharges directly into the condenser water box outlet piping for each of the units (TVA 2009).

Normally, filling and operating of the condensers are accomplished by (1) venting, (2) evacuation of the condenser water box by a vacuum system, and (3) operation of one or more circulating water pumps. The three cooling sections of the three condensers can be operated fully flooded by only one pump. The discharge from the condensers passes to the discharge tunnel and then to the warm water channel going to the cooling towers or to the discharge diffusers in the reservoir or a combination of these discharge paths. Gate No. 1 is provided to allow the discharge from the condenser to pass out through the diffusers in the reservoir and to divert the water to the warm water channel by way of the vacuum loop. Gate No. 1 consists of

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three motor-operated wheel gates, with one gate in the discharge conduit from each unit. The gates are controlled to operate independently of one another (TVA 2009).

Through various gates, some of this cooling water can also be directed through mechanical draft cooling towers (seven in total) to reduce its temperature as necessary to comply with environmental regulations (i.e. helper mode). Water is pumped to the seven cooling towers by pumps located in seven pumping stations located along the warm water channel. Each pumping station for Cooling Towers 1 through 6 have two 137,500-gpm pumps at a design head of 75 ft. The pumping station for Cooling Tower 7 has four 102,500-gpm pumps at a design head of 83.5 ft. The discharge from the cooling tower cold water basins flows into an open channel, over a discharge control structure, and then through Gate No. 1 back to the reservoir through the diffuser (TVA 2009).

The capacity also exists to recycle cooling water from the cooling towers directly back to the intake structure without being discharged to the reservoir (i.e. closed mode). However, TVA has not operated in closed mode for many years due to the difficulty in maintaining temperature limits specified in the NPDES permit during the hottest part of the summer (typically July and August; NRC 2005).

Taking the most recent and most representative seven-year period of operations (see § 125.92(a)), the annual average daily inflow to the CCW (i.e. actual intake flow or AIF) from 2014-2020 was approximately 4,311 cfs or 2,786 mgd (Table 3). BFN operates as a base load facility (2014–2019 mean capacity factors of 91%, 90%, and 87% for Units 1, 2, and 3, respectively). The operations of the CCW system are essentially continuous throughout the year, except for periods of planned outages for each unit equivalent to approximately 25-30 days duration each 2 years for maintenance and refueling. With the exception of these planned outages at the CCW, there are no seasonal variations in operation. Figure 5 illustrates seasonal generation during 2019 and 2020. The BFN plant operated at full capacity (three units, nine pumps) 79% of these years, two units 19%, and one unit 2%. The plant reduced operation to two units during spring (March–April) and autumn (October–November) during both years.

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(iv) A flow distribution and water balance diagram that includes all sources of water to the facility, recirculating flows, and discharges;

Figure 6 illustrates the routing of cooling water through the CCW system.

(v) Engineering drawings of the cooling water intake structures.

Engineering drawings of the nuclear plant's cooling water intake structures are security-related and cannot be shared with the public (see 10 CFR 2.390).

2.3 Source Water Baseline Biological Characterization Data § 122.21(r)(4)

(i) A list of the data in paragraphs (r)(4)(ii) through (vi) of this section that are not available and efforts made to identify sources of the data;

Nearly all of the information used in (r)(4)(ii) through (vi) of this section are available in TVA documents available to the public except for relative abundances of the crayfish. The data included in the paragraphs below are based on TVA's sampling. TVA contacted Alabama Department of Environment to request data that would compliment TVA's (including crayfish abundance data); however, data that would satisfy the requirements were not available.

ii) A list of species (or relevant taxa) for all life stages and their relative abundance in the vicinity of the cooling water intake structure

The new § 316(b) Rule focuses on the protection of all life stages of fish and shellfish (limited to crayfish and freshwater mussels in freshwater systems) as defined at 125.92(b). The following section discusses species of fish, freshwater mussels, and crayfish known to occur in the vicinity of the BFN CWIS.

Fish

Table 4 lists fish species collected by TVA in the vicinity of BFN during 36 samples from autumn 1993–1997, 1999–2011, 2013, 2015, 2017, 2019, and 2020, along with catch rates and number of occurrences of each. Sampling sites were nominally located at TRMs 292.5 and 295.9, but actual electrofishing and gill netting locations ranged from 0.5 to 1.0 mile upstream

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and downstream of these river mile locations (Figure 7). Of the 69 total fish species collected (not counting hybrids), Mississippi silverside, gizzard shad, emerald shiner, and threadfin shad had the highest average catch rates per sample at 17.2, 15.7, 11.8, and 9.8 fish per effort, respectively. Seven species were collected during all 45 samples, and fifteen were only collected during one sample (Table 4).

Freshwater mussels

Historically, 39 mussel species occurred in Wheeler Reservoir. Thirty-one of these species were considered riverine (i.e., those that evolved in free-flowing reaches), with 19 of these species now considered non-reproducing riverine species within Wheeler Reservoir (TVA 1992). In 1982, 12 mussel species were collected during a survey for the proposed barge facility at BFN (Pryor 1982), and 11 species were collected across the river during a survey for a proposed barge terminal for the Mallard-Fox Creek Development Project (Carroll 1982). The washboard (*Megalonaias nervosa*) was the most common species collected during both surveys. None of the species collected were Federally or State protected. In 1991, twenty-four species of mussels were collected from seven locations in Wheeler Reservoir (TRM 276.9–347.2), with six species represented by weathered, empty shells (TVA 1992). The 24 species included all species previously collected near BFN in the two 1982 collections by Pryor (1982) and Carroll (1982). The most common species collected in 1991 were the elephant-ear (*Elliptio crassidens*), washboard, pink heelsplitter (*Potamilus alatus*), and threehorn wartyback (*Obliquaria reflexa*). From the stations in the vicinity of BFN (TRMs 287.4, 292.7, 313.2, and 313.9), 133 mussels of 10 species were collected. *Elliptio crassidens*, *Megalonias nervosa*, and *Quadrula pustulosa* were the most abundant species collected, accounting for 25%, 21%, and 20% of the population, respectively (Table 5; TVA 1992). In 1998, seventeen mussel species were collected on the east channel of Wheeler Reservoir near Hobbs Island, about 40 river miles upstream of BFN, between TRMs 336.4 and 335.5. The two most common mussel species were the elephant-ear and the Ohio pigtoe. Two Federally endangered species were also collected: one specimen of the rough pigtoe (*Pleurobema plenum*) and 16 specimens of the pink mucket (*Lampsilis abrupta*)(Yokely 1998). In 1999, 16 native mussel species were collected in the vicinity of BFN: 14 species at TRM 298 upstream of BFN and 12 species at TRM 292 downstream of BFN. None of these were Federally listed species (TVA 2003).

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Crayfish

Table 6 lists crayfish species collected from streams within Limestone, Lawrence, and Morgan counties that drain to Wheeler Reservoir in the vicinity of BFN (TRM 275 to TRM 317). No surveys specifically targeting crayfish have been conducted in the reservoir near BFN; the listed crayfish were collected during benthic macroinvertebrate portions of stream community surveys, by digging out visible burrows, or incidentally during reservoir fish surveys. One species of crayfish (*Faxonuis forceps*) was collected twice from the reservoir proper. Twelve species were collected from tributary streams in these three counties entering Wheeler Reservoir. It is reasonable to assume these twelve species of crayfish could occur in the reservoir as well, given the proximity of the collection localities to the reservoir.

In freshwater, crustaceans and mollusks (shellfish) are limited to crayfish and freshwater mussels, and although these occur in Wheeler Reservoir near BFN, neither are generally susceptible to impingement and entrainment. This is supported by the fact that only one crayfish has been collected in impingement or entrainment samples at BFN.

(iii) Identification of the species and life stages that would be most susceptible to impingement and entrainment. Species evaluated must include the forage base as well as those most important in terms of significance to commercial and recreational fisheries

TVA collected impingement data for the BFN CWIS during the period from 2007 through 2009 (TVA 2010) and entrainment data 2018 through 2019 [to fulfill requirements of § 122.21(r)(9)]. These data provide a general indication of the fish species present in Wheeler Reservoir that were most susceptible to impingement and entrainment at the BFN CWIS. Table 7 lists fish taxa collected in impingement samples from 2007 to 2009 and entrainment samples from 2018 to 2019, and designation as forage, commercial, and/or recreational species. Forage fish were defined as those generally regarded as prey for top carnivore fish. Commercially valuable species were defined as those that may be harvested and sold commercially for food or bait in Alabama. Recreationally valuable species were those targeted by anglers or used as bait. Of the 54 total distinct taxa collected during 2007 through 2009 and 2018 through 2019 monitoring, 51 were collected during impingement monitoring and 24 during entrainment monitoring. Sixteen

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taxa were considered forage taxa, 18 commercially valuable, and 28 recreationally valuable (Table 7).

Impingement

Table 8 lists relative abundance of fish species collected from BFN's CCW traveling screens during 24-hour impingement sampling conducted by TVA from September 2007 to September 2008 and October 2008 to September 2009.

Methods

To collect each sample, CCW intake screens were rotated and washed on a prearranged schedule by the plant assistant unit operator to remove all fish and debris. After 24 hours, screens were again rotated and washed with TVA staff on site. Fish and debris were collected in a catch basket constructed of 3/8 in mesh located at the end of the sluice pipe where the monitoring staff removed and processed the sample. Fish were sorted from debris, identified, separated into 25-millimeter (1-in) length classes, enumerated, and weighed. Incidental numbers of fish which appeared to have been dead for more than 24 hours (i.e., exhibiting pale gills, cloudy eyes, fungus, or partial decomposition) were not included in the sample. Fish collected alive were returned to the reservoir after processing. Impingement data from weekly 24-hour impingement samples were extrapolated (multiplied by 7) to provide estimates of total fish impinged by week; weekly estimates were then totaled for each year of study to provide annual estimates.

Results

Actual numbers of fish collected in impingment samples during the first year (2,810,778) were more than two times higher than that of the second year (1,172,660), but total taxa were similar between years—46 and 43 taxa during 2007–2008 and 2008–2009, respectively. The increase was due to much higher numbers of threadfin shad. Thirty-eight species were collected during both years, and thirteen were collected during only one year (Table 8).

The fish species most susceptible to impingement on the CCW intake screens are threadfin shad. This species accounted for the majority (96%) of fish impinged during the two-year survey. Of the non-clupeid species, yellow bass, bluegill, and freshwater drum were most susceptible to

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impingement (Table 8). Threadfin and/or gizzard shad typically comprise over 90% of fish impinged on cooling-water intake screens of thermal power stations in the Southeastern U. S. (EPRI 2005). The preamble to the §316(b) existing facilities rule acknowledges the susceptibility and fragility of these species to impingement and focuses impingement mortality requirements on non-fragile species, unless additional measures are specified by ADEM.

The estimated average annual impingement at the CCW intake during the 2007–2009 sampling event was 13,942,033 fish; of these, 96% were fragile threadfin shad (Table 8). Peak impingement periods were during the cooler months (November–January; Figure 8) suggesting shad impingement may be related to cold shock.

Entrainment

TVA conducted entrainment monitoring (February 2018–December 2019) required of the BFN facility as specified in the § 316(b) rule at § 122.21 under paragraph (r)(9). Detailed methods and results are included in a separate report ["Entrainment Characterization Study" § 122.21(r)(9)]. The following is a summary of methods and results from this monitoring.

Methods

Samples were collected from two locations—outside the skimmer wall of the BFN CCW intake and along a reservoir transect located at TRM 294.5—during day and night sampling from February 20, 2018 through December 19, 2019. During both years, samples were collected weekly during March through August (expected period of fish spawning) then monthly from September through February. Ichthyoplankton samples provided temporal and spatial abundance of larval fish and eggs at four equidistant stations along a transect perpendicular to river flow just upstream of the plant intake channel at TRM 294.5. Full-stratum samples were taken at either shoreline and at a mid-channel station; two samples were taken from the mid-channel station, one from river bottom to mid-depth and one from mid-depth to surface.

TVA was not able to collect ichthyoplankton inside the BFN intake channel (Figure 2) due to security reasons; therefore, three replicate, ten-minute samples were collected from the depth of the skimmer wall opening (within the BFN CWIS's area of influence) immediately outside the

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intake channel as representative of BFN entrainment. Intake and reservoir samples were collected with a 0.75-meter (m) circular beam net with 363-micron "Nitex®" mesh netting, and reservoir samples towed upstream at a speed of 1.0 meter/second for approximately ten minutes to filter approximately 150 cubic meters (m^3) of water per sample.

To ensure sample collections were not biased towards a particular day and/or night period, sampling events were alternated weekly between four six-hour periods—two day (06:00–12:00; 12:00–18:00) and two night (18:00–0:00; 0:00–06:00). For example, during one week the day samples would be collected in the period 06:00–12:00, and the next week 12:00–18:00.

Larval fish and eggs were removed from the samples, identified to the lowest possible taxon, counted and measured to the nearest millimeter total length. Densities were expressed as numbers per 1,000 m^3 using the equation:

$$Density = \frac{1{,}000(Number\ fish\ eggs\ or\ larvae\ collected)}{Sample\ volume}$$

Estimated numbers entrained or available for entrainment was estimated using the equation:

$$Estimated\ numbers\ entrained\ or\ available\ for\ entrainment = \frac{\sum Density\ x\ Flow}{1{,}000}$$

Daily CCW intake flows were provided by the BFN facility and river flow past BFN obtained from TVA's Reservoir Operations database. The estimated weekly or monthly entrainment for each taxon was then summed for the entire sample year to determine estimated annual numbers of fish entrained and available for entrainment.

The percent of fish eggs and larvae in the river/reservoir that were entrained at the BFN CCW intake was estimated using the formula:

$$Percent\ entrainment = \frac{100(Estimated\ numbers\ entrained)}{(Estimated\ numbers\ available\ for\ entrainment)}$$

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The annual percent of total fish eggs and larvae entrained was determined using the above formula with annual totals of numbers entrained and numbers available for entrainment.

Results

Table 9 lists numbers and relative abundance of fish eggs and larvae collected during day and night in the vicinity of BFN. Table 10 lists estimated numbers of the taxa entrained at the BFN CCW intake by sample period. Table 11 lists by sample period average densities of each family of ichthyoplankton collected.

Based on the February 20, 2018 through December 19, 2019 sampling effort, fish eggs most susceptible to entrainment by the BFN CCW intake are those of freshwater drum (Sciaenidae). Eggs of this species made up 94.0% of all fish eggs collected in intake samples during both years combined (Table 9). Freshwater drum eggs are typically entrained in highest densities, due to their planktonic and buoyant nature. Clupeid (most likely gizzard and threadfin shad), moronid, atherinopsid, and centrarchid larvae are the most susceptible to entrainment by BFN. In intake samples, clupeids composed approximately 83%, moronids 10%, atherinopsids 3%, and centrarchids 2% of the total sample.

The estimated total entrainment at the CCW intake during the two-year monitoring was approximately 6,300,000,000 fish eggs and larvae. Non-clupeid entrainment was approximately 1,250,000,000 fish eggs and larvae for the CCW intake (Table 10).

(iv) Identification and evaluation of the primary period of reproduction, larval recruitment, and period of peak abundance for relevant taxa

Impingement

Estimated numbers of numerically dominant taxa impinged at the BFN CCW intake during Spetember 2007 through September 2009 are depicted in Figure 9. As stated previously, clupeid impingement—and to a lesser extent bluegill, freshwater drum, and yellow bass—was highest during the cooler months (TVA 2010).

Entrainment

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Figure 10 illustrates densities of the numerically dominant taxa by sample week collected during February 2018 through December 2019. Table 11 lists densities by sample period and transect.

Clupeids spawned from April through June primarily, with additional clupeid larvae being collected in reservoir samples into August and September. Clupeid densities peaked twice on the third and fifth weeks of May during the first year, and during the end of May the second year. During both years, clupeid spawning began when water temperatures were 56 to 59°F, with peaks occurring at 79 to 83°F the first year and 71°F the second (Figure 10).

Moronid larvae were one of the first taxa to be collected during both years (February 26-27 and March 26-28, respectively) when water temperatures were 58°F the first year and 47°F the second. Moronidae larval collection ceased in late May/early June, with peaks occurring in April during both years. Water temperatures during these peaks were about 56 to 59°F (Figure 10).

The duration of Atherinopsidae (silverside) collections in intake and reservoir samples was longer the first year (as long as 18 sample periods) than the second (13 sample periods), and continued into August the first year and July the second. Atherinopsids were collected when water temperatures were 59 to 87°F (Figure 11).

Centrarchid spawning began in March during both years, when water temperatures were 56 to 59°F, and continued through August. Peaks occurred in June when water temperatures were 85°F in Year 1 and 77°F in Year 2 (Figure 11).

Larval densities of cluepids, moronids, atherinopsids, and centrarchids were generally similar between day and night samples during the first year. During the second year, intake densities of fish eggs and larvae were higher in nighttime samples. Reservoir densities were generally highest at the station located along the right descending bank, the same side of the river as the BFN intake (Table 11).

(v) Data representative of the seasonal and daily activities (e.g., feeding and water column migration) of biological organisms in the vicinity of the cooling water intake structure

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TVA has not conducted studies specifically designed to determine seasonal and daily activities (e.g., feeding and water column migration) of fish in the vicinity of the BFN intake. However, § 316(a) thermal discharge-related reservoir fish assemblage monitoring was conducted in the vicinity of BFN during spring and autumn 2007 (Baxter and Simmons 2008), and § 316(b) entrainment monitoring was conducted during day and night periods using full-stratum tows during 2018 and 2019. Results of these monitoring events provide some information of seasonal activities of adult fish and daily activities of larval fish, respectively, in the vicinity of the BFN intake.

Seasonal

The § 316(a) thermal discharge-related reservoir fish assemblage monitoring used boat electrofishing and gill netting to collect juvenile and adult fish at proximate sampling sites upstream and downstream of BFN. Total numbers of species collected were similar between seasons, but autumn catch rates were slightly greater than those in spring. The difference in catch rates between seasons was primarily due to higher numbers of gizzard shad, which is a schooling species and typically collected in large numbers. Twenty-nine of the 36 total species were collected during both seasons; six of the top eight species proportionally were the same between seasons (Table 12). Regarding trophic composition of the fish communities from from spring to autumn, insectivore species decreased, insectivore and omnivore species increased, and numbers of top carnivore and planktivore species remained the same. Proportions of omnivores increased in autumn, planktivores decreased, and others remained similar (Table 13). These results indicate small trophic assemblage shifts and little migration into and out of the BFN source waterbody in the vicinity of the plant from spring to autumn.

Daily

Average densities of certain taxa (cluepids and moronids) were higher during nighttime the second year, but, along with the remaining taxa, were similar between diel periods during the first year (Table 11). This indicates preferred spawning conditions may not include diel period. Regarding water column migration information, TVA sampled the entire water column for ichthyoplankton, but did not record species and abundance data at various depths within the water column.

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(vi) Identification of all threatened, endangered, and other protected species that might be susceptible to impingement and entrainment at your cooling water intake structures

The TVA's Regional Natural Heritage Database (queried 24 March 2021) indicated records of twelve aquatic species that currently or historically occur within a ten-mile radius of BFN (Table 14), which included ten federally listed as endangered mussels (birdwing pearlymussel, cracking pearlymussel, Cumberlandian combshell, dromedary pearlymussel, fluted kidneyshell, pink mucket, ring pink, rough pigtoe, spectaclecase, and tuberculed blossom pearlymussel), one endangered snail (slender Campeloma), and one fish listed as threatened (spring pygmy sunfish). Ten mussel, one amphibian, eight fish and three snail species are tracked or listed at only the state level (Table 14).

The spring pygmy sunfish is considered extirpated within the vicinity of BFN. In the samples conducted by TVA from 1993 to 2020 in the vicinity of BFN, no spring pygmy sunfish have been collected (Table 4). It is highly unlikely this species would be collected in Wheeler Reservoir given its preference for spring habitat. The mussel species listed as federally endangered are either extant, extirpated, or considered a historical (>25 years old) record. A mussel survey conducted by TVA in 1991 supports these listings, showing that all sites near BFN supported relatively low-diversity, low-abundance mussel and snail communities due to lack of suitable habitat. One federally-listed mussel (pink mucket *Lampsilis abrupta*) was collected during this study, but was done so roughly 50 river miles upstream of the plant (TVA 1992). Freshwater mussels are sedentary, bottom-oriented organisms that are not susceptible to entrainment or impingement, although the larval stages (glochidia) might be.

TVA also queried the Alabama Department of Conservation and Natural Resources (ADCNR) internet resource page that included listed species reports; however, these query results are by state and therefore likely includes species that do not occur near BFN. In addition to the aforementioned species, the ADCNR website lists nineteen additional federally listed species—lake sturgeon, shovelnose sturgeon, slackwater darter, boulder darter, fanshell, oyster mussel, fine-rayed pigtoe, littlewing pearlymussel, orangefoot pimpleback, sheepnose mussel, round

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pigtoe, pyramid pigtoe, slabside pearlymussel, rabbitsfoot, Cumberland monkeyface, pale lilliput, armored snail and Anthony's river snail.

Additionally, TVA queried the U.S. Fish and Wildlife Service (USFWS) Environmental Conservation Online System (ECOS) and the USFWS Information for Planning and Consultation (IPAC) (queried 24 March 2021) to supplement information on rare aquatic species and designated potentially occurring near BFN. The ECOS and IPAC systems utilize known federally listed species by county. These data inherently search broader areas than the TVA Database queries and, consequently, listed additional federally listed species as potentially occurring near the BFN project. While TVA recognizes these additional species may occur or have occurred in Limestone County, Alabama, we have determined that they would not be affected by BFN since they are either no longer occurring in the Tennessee River near BFN or occur in habitats outside of the affected BFN project area within Limestone County.

The ECOS system showed designated critical habitat for the federally threatened fluted kidneyshell and slabside pearlymussel in the vicinity of the BFN CWIS's area of hydraulic influence. Critical habitat includes specific areas (occupied or unoccupied by the species) on which are found physical or biological features essential to the conservation of the species (constituent elements) and may require special management. The constituent elements for the fluted kidneyshell and slabside pearlymussel critical habitat include: geomorphically stable river channels and banks; a hydrologic flow regime necessary to maintain benthic habitats where the species is found; water and sediment quality necessary to sustain natural physiological processes; the presence and abundance of fish hosts; and either little or no competitive or predaceous invasive species.

(vii) Documentation of any public participation or consultation with Federal or State agencies undertaken in development of the plan

Consultations with Federal and State agencies regarding listed species at the Browns Ferry Nuclear Plant are carried out by the U.S. Nuclear Regulatory Commission (NRC) as part of its licensing process. During a license amendment request regarding an extended power uprate

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(EPU) in 2015, the NRC corresponded with the USFWS regarding any effects to protected species from the project actions (including continued operation of the CWIS).

In letters dated February 1, 2016 and March 30, 2017, the USFWS provided to the NRC lists of threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of the proposed project and/or may be affected by the proposed project. (Appendix A-1 and Appendix A-2).

(viii) If you supplement the information requested in paragraph (r)(4)(i) of this section with data collected using field studies, supporting documentation for the Source Water Baseline Biological Characterization must include a description of all methods and quality assurance procedures for sampling, and data analysis including a description of the study area; taxonomic identification of sampled and evaluated biological assemblages (including all life stages of fish and shellfish); and sampling and data analysis methods. The sampling and/or data analysis methods you use must be appropriate for a quantitative survey and based on consideration of methods used in other biological studies performed within the same source water body. The study area should include, at a minimum, the area of influence of the cooling water intake structure.

Much information for paragraph (r)(4)(1) of the Rule was available in existing TVA reports, which contain the information requested here (TVA 2010, TVA 2018, TVA 1992). TVA conducted new field studies to characterize entrainment; the requested information is contained in the section of this report responding to (r)(9) of the Rule.

(ix) In the case of the owner or operator of an existing facility or new unit at an existing facility, the Source Water Baseline Biological Characterization Data is the information in paragraphs (r)(4)(i) through (xii) of this section.

The information is provided for paragraphs (r)(4)(i) through (r)(4)(xii) of this document.

(x) For the owner or operator of an existing facility, identification of protective measures and stabilization activities that have been implemented, and a description of how these measures and activities affected the baseline water condition in the vicinity of the intake

Placement and operation of the BFN CCW intake results in a number of benefits with regard to reducing potential impingement mortality and entrainment, including:

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- incorporation of a skimmer wall at the opening to the intake canal helps deter actively swimming fish from entering the canal and being subject to impingement;
- location deep in the water column (withdrawal under the skimmer wall) reduces potential impingement and entrainment of surface-oriented fish;
- sweeping river flows occur along the face of the skimmer wall limit the exposure time of small, passive life stages (fish eggs and larvae) to the hydraulic influence of the CWIS; thus, entrainment is reduced;
- located on an inside bend of the river/reservoir away from areas of greater flow that might transport passive fish life forms past the CWIS; thus, reducing potential for entrainment;
- location in a man-made reservoir where fisheries are actively managed and supplementally stocked (status acknowledged in § 125.95(a)(3));
- reproductive strategy of reservoir fish species of recreational and commercial interest is such that entrainment of early life stages is reduced. EPA previously acknowledged this attribute in its Phase II regulations and exempted facilities on reservoirs from the entrainment requirements;
- the proportion of water withdrawn is small (8.9%) compared to the long-term average river flow (48,300 cfs) passing the intake structure; and
- TVA located BFN on a waterbody where federally listed threatened or endangered species are not present in the vicinity of the CWIS area of hydraulic influence; and thus, not subject to impingement or entrainment.

(xi) A list of fragile species, as defined at 40 CFR 125.92(m), at the facility. The applicant need only identify those species not already identified as fragile at 40 CFR 125.92(m)

"Fragile species" are defined at 40 CFR 125.92(m) as those species of fish and shellfish with impingement survival rates of less than 30%. In addition to gizzard shad (a fragile species already identified in the final Rule), threadfin shad is a species commonly collected in impingement samples at the BFN intake with low impingement survival rates. Recent fish impingement survival studies conducted by EPRI at Alabama Power Company's Plants Gorgas and Barry provide very robust and conclusive data that threadfin shad have an impingement survival rate of less than 30 percent (actually <1% on average) (EPRI 2014b and 2015, and

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personal communication with Justin Mitchell, Alabama Power Company). It is important to note that the objectives of the Plant Gorgas and Plant Barry studies were to measure fish survival rates when encountering fish-friendly screen and return system technology. For fish other than gizzard shad and threadfin shad, it is likely that optimization studies will be conducted at BFN after the entrainment BTA determination. During the course of those studies, additional fragile species with survival rates less than 30% may be identified and reported with optimization study results.

(xii) For the owner or operator of an existing facility that has obtained incidental take exemption or authorization for its cooling water intake structure(s) from the U.S. Fish and Wildlife Service or the National Marine Fisheries Service, any information submitted in order to obtain that exemption or authorization may be used to satisfy the permit application information requirement of paragraph 40 CFR 125.95(f) if included in the application.

BFN has not obtained incidental take exemption or authorization from U.S. Fish and Wildlife Service (USFWS), due to the fact there have been no occurrence records of Federally-listed species near enough to the BFN intake to warrant this action. TVA conducted a mussel survey in Wheeler Reservoir (including transects in the vicinity of BFN) to determine the status of commercial mussel populations throughout the reservoir (TVA 1992). One individual of the federally-listed pink mucket (*Lampsilis abrupta*) was collected approximately 50 river miles upstream of the BFN plant. Additionally, no listed mussel species were collected from locations near the BFN plant (TRMs 292 and 298) in 1999. TVA will again consult the USFWS and ADCNR websites and TVA's Natural Heritage Database immediately before document submittal to ensure the information included was accurate.

2.4 Cooling Water System Data § 122.21(r)(5)

i) A narrative description of the operation of the cooling water system and its relationship to cooling water intake structures; the proportion of the design intake flow that is used in the system; the number of days of the year the cooling water system is in operation and seasonal changes in the operation of the system, if applicable; the proportion of design intake flow for contact cooling, non-contact cooling, and process uses; a distribution of water reuse to include cooling water reused as process water, process water reused for cooling, and the use of gray water for cooling; a description of reductions in total water withdrawals including cooling

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water intake flow reductions already achieved through minimized process water withdrawals; a description of any cooling water that is used in a manufacturing process either before or after it is used for cooling, including other recycled process water flows; the proportion of the source waterbody withdrawn (on a monthly basis);

The CCW system is designed for operation in either open or helper mode. In the open mode, water is drawn into the circulating water pumping station forebay from the reservoir, pumped through the main condenser, passed through Gate No. 1, and discharged back into the reservoir through the diffusers. Gate Structure No. 3 (skimmer wall) is open to allow water to flow into the pumping station forebay, Gate No. 1 is open to allow water to flow back to the reservoir from the plant and to allow rainfall in the cooling tower area to run off, and Gate No. 2 is closed. Additionally, Gate No. 1 can be opened to assist in CCW pump back pressure control (TVA 2009).

In the helper mode, water is drawn into the circulating water pumping station forebay from the reservoir, pumped through the main condenser, diverted through the vacuum loop into the warm water channel going to the cooling towers, and pumped out of the warm water channel through the cooling towers by the lift pumps. The discharge from the cooling towers flows into the cold water channel, over the discharge control structure, and is then diverted through Gate No. 1 (Gate No. 2 is closed) to be discharged back to the reservoir through the discharge diffusers (TVA 2009).

The CCW provides water for the raw cooling water. At maximum CCW design intake flow, about 97% of water withdrawn from the reservoir is used in the condensers of the electric power production units. The remainder (~3%) is used for emergency equipment cooling water, residual heat removal service water, raw cooling water, fire protection, and raw service water systems. Almost all of this water is ultimately returned to the river, either directly or indirectly through leakage drains. The only consumption of this ~3% remainder would be from a negligible and unquantifiable amount of evaporation wherever the water is exposed to air.

BFN also consumes a relatively small amount of river water for use in making highly purified or "demineralized" water for various uses in the plant that require high-grade water. Most of the demineralized water lost to various leakages in the plant is recovered and reprocessed for

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recycling, but some of it is lost through evaporation as it passes to floor drains and other open-air collection, and the remainder is consumed via end uses such as evaporative losses in air scrubbers, make-up for auxiliary boiler blow-down, auxiliary decay heat removal during refueling, and spent fuel pool evaporative make-up. No raw water is recycled or re-used for any secondary purpose within the plant (TVA 2003).

At full design capacity, BFN can withdraw an estimated average of just under 13 billion cubic feet (12,916,620,000 ft^3) of water from Wheeler Reservoir each month, between 0.9 and 1.1% of the estimated average monthly volume of water stored in Wheeler Reservoir (Table 15). BFN is a baseline plant in the TVA system; all generation units operate full time at maximum capacity except during outages scheduled for maintenance and inspection.

(ii) Design and engineering calculations prepared by a qualified professional and supporting data to support the description required by paragraph (r)(5)(i) of this section;

All data and calculations supporting the information presented in paragraph (r)(5)(i) are found in the Updated Final Safety Analysis Report for Browns Ferry Nuclear Plant (TVA 2009), which is maintained up-to-date as required for NRC licensing. Calculations of the average proportion of reservoir volume consumed by BFN (Table 15) were determined using average monthly storage volumes obtained from TVA's Reservoir Management (RvM) electronic database (Table 16).

(iii) Description of existing impingement and entrainment technologies or operational measures and a summary of their performance, including but not limited to reductions in impingement mortality and entrainment mortality due to intake location and reductions in total water withdrawals and usage.

Section (iii) of the § 316(b) rule refers specifically to those process units that use cooling water for purposes other than power generation or steam, and where the owner or operator intends to comply with the BTA for impingement mortality through either the use of flow reduction measures or the reuse of other water for cooling purposes. BFN uses cooling water solely as part of the generation of electric power, and TVA will comply with BTA requirements through other measures.

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2.5 Chosen Method of Compliance With Impingement Mortality Standard § 122.21(r)(6)

Identify the chosen compliance method for the entire facility; alternatively, the applicant must identify the chosen compliance method for each cooling water intake structure at its facility. The applicant must identify any intake structure for which a BTA determination for Impingement Mortality under 40 CFR 125.94 (c)(11) or (12) is requested.

For the CCW intake, TVA will defer the final decision of a chosen method of compliance with impingement mortality standard until after the BTA determination for entrainment. If ADEM determines that existing technology represents BTA for entrainment, TVA will select option 5, to operate modified traveling screens that Director determines is BTA for impingement reduction.

2.6 Entrainment Performance Studies § 122.21(r)(7)

The owner or operator of an existing facility must submit any previously conducted studies or studies obtained from other facilities addressing technology efficacy, through-facility entrainment survival (distinguished for eggs and larvae), and other entrainment analysis studies. Any such submittals must include a description of each study, together with underlying data, and a summary of any conclusions or results. Any studies conducted at other locations must include an explanation as to why the data from other locations are relevant and representative of conditions at your facility. In the case of studies more than 10 years old, the applicant must explain why the data are still relevant and representative of conditions at the facility and explain how the data should be interpreted using the definition of entrainment at 40 CFR 125.92(h).

If the owner or operator has conducted studies, or chooses to use previously conducted studies obtained from other facilities, you must submit a description of those biological survival studies conducted, together with underlying data, and a summary of any conclusions or results;

TVA has not conducted any studies at BFN or its other facilities addressing the efficacy of any available technologies for reducing entrainment-related mortality of fish eggs and/or larvae; and has no information pertaining to through-facility entrainment survival.

However, TVA did participate in an EPRI §316(b) supplemental project that included conducting a literature survey of all impingement and entrainment performance studies that could be located. The final report for the literature survey is titled: "*Narrative Descriptions of*

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Impingement and Entrainment Survival Studies" (EPRI 2014a). This study identified 16 entrainment survival studies, some of which were through-plant survival studies and some of which were survival after collection on fine-mesh traveling water screens. However, 13 of the studies were conducted at facilities located on oceans and estuaries where species are not representative for freshwater facilities. For the three freshwater facilities, two were conducted on the Great Lakes and studies are also not considered representative of southeastern U.S. species that would be relevant for BFN. The remaining freshwater facility was the Fort Calhoun Nuclear Station that withdraws cooling water from the Missouri River and has a number of species relevant for BFN. This study was to examine through-plant entrainment mortality comparing larval fish mortality at the intake and discharge. The results from the EPRI report are provided below.

Larval entrainment studies were conducted from 1974 to 1977 at Fort Calhoun Station located on the Missouri River 20 miles northwest of Omaha, Nebraska (King 1977). Fort Calhoun is a nuclear-fueled facility with a generating capacity of 481 MW, which withdraws 120,000 gpm of cooling water using three circulating pumps and discharges back to the river through a submerged discharge tunnel.

Duplicate samples were collected at six locations including the intake, discharge and discharge plume from mid-April through early-August during each year. Samples were collected with two 0.5-m diameter nets with 571-micron mesh suspended from booms attached to each side of a boat for duration of 3 to 7 minutes in 1974 and 1975. In 1976 and 1977, the sampling duration was shortened to 1 to 3 minutes and the nets were changed to 0.75-m diameter. All samples were collected a meter from the water surface with the exception of the discharge after mid-June 1976 when a frame was installed to allow sampling over the end of the discharge tunnel port. After collection, larvae were enumerated as live or dead and all larvae were then preserved for later identification. In 1977, dead larvae were further separated into opaque and transparent as it was hypothesized that opaque larvae were dead prior to collection and therefore represented natural mortality.

Freshwater drum (*Aplodinotus grunniens*) was the most abundant species collected ranging from 43.7% (1974) to 88.2% (1977) of the total yearly larval collection (Table 17). Catostomids;

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consisting of carpsucker (*Carpiodes* spp.), white sucker (*Catostomus commersoni*), buffalo (*Ictiobus* spp.), and redhorse (*Moxostoma* spp.) were the only other taxa collected in sufficient number for survival analysis. Discharge mortalities of all species averaged 86.4% over the four-year study, with a range of 57 to 95% in June and July during peak seasonal larval abundance. Freshwater drum which accounted for nearly 75% of the entrained larvae, experienced 96% entrainment mortality, while catostomids experienced nearly 49% mortality at the discharge. Collection in 1977 samples indicated that nearly 62% of the larvae collected at the intake were dead. The author attributed the high intake mortality to net- and naturally-induced mortality. Additionally, the data obtained from separation of opaque and transparent dead larvae indicated that natural mortality was less than 60% at the intake (Table 17).

2.7 Operational Status § 122.21(r)(8)

The owner or operator of an existing facility must submit a description of the operational status of each generating, production, or process unit that uses cooling water, including but not limited to:

(i) For power production or steam generation, descriptions of individual unit operating status including age of each unit, capacity utilization rate (or equivalent) for the previous 5 years, including any extended or unusual outages that significantly affect current data for flow, impingement, entrainment, or other factors, including identification of any operating unit with a capacity utilization rate of less than 8 percent averaged over a 24-month block contiguous period, and any major upgrades completed within the last 15 years, including but not limited to boiler replacement, condenser replacement, turbine replacement, or changes to fuel type;

Commercial operation of the Browns Ferry Nuclear Plant (BFN) Unit 1 began on August 1, 1974; Unit 2 March 1, 1975; and Unit 3 March 1, 1977. A fire shut down BFN Unit 1 in 1975 for one year. All three units were taken offline in 1985 when TVA idled its nuclear fleet. After an extended shutdown to review the TVA nuclear power program and to correct significant weaknesses, Unit 2 returned to service in May 1991, and Unit 3 in November 1995. Following extensive repairs and refurbishment, Unit 1 was subsequently recovered and came back on line in May 2007. Each unit operates at full capacity except for a scheduled outage of 25 to 30 days every 24 months for maintenance and inspection (personal communication with Antonio Diaz-Lucier, TVA BFN Thermal Performance Engineer).

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Units were upgraded extensively due to the extended power uprate (EPU) in 2017. Upgrades resulting from the EPU are listed in Table 18. The only major upgrade since the EPU was low pressure turbines of Unit 2 (personal communication with Antonio Diaz-Lucier, TVA BFN Thermal Performance Engineer).

For the previous five years (2014 to 2019), capacity utilization rates Unit 1 ranged from 83 to 99% (mean 91%), Unit 2 from 80 to 98% (mean 90%), and Unit 3 from 80 to 94% (mean 87%). During this same period, mean total monthly CCW intake flows ranged from approximately 110,000 cfs in March to 141,000 cfs in July, August, and December (Table 3).

(ii) Descriptions of completed, approved, or scheduled uprates and Nuclear Regulatory Commission relicensing status of each unit at nuclear facilities;

TVA received full power operating licenses for BFN units 1, 2, and 3 on December 20, 1973, June 28, 1974, and July 2, 1976, respectively. Each unit was uprated by five percent from original design, 3,293 megawatts thermal (MWt) to 3,458 MWt (NRC 1998; TVA 2006). The license for each uprated unit was renewed on May 4, 2006 (NRC 2006) for an additional 20-year period. In 2015, TVA submitted a license amendment request to increase the maximum thermal power level (i.e., extended power uprate [EPU]) at each of the three BFN units from 3,458 MWt to 3,952 MWt, an increase of approximately 14% above the current licensed thermal limit. The NRC approved the EPU in August 2017 (NRC 2017).

Unit 1 is granted operation through December 20, 2033 (Docket number 05000259, License Numbe DPR-33); unit 2 through June 28, 2034 (Docket Number 05000260, License Number DPR-52); and unit 3 through July 2, 2036 (Docket Number 05000296, License Number DPR-68). These licenses also apply to those NRC source materials, special nuclear material, and by-product material licenses that are subsumed or combined with the facility operating licenses.

(iii) For process units at your facility that use cooling water other than for power production or steam generation, if you intend to use reductions in flow or changes in operations to meet the requirements of 40 CFR 125.94(c), descriptions of individual production processes and

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product lines, operating status including age of each line, seasonal operation, including an extended or unusual outages that significantly affect current data for flow, impingement, entrainment, or other factors, any major upgrades completed within the last 15 years, and plans or schedules for decommissioning or replacement of process units or production processes and product lines;

N/A – TVA's Browns Ferry Nuclear Plant is a facility for generation of electric power and does not manufacture or process any product.

(iv) For all manufacturing facilities, descriptions of current and future production schedules

N/A — TVA's Browns Ferry Nuclear Plant is not a manufacturing facility.

(v) Descriptions of plans or schedules for any new units planned within the next 5 years.

TVA has no plans within the next five years to construct any new power production units at BFN.

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Figures

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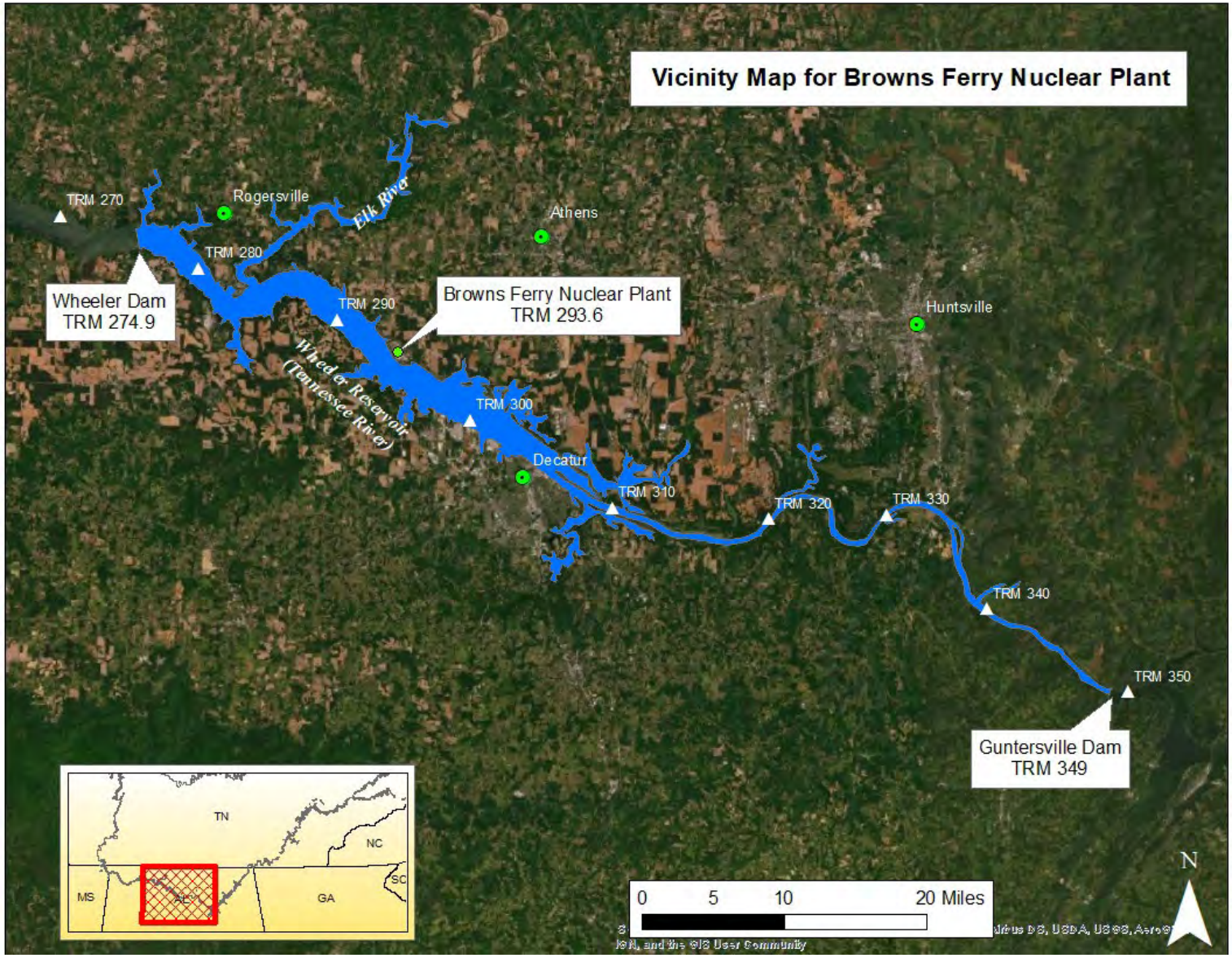


Figure 1. Location of Browns Ferry Nuclear Plant on Wheeler Reservoir

***TRM (Tennessee River mile)**

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Figure 2. Location of Condenser Circulating Water (CCW) intake and discharge an cooling towers (CT) at Browns Ferry Nuclear Plant

***TRM (Tennessee River mile)**

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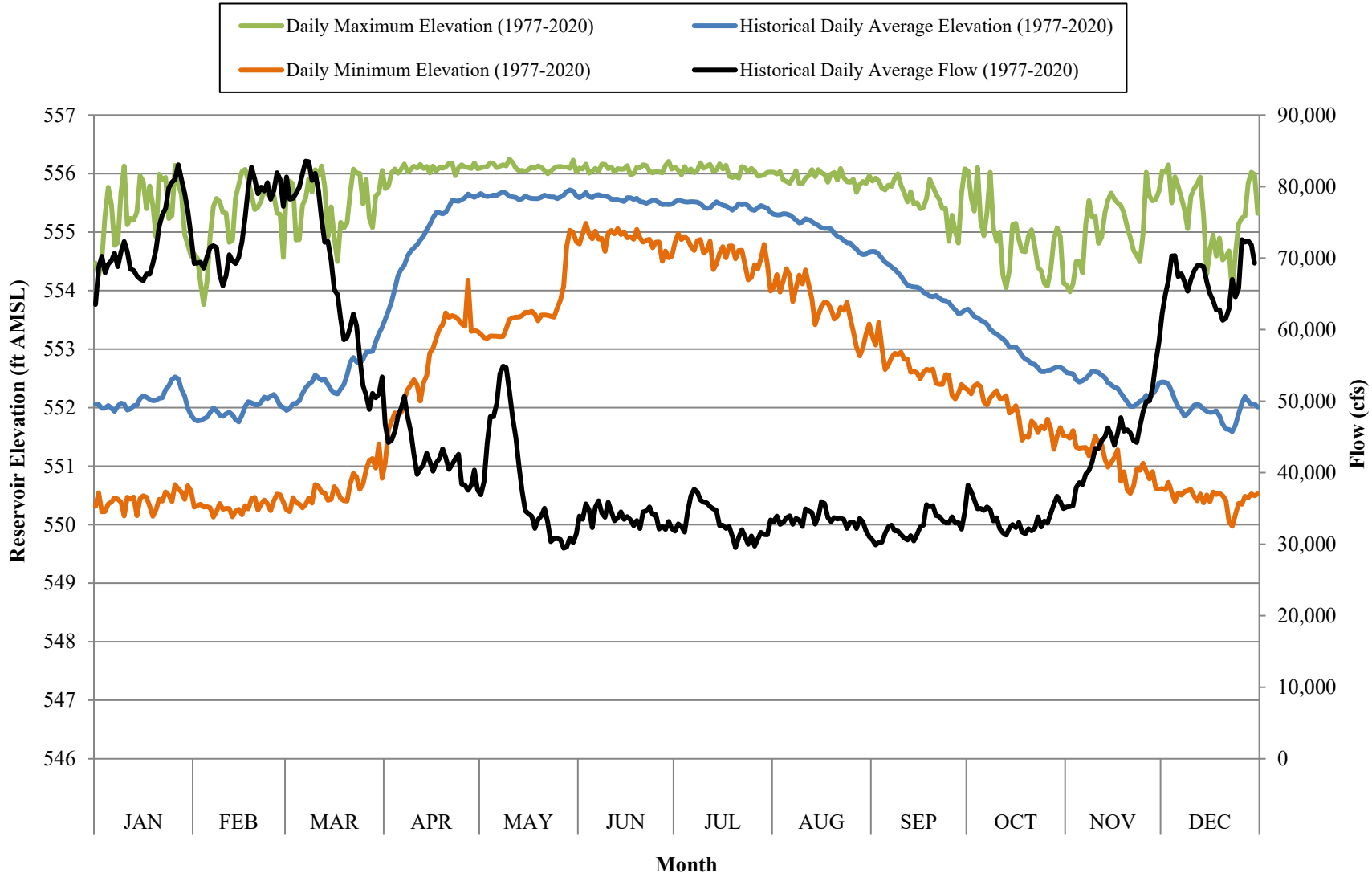


Figure 3. Daily average flow and daily minimum, maximum, and average surface elevation of Wheeler Reservoir from 1977 to 2020

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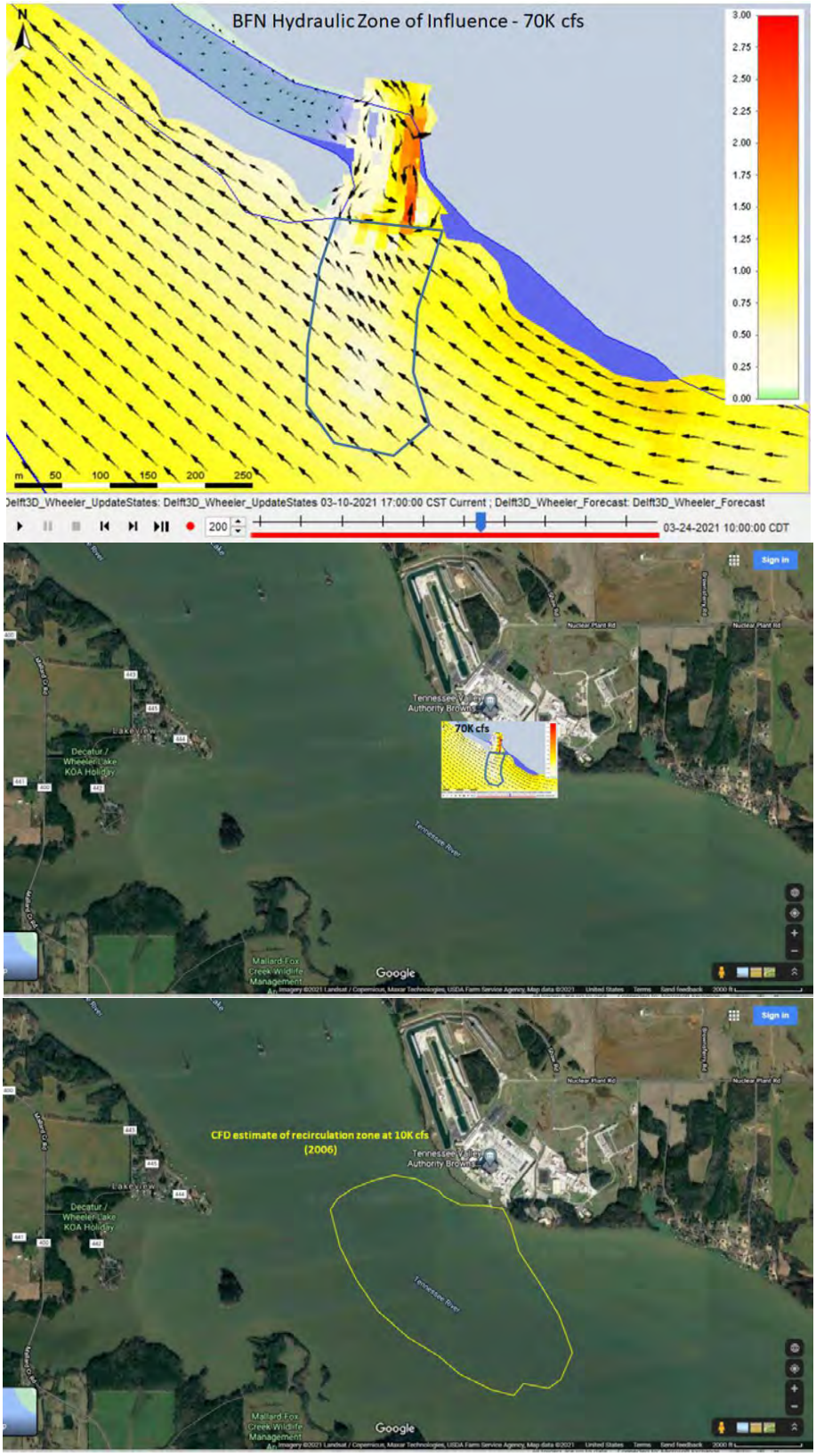


Figure 4. Depictions of 1.) BFN CWIS's area of hydraulic influence (AHI; top image) outlined conservatively based on directionally altered arrows using results of three-dimensional computational fluid dynamics (CFD) modeling in Wheeler Reservoir at flow rate of 70,000 cfs past the BFN plant, 2.) scaled aerial image depicting size of AHI at 70,000 cfs, and 3.) estimated AHI at a flow rate of 10,000 cfs

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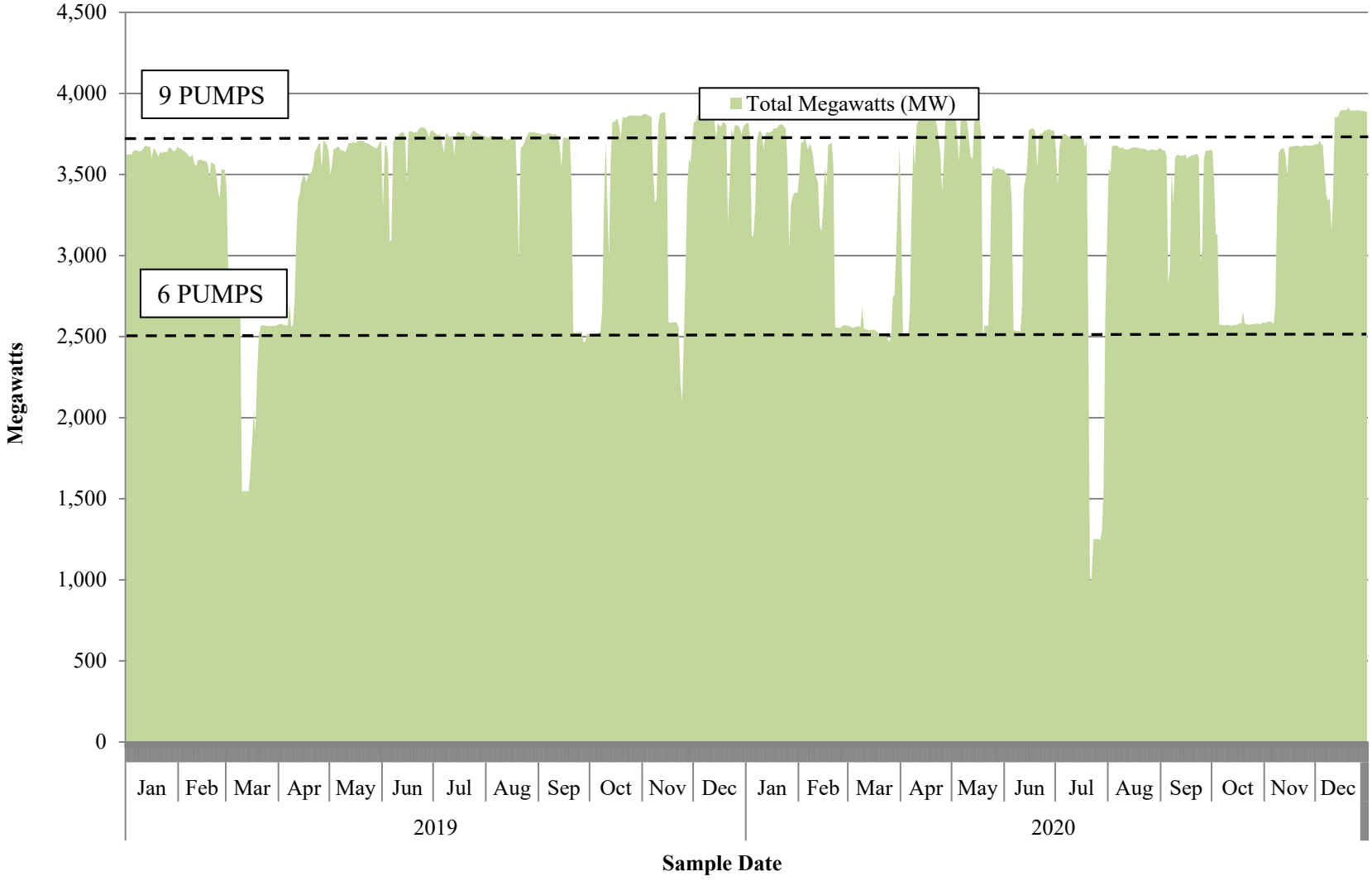


Figure 5. Total daily generation at Browns Ferry Nuclear Plant during 2019 and 2020

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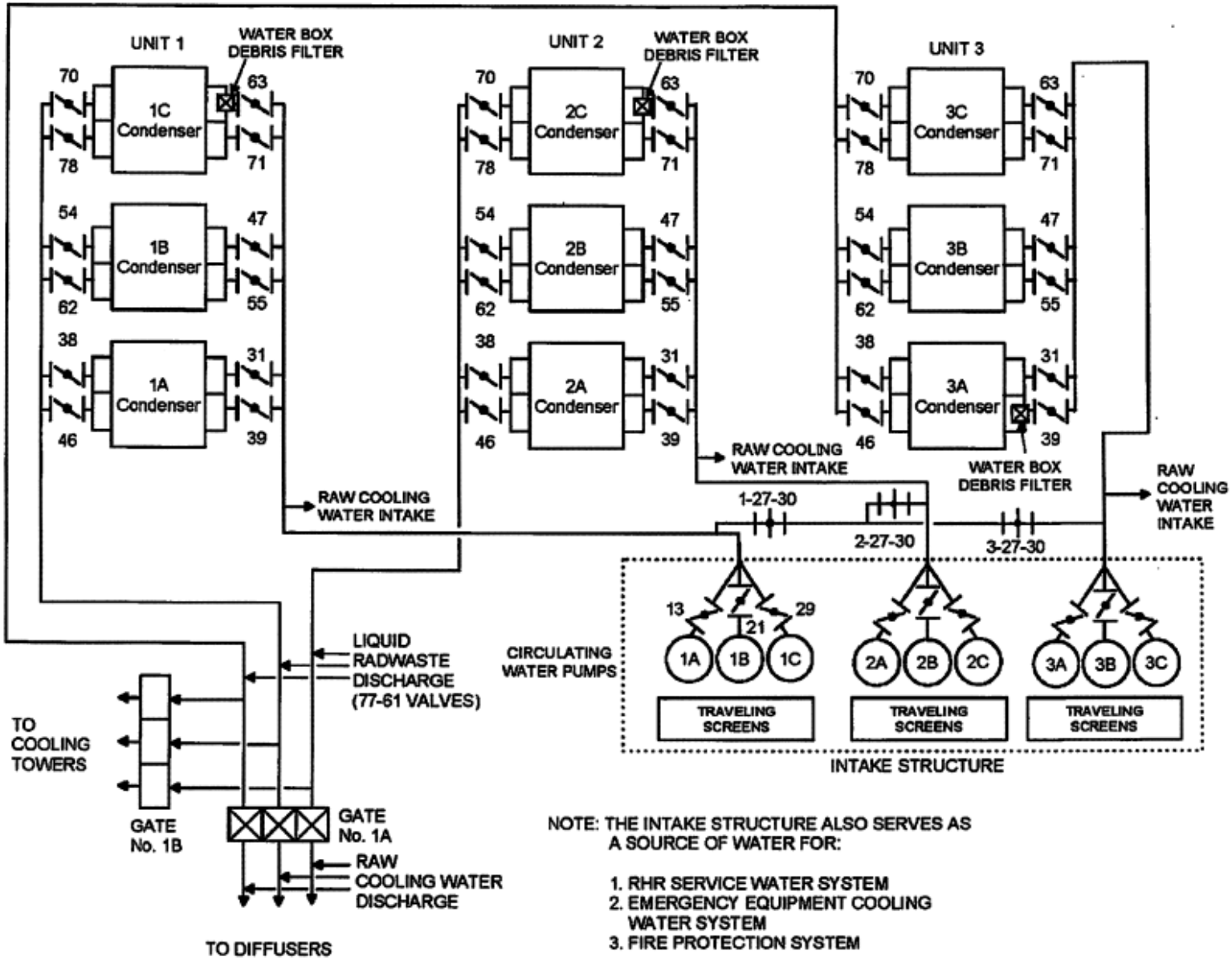


Figure 6. Flow diagram of Browns Ferry Nuclear Plant's condenser circulating water, raw water, and fire protection systems

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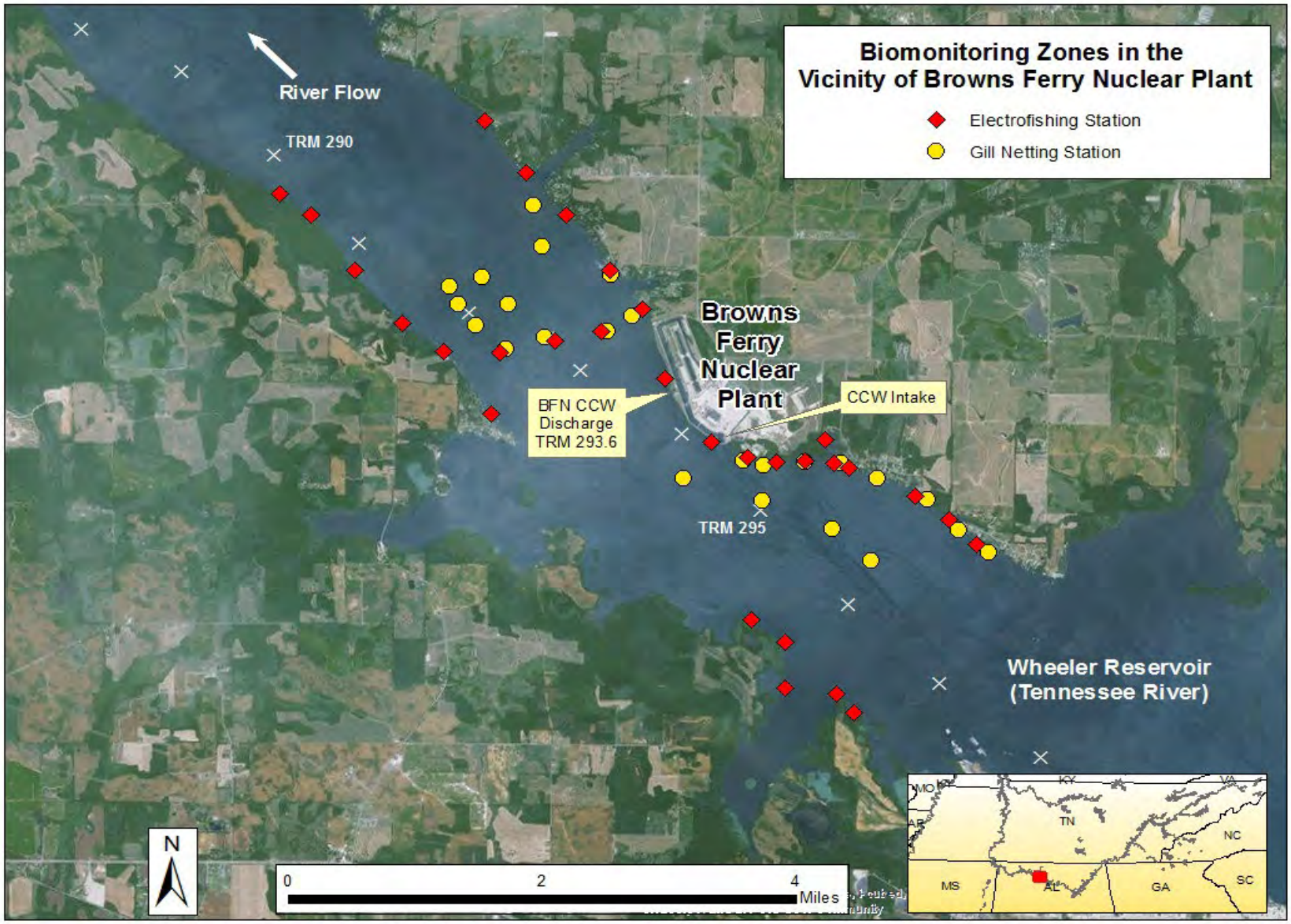


Figure 7. Sampling locations (nominally Tennessee River miles 292.5 and 295.9) used during 45 adult fish collection surveys from 1993 through 2020

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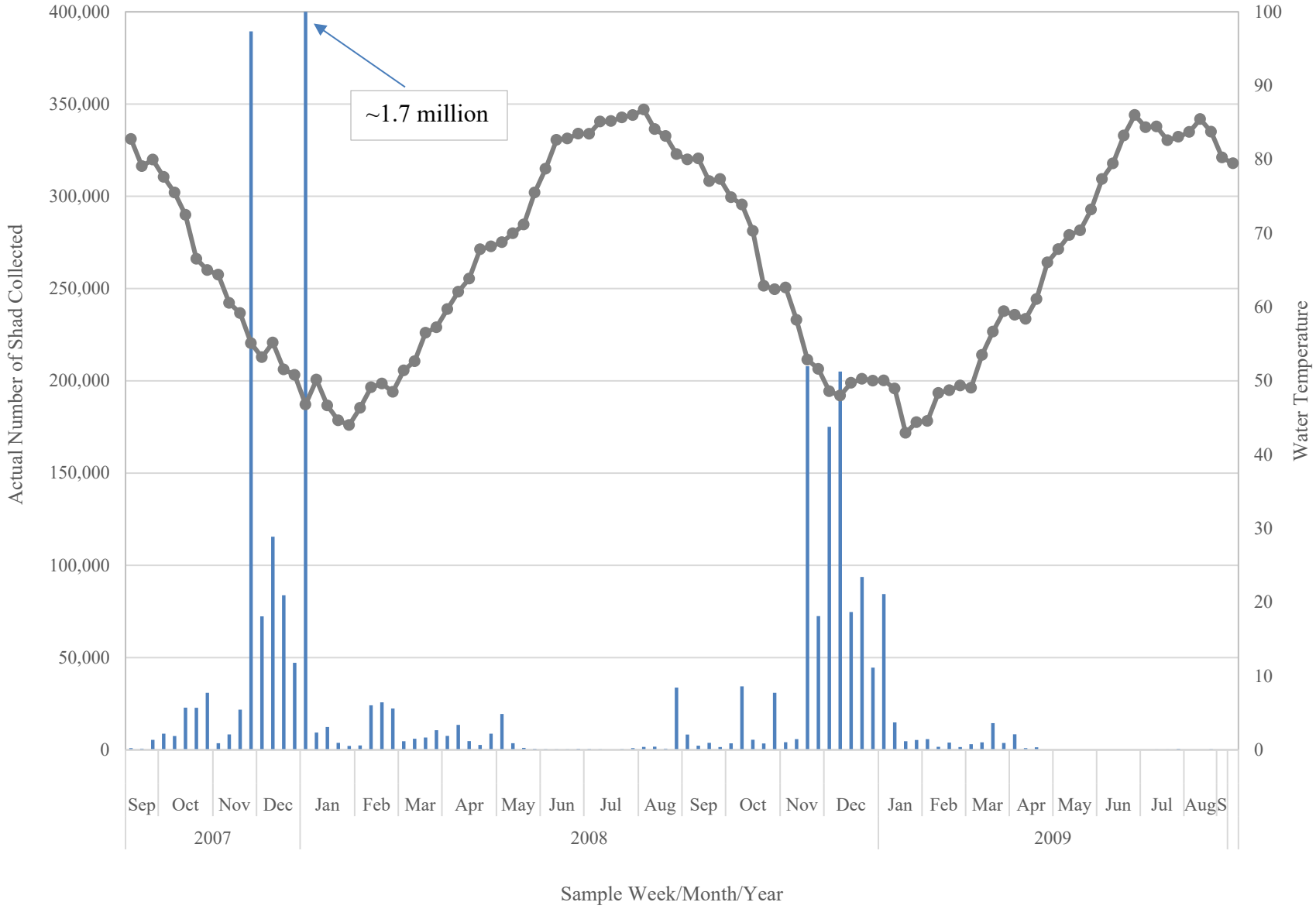


Figure 8. Actual number of shad collected in weekly impingement samples at TVA's Browns Ferry Nuclear Plant intake, 2007-2009

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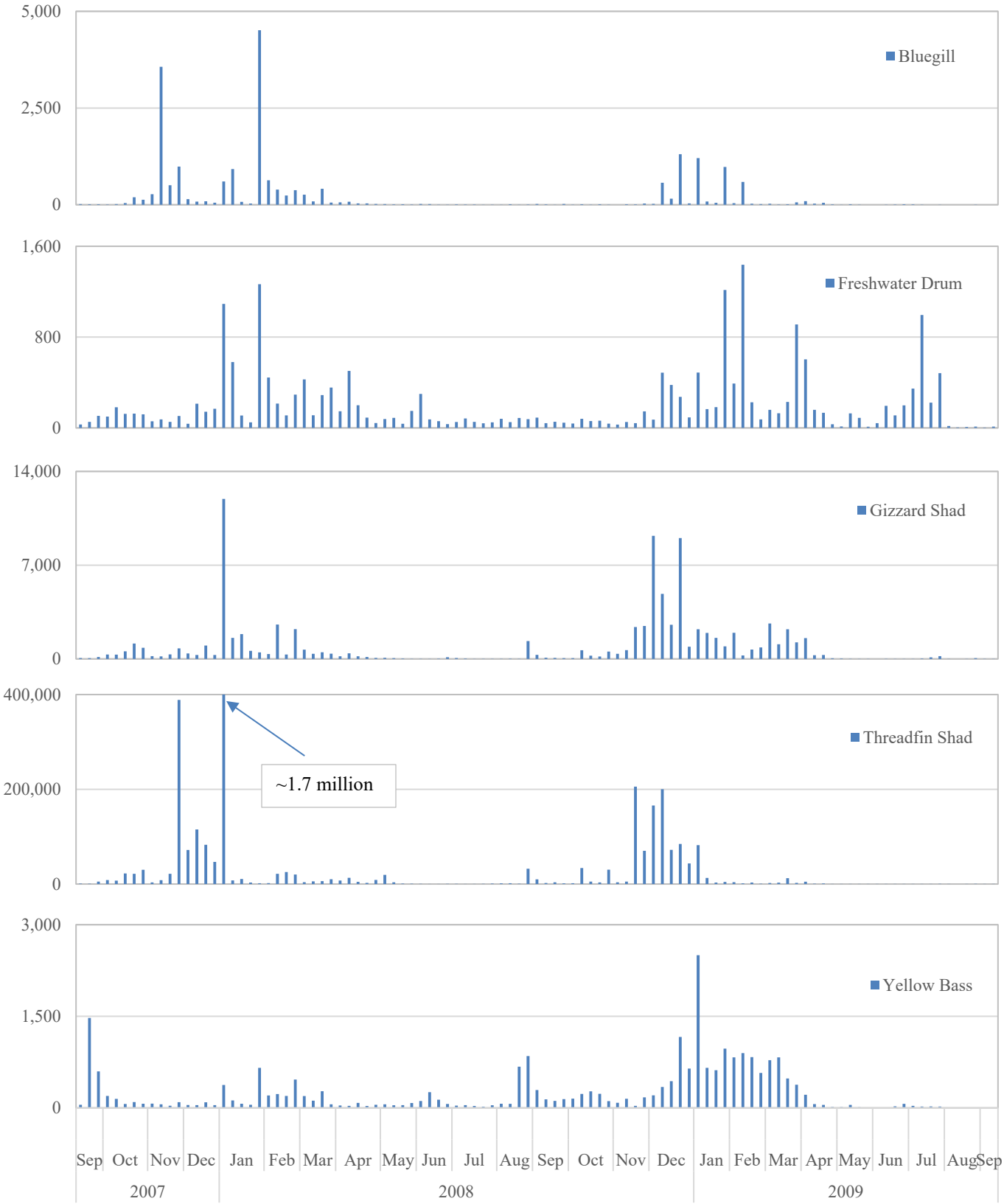


Figure 9. Estimated numbers of numerically dominant taxa impinged at TVA's Browns Ferry Nuclear Plant CCW intake, 2007–2009

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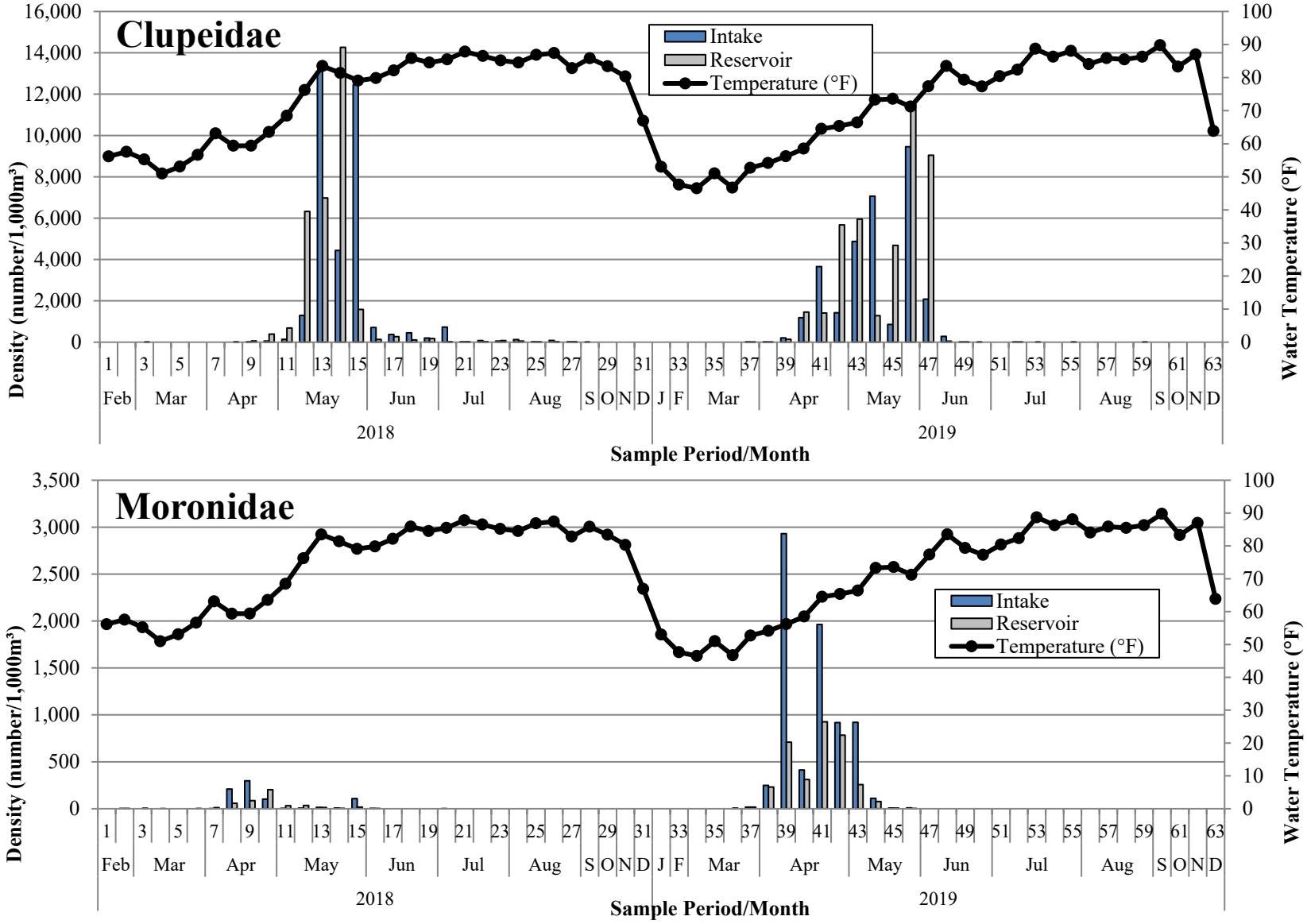


Figure 10. Densities of numerically dominant fish eggs and larvae (Clupeidae and Moronidae) collected at a reservoir transect (TRM 294.5) and along skimmer wall of Browns Ferry Nuclear Plant intake from February 2018 through December 2019

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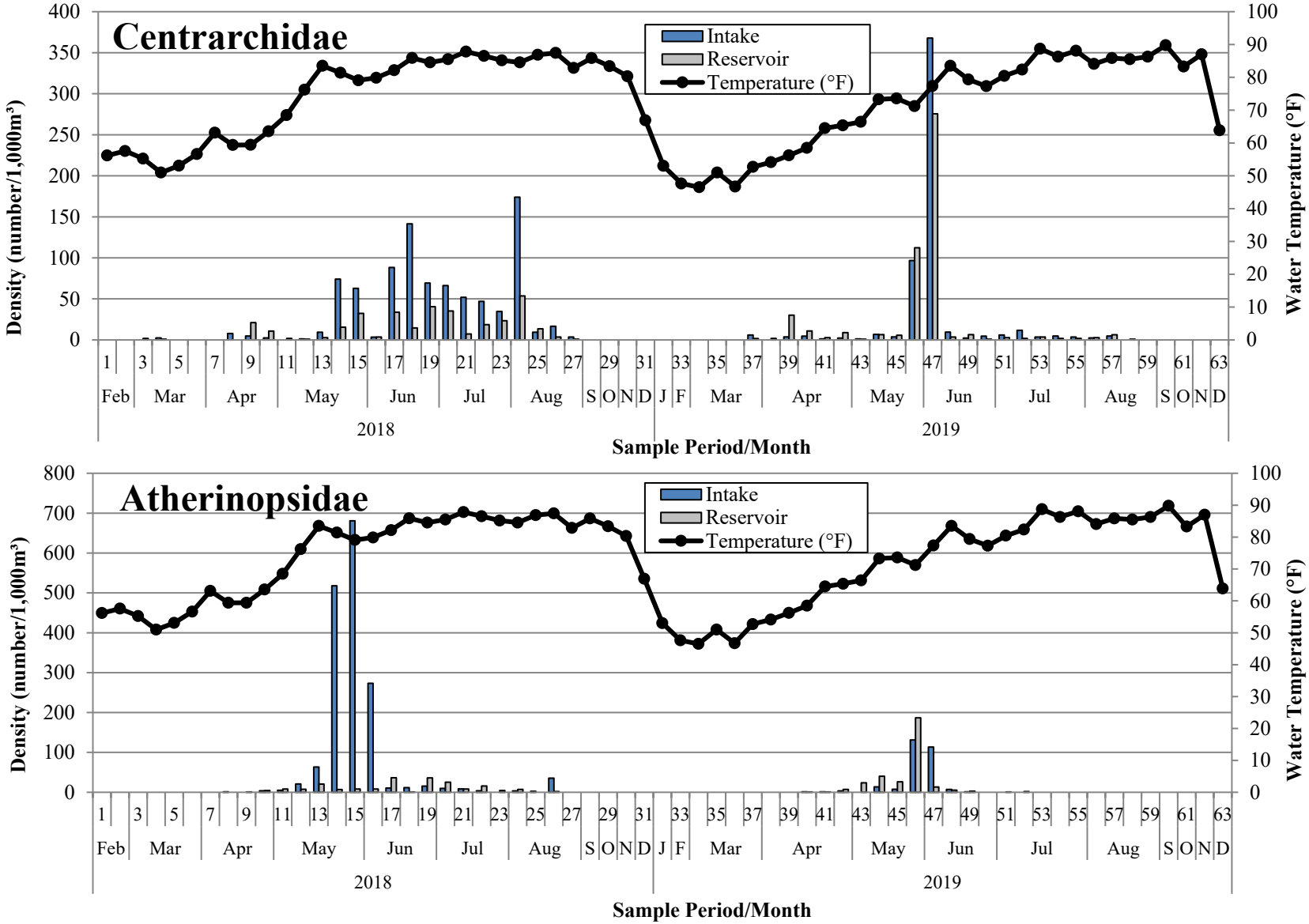


Figure 11. Densities of numerically dominant fish eggs and larvae (Centrarchidae and Atherinopsidae) collected at a reservoir transect (TRM 294.5) and along skimmer wall of Browns Ferry Nuclear Plant intake from February 2018 through December 2019

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Tables

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Table 1. Monthly water quality parameters collected along vertical depth profiles upstream (TRM 295.9) and downstream (TRM 292.5) of the Browns Ferry Nuclear Plant in Wheeler Reservoir, 2010-2020

TRM 295.9 Month/ Depth (m)	Water Temperature (°F)	Dissolved Oxygen (% Sat.)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH
April					
0.3	62.8	104.2	9.8	180.4	7.6
1.5	62.4	102.4	9.7	180.2	7.5
3	62.3	98.6	9.3	182.7	7.2
4	63.4	100.0	9.4	182.1	7.4
5	59.1	105.0	10.5	183.5	7.3
6	64.3	97.3	9.0	182.5	7.4
7	61.8	94.3	9.0	193.9	7.1
8	63.8	99.2	9.3	173.5	7.6
9	61.0	93.9	9.1	185.9	7.2
AVG	**62.3**	**99.4**	**9.5**	**182.7**	**7.4**
May					
0.3	74.0	117.2	9.7	160.8	7.9
1.5	73.3	111.0	9.3	161.4	7.8
3	74.0	106.7	8.9	163.2	7.6
4	70.8	93.3	8.1	154.8	7.4
5	73.2	95.1	8.0	162.6	7.5
6	70.0	78.9	6.9	158.4	7.1
7	76.7	95.7	7.7	156.9	7.3
8	70.9	69.7	6.0	167.9	7.1
9	70.0	92.6	8.1	153.2	7.4
AVG	**72.5**	**95.6**	**8.1**	**159.9**	**7.5**
June					
0.3	83.4	110.3	8.0	171.3	7.8
1.5	82.3	102.1	7.7	172.2	7.7
3	81.8	88.9	6.8	174.6	7.4
4	81.9	92.5	7.2	170.3	7.5
5	81.1	79.5	6.3	173.5	7.3
6	82.1	74.4	5.7	184.2	7.2
7	80.9	71.9	6.1	165.8	7.4
8	81.6	65.0	5.0	186.5	7.2
9	79.5	61.9	4.9	173.9	7.3
AVG	**81.6**	**82.9**	**6.4**	**174.7**	**7.4**

ADEM Watermark

Table 1. (continued)

TRM 295.9 Month/ Depth (m)	Water Temperature (°F)	Dissolved Oxygen (% Sat.)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH
July					
0.3	85.6	106.1	7.9	166.2	7.7
1.5	85.1	97.1	7.3	166.6	7.5
3	84.2	89.9	6.8	158.5	7.3
4	84.4	90.3	6.8	162.9	7.4
5	83.7	89.0	6.8	167.2	7.3
6	85.8	83.0	6.2	175.9	7.4
7	83.2	86.3	6.6	154.2	7.2
8	85.6	82.8	6.2	168.8	7.3
9	84.3	57.8	4.3	191.2	7.2
AVG	**84.7**	**86.9**	**6.5**	**167.9**	**7.4**
August					
0.3	85.4	94.9	7.1	169.9	7.6
1.5	84.9	86.7	6.5	169.0	7.4
3	83.8	84.9	6.4	163.8	7.4
4	85.6	84.4	6.3	172.0	7.4
5	83.4	76.0	5.8	165.6	7.2
6	85.5	81.1	6.1	171.6	7.4
7	83.3	74.8	5.7	161.5	7.1
8	84.5	77.6	5.9	175.6	7.2
9	89.0	70.7	5.1	177.1	7.3
AVG	**85.0**	**81.2**	**6.1**	**169.6**	**7.3**
September					
0.3	79.9	93.3	7.3	172.8	7.6
1.5	79.1	86.0	6.8	173.4	7.5
3	79.1	81.4	6.5	172.7	7.4
4	77.8	81.9	6.6	167.4	7.4
5	78.6	76.8	6.1	178.2	7.4
6	78.7	87.2	7.0	161.4	7.4
7	81.5	76.8	6.0	167.3	7.3
8	77.2	80.5	6.5	178.2	7.3
9	75.2	66.7	5.5	175.0	7.2
AVG	**78.6**	**81.2**	**6.5**	**171.8**	**7.4**

ADEM Watermark

Table 1. (continued)

TRM 292.5 Month/ Depth (m)	Water Temperature (°F)	Dissolved Oxygen (% Sat.)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH
October					
0.3	72.3	--	8.2	188.6	7.7
1	71.7	--	8.2	188.8	7.6
2	70.6	--	8.0	188.9	7.5
3	67.4	--	8.7	209.1	7.5
4	71.0	--	7.8	181.7	7.5
5	67.2	--	8.6	212.8	7.5
6	68.8	--	7.8	190.1	7.3
7	72.3	--	8.2	188.6	7.7

ADEM Watermark

Table 2. Daily average, minimum, and maximum surface elevation and daily average flow (1977-2020) in Wheeler Reservoir by month

	Elevation			Flow		
Month	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**
January	552.1	550.7	553.7	73,374	20,558	144,488
February	552.0	550.6	553.6	76,615	25,592	188,000
March	551.3	538.1	554.1	68,925	18,053	159,686
April	555.0	553.1	555.7	44,171	9,209	144,037
May	555.6	553.7	556.0	39,175	8,046	133,024
June	555.6	555.1	555.9	33,857	11,263	96,818
July	555.5	555.1	555.8	32,901	13,870	92,828
August	554.8	541.4	555.8	33,396	15,084	50,883
September	554.2	553.0	555.2	32,466	12,081	75,301
October	552.7	539.2	554.0	34,301	12,497	87,401
November	552.4	551.4	554.2	44,978	11,802	86,403
December	552.0	550.8	553.5	66,939	11,891	153,865
Avg Dec–Feb				**72,309**		
Avg Apr–Oct				**35,752**		
Avg Jan–Dec				**48,425**		

ADEM Watermark

Table 3. Net capacity factors (%) and monthly intake flow (cfs) for the period 2014 to 2020

	2014	2015	2016	2017	2018	2019	2020	AVG
Net Capacity Factor (%)*								
BFN Unit 1	90	94	83	97	82	99		**91**
BFN Unit 2	98	85	94	83	97	80		**90**
BFN Unit 3	88	92	80	93	76	94		**87**
Monthly Intake Flow**								
January	120,567	139,071	146,245	133,476	135,729	142,886	114,297	**133,182**
February	88,287	125,613	136,810	119,183	102,251	119,699	109,723	**114,509**
March	104,628	116,642	146,245	105,877	92,146	95,831	109,930	**110,185**
April	116,678	122,004	131,387	130,260	132,138	133,321	141,553	**129,620**
May	132,505	134,295	136,856	139,109	139,109	142,114	128,762	**136,107**
June	134,585	134,585	141,527	134,767	130,260	130,260	138,854	**134,977**
July	139,071	139,071	146,245	134,602	146,274	145,897	133,921	**140,726**
August	137,878	139,071	134,602	134,602	146,274	146,274	146,245	**140,707**
September	132,198	134,585	130,636	141,555	141,555	127,724	134,767	**134,717**
October	104,094	137,579	104,409	146,274	111,956	146,274	124,581	**125,024**
November	134,585	138,982	134,016	135,920	107,452	138,155	141,555	**132,952**
December	139,071	146,245	143,240	137,992	144,367	139,877	134,602	**140,771**
Monthly Average (cfs)	**123,679**	**133,978**	**136,018**	**132,801**	**127,459**	**134,026**	**129,899**	
Daily Average (cfs)	**4,066**	**4,405**	**4,472**	**4,366**	**4,190**	**4,406**	**4,271**	
Daily Average (mgd)	**2,628**	**2,847**	**2,890**	**2,822**	**2,708**	**2,848**	**2,760**	

*** Data source NRC (2020)**
****Data provided by BFN**

ADEM Watermark

Table 4. Catch rates (CPUE; number per electrofishing run/gill net) of fish species collected by electrofishing and gill netting during 45 sampling events in the vicinity of Browns Ferry Nuclear Plant (Tennessee River miles 292.5 and 295.9) from 1993 through 2020

Scientific Name	Common Name	Average CPUE	CPUE Range	Number of Samples Species Was Collected (Out of 45 Samples)
Menidia audens	Mississippi silverside	17.2	0.1 - 80.7	40
Dorosoma cepedianum	Gizzard shad	15.7	0.3 - 45.7	45
Notropis atherinoides	Emerald shiner	11.8	0.1 - 220.3	27
Dorosoma petenense	Threadfin shad	9.8	0.1 - 133.3	39
Lepomis macrochirus	Bluegill	5.4	0.2 - 19.1	45
Micropterus salmoides	Largemouth bass	3.6	0.4 - 13.0	45
Ammocrypta pellucida	Eastern sand darter	3.1	3.1 - 3.1	1
Ictalurus punctatus	Channel catfish	3.1	0.2 - 7.9	45
Lepomis megalotis	Longear sunfish	2.1	0.1 - 5.6	43
Alosa chrysochloris	Skipjack herring	2.0	0.1 - 8.0	45
Cyprinella spiloptera	Spotfin shiner	1.5	0.1 - 2.7	30
Lepomis microlophus	Redear sunfish	1.5	0.1 - 4.6	45
Aplodinotus grunniens	Freshwater drum	1.5	0.3 - 3.3	45
Percina caprodes	Logperch	1.4	0.1 - 13.7	35
Morone chrysops	White bass	1.3	0.1 - 8.6	41
Micropterus dolomieu	Smallmouth bass	1.2	0.1 - 5.0	44
Morone mississippiensis	Yellow bass	1.1	0.1 - 5.0	44
Minytrema melanops	Spotted sucker	1.1	0.1 - 8.9	43
Lepomis cyanellus	Green sunfish	1.0	0.1 - 6.6	39
Labidesthes sicculus	Brook silverside	0.9	0.1 - 3.8	5
Ictiobus bubalus	Smallmouth buffalo	0.9	0.1 - 2.4	42
Ictalurus furcatus	Blue catfish	0.8	0.1 - 4.5	44
Sander canadensis	Sauger	0.8	0.1 - 4.1	37
Micropterus punctulatus	Spotted bass	0.7	0.1 - 2.7	42
Ameiurus natalis	Yellow bullhead	0.7	0.7 - 0.7	1
Pylodictis olivaris	Flathead catfish	0.5	0.1 - 1.6	44
Lepisosteus osseus	Longnose gar	0.5	0.1 - 1.8	9
Lepisosteus oculatus	Spotted gar	0.5	0.1 - 1.8	33
Notemigonus crysoleucas	Golden shiner	0.4	0.1 - 1.8	29
Percina vigil	Saddleback darter	0.4	0.4 - 0.4	1
Morone saxatilis x M. chrysops	Hybrid striped x white bass	0.4	0.1 - 1.4	11
Morone saxatilis	Striped bass	0.3	0.1 - 1.3	21
Ictiobus niger	Black buffalo	0.3	0.1 - 1.6	17
Cyprinus carpio	Common carp	0.3	0.1 - 1.3	35
Sander vitreus	Walleye	0.3	0.1 - 0.5	4
Moxostoma erythrurum	Golden redhorse	0.2	0.1 - 1.3	20
Moxostoma anisurum	Silver redhorse	0.2	0.1 - 0.9	9
Acipenser fulvescens	Lake sturgeon	0.2	0.2 - 0.2	1
Lepomis humilis	Orangespotted sunfish	0.2	0.1 - 0.3	4

ADEM Watermark

Table 4. (continued)

Scientific Name	Common Name	Average CPUE	CPUE Range	Number of Samples Species Was Collected (Out of 45 Samples)
Luxilus chrysocephalus	Striped shiner	0.2	0.1 - 0.3	4
Perca flavescens	Yellow perch	0.2	0.1 - 0.7	15
Moxostoma duquesnei	Black redhorse	0.2	0.1 - 0.7	26
Pomoxis annularis	White crappie	0.2	0.1 - 0.8	24
Carpiodes cyprinus	Quillback	0.2	0.1 - 0.3	6
Pimephales vigilax	Bullhead minnow	0.1	0.1 - 0.5	20
Pimephales notatus	Bluntnose minnow	0.1	0.1 - 0.3	6
Pomoxis nigromaculatus	Black crappie	0.1	0.1 - 0.4	24
Lepomis gulosus	Warmouth	0.1	0.1 - 0.5	33
Etheostoma duryi	Blackside snubnose darter	0.1	0.1 - 0.1	1
Hiodon tergisus	Mooneye	0.1	0.1 - 0.2	3
Hybrid Lepomis sp.	Hybrid sunfish	0.1	0.1 - 0.2	6
Fundulus notatus	Blackstripe topminnow	0.1	0.1 - 0.1	2
Percina shumardi	River darter	0.1	0.1 - 0.1	2
Moxostoma carinatum	River redhorse	0.1	0.1 - 0.2	4
Lepisosteus platostomus	Shortnose gar	0.1	0.1 - 0.1	1
Moxostoma breviceps	Smallmouth redhorse	0.1	0.1 - 0.1	1
Etheostoma kennicotti	Stripetail darter	0.1	0.1 - 0.1	4
Hypentelium nigricans	Northern hog sucker	0.1	0.1 - 0.3	14
Campostoma oligolepis	Largescale stoneroller	0.1	0.1 - 0.2	10
Lepomis auritus	Redbreast sunfish	0.1	0.1 - 0.3	15
Amia calva	Bowfin	0.1	0.1 - 0.1	4
Ictiobus cyprinellus	Bigmouth buffalo	0.1	0.1 - 0.1	7
Ichthyomyzon castaneus	Chestnut lamprey	0.1	0.1 - 0.1	7
Strongylura marina	Atlantic needlefish	0.1	0.1 - 0.1	1
Fundulus olivaceus	Blackspotted topminnow	0.1	0.1 - 0.1	1
Campostoma anomalum	Central stoneroller	0.1	0.1 - 0.1	1
Ctenopharyngodon idella	Grass carp	0.1	0.1 - 0.1	1
Hybrid Micropterus sp.	Hybrid bass	0.1	0.1 - 0.1	2
Sander vitreus x S. canadensis	Hybrid walleye x sauger	0.1	0.1 - 0.1	1
Notropis volucellus	Mimic shiner	0.1	0.1 - 0.1	1
Ambloplites rupestris	Rock bass	0.1	0.1 - 0.1	1
Macrhybopsis storeriana	Silver chub	0.1	0.1 - 0.1	4
Etheostoma simoterum	Snubnose darter	0.1	0.1 - 0.1	1

ADEM Watermark

Table 5. Freshwater mussels collected in the vicinity of Browns Ferry Nuclear Plant (TRM 276.9–347.2) during 1991 (TVA 1992)

Scientific Name	River Mile							Total Number Collected	Relative Abundance (%)
	276.9	287.4	292.7	313.2	313.9	346.0	347.2		
Amblema plicata	24	-	1	-	-	2	17	44	7.4
Anodonta grandis	1	1	-	-	-	-	-	2	0.3
Anodonta suborbiculata	-	1	-	-	-	-	-	1	0.2
Cyclonaias tuberculata	-	-	-	-	-	8	4	12	2.0
Ellipsaria lineolata	-	-	-	-	-	16	16	32	5.4
Elliptio crassidens	4	1	-	2	13	61	83	152	25.4
Lampsilis abrupta	-	-	-	-	-	1	-	1	0.2
Lampsilis anodontoides	-	-	-	1	-	-	-	1	0.2
Megalonaias nervosa	24	48	34	1	-	8	4	119	19.9
Obliquaria reflexa	16	-	2	1	-	1	-	20	3.3
Pleurobema cordatum	-	1	-	-	1	4	12	18	3.0
Potamilus alatus	10	5	6	3	5	4	17	50	8.4
Quadrula metanevra	-	-	-	-	-	3	-	3	0.5
Quadrula pustulosa	100	2	2	2	-	10	9	125	20.9
Quadrula quadrula	7	-	-	-	-	-	-	7	1.2
Tritogonia verrucosa	10	-	-	-	-	1	-	11	1.8
Number of Samples	**30**	**50**	**10**	**2**	**4**	**2**	**10**	**108**	
Number of Mussels	**196**	**59**	**45**	**10**	**19**	**119**	**162**	**598**	
Total Number of Species	**9**	**7**	**5**	**6**	**3**	**12**	**8**	**16**	

ADEM Watermark

Table 6. Crayfish records identified from tributaries that drain to Wheeler Reservoir in the vicinity of BFN (TRM 294)*

Genus	Species	Non-Native?	Waterbody	River Mile	County	State	Collection Date	Latitude	Longitude
Procambarus	acutus		Mallard Creek	3	Lawrence	AL	3/25/2015	34.67860	-87.18980
Faxonius	alabamensis		No Business Creek	2.3	Morgan	AL	5/24/2010	34.44450	-87.02116
Procambarus	clarkii	Yes	Pryor Branch	N/A	Limestone	AL	4/17/2013	34.67565	-86.95012
Procambarus	clarkii	Yes	Crowdabout Creek	5.5	Morgan	AL	4/17/2017	34.39732	-87.02201
Procambarus	clarkii	Yes	No Business Creek	2.3	Morgan	AL	5/24/2010	34.44450	-87.02116
Faxonius	compressus		Little Limestone Creek	1.4	Limestone	AL	6/27/2008	34.91210	-86.80010
Faxonius	compressus		Piney Creek	25	Limestone	AL	5/22/2008	34.86160	-86.90720
Faxonius	compressus		Piney Creek	6.7	Limestone	AL	4/17/2008	34.67190	-86.90710
Faxonius	compressus		Piney Creek	6.7	Limestone	AL	6/7/2018	34.67190	-86.90710
Faxonius	erichsonianus		Cotaco Creek	14.5	Morgan	AL	7/8/2009	34.43970	-86.70056
Faxonius	forceps		Big Nance Creek	2.9	Lawrence	AL	4/10/2013	34.76630	-87.37120
Faxonius	forceps		Big Nance Creek	2.9	Lawrence	AL	6/25/2008	34.76630	-87.37120
Faxonius	forceps		Tennessee River (Wilson Reservoir)		Lawrence	AL	7/25/2018	34.79239	-87.39355
Faxonius	forceps		Elk River	31	Limestone	AL	7/22/2010	34.97170	-87.00910
Faxonius	forceps		Limestone Creek	17	Limestone	AL	7/8/1997	34.75170	-86.82310
Faxonius	forceps		Limestone Creek	17	Limestone	AL	6/9/2018	34.75170	-86.82310
Faxonius	forceps		Swan Creek	2.2	Limestone	AL	7/7/2009	34.68852	-86.95333
Faxonius	forceps		Tennessee River	294	Limestone	AL	8/12/2008	34.70144	-87.11930
Cambarus	giardianus		Big Nance Creek	2.9	Lawrence	AL	4/10/2013	34.76630	-87.37120
Cambarus	giardianus		Big Nance Creek	2.9	Lawrence	AL	6/11/2018	34.76630	-87.37120
Cambarus	giardianus		Clear Fork	3.6	Lawrence	AL	5/12/2008	34.53870	-87.28330
Cambarus	giardianus		Shoal Creek	3.2	Limestone	AL	6/28/2001	34.95296	-87.06721
Cambarus	graysoni		Limestone Creek	17	Limestone	AL	4/9/2008	34.75170	-86.82310
Cambarus	striatus		Elam Creek	0.9	Lawrence	AL	4/19/2010	34.46417	-87.19585
Cambarus	striatus		Mallard Creek	3	Lawrence	AL	3/25/2015	34.67860	-87.18980
Cambarus	striatus		Limestone Creek	17	Limestone	AL	4/9/2008	34.75198	-86.82314
Cambarus	striatus		Little Limestone Creek	1.4	Limestone	AL	6/27/2008	34.91210	-86.80010
Cambarus	striatus		Piney Creek	6.7	Limestone	AL	6/7/2018	34.67190	-86.90710
Cambarus	striatus		Piney Creek	6.7	Limestone	AL	4/17/2008	34.67190	-86.90710

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Table 6. (continued)

Genus	Species	Non-Native?	Waterbody	River Mile	County	State	Collection Date	Latitude	Longitude
Cambarus	striatus		Unnamed tributary to Piney Creek	N/A	Limestone	AL	5/8/2013	34.895367	-86.892676
Cambarus	striatus		Unnamed tributary to Piney Creek	N/A	Limestone	AL	5/9/2013	34.864654	-86.913232
Faxonius	validus		Mallard Creek	3	Lawrence	AL	3/25/2015	34.678600	-87.189800
Faxonius	validus		Muddy Fork	2.8	Lawrence	AL	5/20/2008	34.554600	-87.344400
Faxonius	validus		Town Creek	33.2	Lawrence	AL	5/13/2008	34.536500	-87.490300
Faxonius	validus		French Mill Creek	0.3	Limestone	AL	7/9/1997	34.756447	-86.895332
Faxonius	validus		Cotaco Creek	14.5	Morgan	AL	7/8/2009	34.439700	-86.700560
Faxonius	virilis	Yes	Bakers Creek	2.3	Morgan	AL	6/5/2007	34.608505	-87.045220
Faxonius	yanahlindus		West Flint Creek	30.1	Lawrence	AL	5/13/2014	34.437600	-87.184100
Faxonius	yanahlindus		Little Limestone Creek	1.4	Limestone	AL	7/10/1997	34.912100	-86.800100
Faxonius	yanahlindus		Little Limestone Creek	1.4	Limestone	AL	6/27/2008	34.912100	-86.800100
Faxonius	yanahlindus		Piney Creek	25	Limestone	AL	7/10/1997	34.861600	-86.907200
Faxonius	yanahlindus		Piney Creek	18.2	Limestone	AL	7/9/1997	34.788400	-86.889800
Faxonius	yanahlindus		Piney Creek	6.7	Limestone	AL	7/24/2013	34.671900	-86.907100
Faxonius	yanahlindus		Piney Creek	25	Limestone	AL	5/22/2008	34.861600	-86.907200
Faxonius	yanahlindus		Big Nance Creek	2.9	Lawrence	AL	6/11/2018	34.766300	-87.371200
Faxonius	yanahlindus		Clear Fork	3.6	Lawrence	AL	5/12/2008	34.538700	-87.283300
Faxonius	yanahlindus		Elam Creek	0.9	Lawrence	AL	4/19/2010	34.464169	-87.195847
Faxonius	yanahlindus		Muddy Fork	2.8	Lawrence	AL	5/20/2008	34.554600	-87.344400
Faxonius	yanahlindus		Town Creek	33.2	Lawrence	AL	5/13/2008	34.536500	-87.490300
Faxonius	yanahlindus		West Flint Creek	30.1	Lawrence	AL	7/9/2009	34.437600	-87.184100
Faxonius	yanahlindus		Beaverdam Creek	8.3	Limestone	AL	8/27/2015	34.670600	-86.822800
Faxonius	yanahlindus		Elk River	31	Limestone	AL	7/22/2010	34.971700	-87.009100
Faxonius	yanahlindus		Limestone Creek	17	Limestone	AL	4/9/2008	34.751980	-86.823140
Faxonius	yanahlindus		Limestone Creek	17	Limestone	AL	6/9/2018	34.751700	-86.823100
Faxonius	yanahlindus		Piney Creek	6.7	Limestone	AL	4/17/2008	34.671900	-86.907100
Faxonius	yanahlindus		Piney Creek	6.7	Limestone	AL	6/25/2003	34.671900	-86.907100
Faxonius	yanahlindus		Piney Creek	6.7	Limestone	AL	6/7/2018	34.671900	-86.907100
Faxonius	yanahlindus		Round Island Creek	2.1	Limestone	AL	7/28/2009	34.735491	-87.073067
Faxonius	yanahlindus		Flint Creek	28.2	Morgan	AL	6/26/2008	34.396200	-86.952700

*Records from TVA Crayfish Collection

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Table 7. Fish taxa collected in impingement and entrainment samples collected during the period of 2007 to 2009 (impingement) and 2018 to 2020 (entrainment), and designation as forage, commercial (ADCNR 2020), and/or recreational species

Family	Scientific Name	Common Name	Impingement	Entrainment	Forage	Commercial	Recreational
Petromyzontidae	*Ichthyomyzon castaneus*	Chestnut lamprey	X				
Lepisosteidae	*Lepisosteus osseus*	Longnose gar	X			X	
	Lepisosteus oculatus	Spotted gar	X			X	
Hiodontidae	*Hiodon tergisus*	Mooneye	X				
Clupeidae	*Alosa chrysochloris*	Skipjack herring	X	X		X	X
	Alosa pseudoharengus	Alewife	X		X		
	Dorosoma cepedianum	Gizzard shad	X	X	X		
	Dorosoma petenense	Threadfin shad	X	X	X		
	Unspecified clupeids			X			
Cyprinidae	*Ctenopharyngodon idella*	Grass carp		X		X	
	Cyprinus carpio	Common carp	X	X		X	
	Luxilus chrysocephalus	Striped shiner	X		X		
	Notemigonus crysoleucas	Golden shiner	X		X		
	Notropis atherinoides	Emerald shiner	X		X		
	Notropis spiloptera	Spotfin shiner	X		X		
	Pimephales notatus	Bluntnose minnow	X		X		
	Pimephales vigilax	Bullhead minnow	X	X	X		
	Notropis atherinoides type	Emerald shiner type		X	X		
	Pimephales spp.	Unspecified minnow		X	X		
	Cyprinella spp.	Unspecified shiner		X	X		
Catostomidae	*Ictiobus bubalus*	Smallmouth buffalo	X			X	
	Ictiobus niger	Black buffalo	X			X	
	Moxostoma erythrurum	Golden redhorse	X			X	
	Hypentilium nigricans	Northern hogsucker	X			X	
	Carpiodes cyprinus	Quillback	X			X	
	Minytream melanops	Spotted sucker	X	X		X	
	Moxostoma spp.	Unidentified redhorse				X	
	Unspecified catostomids			X			
Ictaluridae	*Ameiurus nebulosus*	Brown bullhead	X			X	
	Ameiurus melas	Black bullhead	X			X	
	Ictalurus furcatus	Blue catfish	X	X		X	X
	Ictalurus punctatus	Channel catfish	X	X		X	X
	Pylodictis olivaris	Flathead catfish	X	X		X	X

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Table 7. (continued)

Family	Scientific Name	Common Name	Impingement	Entrainment	Forage	Commercial	Recreational
Fundulidae	Unspecified fundulid			X			
Poeciliidae	Unspecified poeciliid			X			
Atherinopsidae	*Labidesthes sicculus*	Brook silverside	X		X		
	Menidia audens	Mississippi silverside	X	X	X		
	Labidesthes spp.	Unidentified silverside		X	X		
Belonidae	*Strongylura marina*	Atlantic needlefish	X				
Moronidae	*Morone chrysops*	White bass	X	X			X
	Morone saxatilis	Striped bass	X				X
	Morone mississippiensis	Yellow bass	X	X			X
	Morone saxatilis x *M. chrysops*	Hybrid striped bass	X				X
	Unspecified moronids	Unspecified moronids		X			X
Centrarchidae	*Lepomis auritus*	Redbreast sunfish	X				X
	Lepomis macrochirus	Bluegill	X				X
	Lepomis microlophus	Redear sunfish	X				X
	Lepomis gulosus	Warmouth	X				X
	Lepomis humilis	Orangespotted sunfish	X				X
	Lepomis cyanellus	Green sunfish	X				X
	Lepomis megalotis	Longear sunfish	X				X
	Hybrid *Lepomis* spp..	Hybrid sunfish	X				X
	Lepomis spp.	Unidentified sunfish		X			X
	Micropterus punctulatus	Spotted bass	X				X
	Micropterus dolomieu	Smallmouth bass	X				X
	Micropterus salmoides	Largemouth bass	X				X
	Micropterus spp.	Unidentified black bass					X
	Pomoxis annularis	White crappie	X				X
	Pomoxis nigromaculatus	Black crappie	X				X
	Pomoxis spp.	Unidentified crappie		X			X
Poeciliidae	*Gambusia affinis*	Western mosquitofish			X		

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Table 7. (continued)

Family	Scientific Name	Common Name	Impingement	Entrainment	Forage	Commercial	Recreational
Percidae	*Perca flavescens*	Yellow perch	X	X			X
	Sander canadense	Sauger	X	X			X
	Sander vitreus	Walleye					X
	Percina caprodes	Logperch	X	X			
	Percina shumardi	River darter	X				
	Percina caprodes type	Logperch type		X			
	Etheostoma spp.	Unidentified darter		X			
Sciaenidae	*Aplodinotus grunniens*	Freshwater drum	X	X		X	
Total			**51**	**24**	**16**	**18**	**28**

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Table 8. Numbers (actual and estimated) and percent composition of fish collected in impingement samples during 2007-2009 (TVA 2010) at TVA's Browns Ferry Nuclear Plant

			Actual*						Estimated*		
			Year 1		Year 2		Total				
Family	Scientific Name	Common Name	N	%	N	%	N	%	Year 1	Year 2	Avg.*
Petromyzontidae	*Ichthyomyzon castaneus*	Chestnut lamprey	4	T	2	T	6	T	28	14	21
Lepisosteidae	*Lepisosteus osseus*	Longnose gar	--	--	3	T	3	T	--	21	11
	Lepisosteus oculatus	Spotted gar	16	T	36	T	52	T	112	252	182
Hiodontidae	*Hiodon tergisus*	Mooneye	4	T	--	--	4	T	28	--	14
Clupeidae	*Dorosoma cepedianum*	Gizzard shad	34,015	1.2	54,678	4.7	88,693	2.2	238,105	382,746	310,426
	Alosa chrysochloris	Skipjack herring	54	T	21	T	75	T	378	147	263
	Dorosoma petenense	Threadfin shad	2,731,184	97.2	1,074,676	91.6	3,805,860	95.5	19,118,288	7,522,732	13,320,510
	Alosa pseudoharengus	Alewife	122	T	1,622	0.1	1,744	T	854	11,354	6,104
Cyprinidae	*Pimephales vigilax*	Bullhead minnow	1,622	0.1	197	T	1,819	T	11,354	1,379	6,367
	Pimephales notatus	Bluntnose minnow	10	T	--	--	10	T	70	--	35
	Notropis atherinoides	Emerald shiner	21	T	2	T	23	T	147	14	81
	Notemigonus crysoleucas	Golden Shiner	25	T	65	T	90	T	175	455	315
	Cyprinella spiloptera	Spotfin shiner	5	T	--	--	5	T	35	--	18
	Luxilus chrysocephalus	Striped shiner	5	T	2	T	7	T	35	14	25
	Cyprinus carpio	Common carp	23	T	74	T	97	T	161	518	340
Catostomidae	*Ictiobus bubalus*	Smallmouth buffalo	2	T	2	T	4	T	14	14	14
	Ictiobus niger	Black buffalo	4	T	--	--	4	T	28	--	14
	Moxostoma erythrurum	Golden redhorse	1	T	--	--	1	T	7	--	4
	Hypentelium nigricans	Northern hogsucker	6	T	23	T	29	T	42	161	102
	Carpiodes cyprinus	Quillback	--	--	3	T	3	T	--	21	11
	Minytrema melanops	Spotted sucker	516	T	735	0.1	1,251	T	3,612	5,145	4,379
Ictaluridae	*Ictalurus furcatus*	Blue catfish	516	T	735	0.1	1,251	T	3,612	5,145	4,379
	Ictalurus punctatus	Channel catfish	2,907	0.1	2,565	0.2	5,472	0.1	20,349	17,955	19,152
	Pylodictis olivaris	Flathead catfish	46	T	23	T	69	T	322	161	242
	Ameiurus nebulosus	Brown bullhead	--	--	13	T	13	T	--	91	46
	Ameiurus melas	Black bullhead	3	T	--	--	3	T	21	--	11
Atherinopsidae	*Labidesthes sicculus*	Brook silverside	13	T	--	--	13	T	91	--	46
	Menidia beryllina	Inland Silverside	40	T	1,798	0.2	1,838	T	280	12,586	6,433
Belonidae	*Strongylura marina*	Atlantic needlefish	38	T	11	T	49	T	266	77	172
Moronidae	*Morone chrysops*	White bass	535	T	255	T	790	T	3,745	1,785	2,765
	Morone mississippiensis	Yellow bass	9,280	0.3	15,657	1.3	24,937	0.6	64,960	109,599	87,280
	Morone saxatilis	Striped bass	7	T	8	T	15	T	49	56	53
	Morone saxatilis x M. chrysops	Hybrid striped bass	13	T	5	T	18	T	91	35	63

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Table 8. (continued)

			Actual*						Estimated*		
			Year 1		Year 2		Total				
Family	**Scientific Name**	**Common Name**	**N**	**%**	**N**	**%**	**N**	**%**	**Year 1**	**Year 2**	**Avg.***
Centrarchidae	*Lepomis macrochirus*	Bluegill	15,132	0.5	5,565	0.5	20,697	0.5	105,924	38,955	72,440
	Lepomis auritus	Redbreast sunfish	--	--	58	T	58	T	--	406	203
	Lepomis microlophus	Redear sunfish	4,160	0.1	534	T	4,694	0.1	29,120	3,738	16,429
	Lepomis gulosus	Warmouth	14	T	106	T	120	T	98	742	420
	Lepomis humilis	Orangespotted sunfish	370	T	959	T	1,329	T	2,590	6,713	4,652
	Lepomis cyanellus	Green sunfish	35	T	270	T	305	T	245	1,890	1,068
	Lepomis megalotis	Longear sunfish	132	T	174	T	306	T	924	1,218	1,071
	Hybrid *Lepomis*	Hybrid sunfish	1	T	--	--	1	T	7	--	4
	Micropterus dolomieu	Smallmouth bass	2	T	4	T	6	T	14	28	21
	Micropterus salmoides	Largemouth bass	78	T	73	T	151	T	546	511	529
	Micropterus punctulatus	Spotted bass	79	T	72	T	151	T	553	504	529
	Pomoxis annularis	White crappie	197	T	693	0.1	890	T	1,379	4,851	3,115
	Pomoxis nigromaculatus	Black crappie	20	T	2	T	22	T	140	14	77
Percidae	*Sander canadense*	Sauger	14	T	5	T	19	T	98	35	67
	Perca flavescens	Yellow perch	512	T	212	T	724	T	3,584	1,484	2,534
	Percina caprodes	Logperch	523	T	211	T	734	T	3,661	1,477	2,569
	Percina shumardi	River darter	--	--	3	T	3	T	--	21	11
Sciaenidae	*Aplodinotus grunniens*	Freshwater drum	9,483	0.3	11,426	1.0	20,909	0.5	66,381	79,982	73,182
		Total Number of Fish	**2,810,778**		**1,172,660**		**3,983,438**		**19,675,446**	**8,208,620**	**13,942,033**
		Total Number of Taxa	**46**		**43**		**51**				

*The 24-hr sample totals (Actual) for each taxa were extrapolated to weekly estimates (Estimated) that were averaged for the two years of the impingement study (Avg.).

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Table 9. Number collected and relative abundance (%) of fish eggs and larvae collected in samples filtering 150 m^3 of water at locations outside the skimmer wall (intake) and at stations along a reservoir transect (TRM 294.5) during day and night February 2018 to December 2019 in the vicinity of Browns Ferry Nuclear Plant, Wheeler Reservoir

	Yr 1						Yr 2									
	Intake			Reservoir			Intake			Reservoir			Both Years Combined			
Taxa	Day	Night	%	Day	Night	%	Day	Night	%	Day	Night	%	Int.	%	Res.	%
EGGS																
Clupeidae																
Alosa chrysochloris (skipjack herring) eggs	--	--	--	5	--	0.3	--	1	0.1	1	--	T	1	T	6	0.1
Unspecified clupeid eggs	89	61	18.8	99	2	5.1	3	--	0.2	2	16	0.4	153	5.7	119	1.9
Cyprinidae																
Unspecified cyprinid eggs	--	--	--	--	1	0.1	--	--	--	--	--	--	--	T	1	T
Atherinopsidae																
Unspecified atherinopsid eggs	3	--	0.4	1	--	0.1	--	--	--	--	--	--	3	0.1	1	T
Moronidae																
Unspecified moronid (not *M. saxatilis*) eggs	1	2	0.4	3	1	0.2	--	--	--	--	--	--	3	0.1	4	0.1
Percidae																
Unspecified percid eggs	--	--	--	--	--	--	--	--	--	3	--	0.1	--	T	3	0.1
Sciaenidae																
Aplodinotus grunniens (freshwater drum) eggs	288	348	79.9	888	960	94.2	125	1,750	99.8	498	3,676	99.4	2,511	93.9	6,022	97.8
Unidentifiable Fish Eggs	1	3	0.5	2	--	0.1	--	--	--	--	1	T	4	0.1	3	T
Total Eggs	**382**	**414**		**998**	**964**		**128**	**1,751**		**504**	**3,693**		**2,675**		**6,159**	
LARVAE																
Clupeidae																
Alosa chrysochloris (Skipjack herring)	--	--	--	2	--	T	--	--	--	--	--	--	--	T	2	T
Dorosoma cepedianum (Gizzard shad)	6	24	0.1	--	--	--	--	--	--	--	4	T	30	T	4	T
Dorosoma petenense (Threadfin shad)	376	380	2.3	9	32	0.1	2	1	T	1	2	T	759	1.1	44	T
Unspecified clupeids	15,400	13,125	86.9	16,333	18,321	93.6	9,179	17,613	77.8	26,817	18,740	88.8	55,317	82.2	80,211	90.8

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Table 9. (continued)

Taxa	Yr 1						Yr 2						Both Years Combined			
	Intake			Reservoir			Intake			Reservoir						
	Day	Night	%	Day	Night	%	Day	Night	%	Day	Night	%	Int.	%	Res.	%
Cyprinidae																
Ctenopharyngodon idella (Grass carp)	--	1	T	--	--	--	--	--	--	--	--	--	1	T	--	T
Cyprinus carpio (Common carp)	--	--	--	4	--	T	3	1	T	3	4	T	4	T	11	T
Unspecified cyprinids (*N. atherinoides* group)	1	1	T	--	--	--	1	--	T	--	2	T	3	T	2	T
Unspecified cyprinids (*Cyprinella* group)	--	--	--	--	--	--	--	--	--	1	--	T	--	T	1	T
Unspecified cyprinids (*Pimephales* group)	72	76	0.5	49	63	0.3	10	21	0.1	4	24	0.1	179	0.3	140	0.2
Unspecified cyprinids (Unidentified shiner)	--	--	--	3	--	T	--	1	T	2	1	T	1	T	6	T
Unspecified cyprinids	16	9	0.1	3	7	T	2	6	T	--	1	T	33	T	11	T
Catostomidae																
Minytrema melanops (Spotted sucker)	3	--	T	8	14	0.1	2	--	T	2	3	T	5	T	27	T
Ictiobinae (Buffalofish or carpsucker)	38	45	0.3	80	98	0.5	77	60	0.4	110	243	0.7	220	0.3	531	0.6
Ictaluridae																
Ictalurus furcatus (Blue catfish)	--	1	T	2	1	0.0	--	--	--	--	--	--	1	T	3	T
Ictalurus punctatus (Channel catfish)	7	10	0.1	7	3	T	1	--	T	--	1	T	18	T	11	T
Pylodictus olivaris (Flathead catfish)	--	--	--	1	--	T	--	--	--	--	--	--	--	T	1	T
Fundulidae																
Unspecified fundulids	2	--	T	--	--	--	--	--	--	--	--	--	2	T	--	T
Poeciliidae																
Gambusia affinis (Western mosquitofish)	1	--	T	--	--	--	--	--	--	--	--	--	1	T	--	T
Atherinopsidae																
Menidia audens (Mississippi silverside)	145	96	0.7	--	1	T	--	2	T	--	48	0.1	243	0.4	49	0.1
Unspecified silversides	507	693	3.7	108	112	0.6	20	214	0.7	141	152	0.6	1,434	2.1	513	0.6
Moronidae																
Morone chrysops (White bass)	18	15	0.1	--	1	T	2	6	T	1	1	T	41	0.1	3	T
Morone mississippiensis (Yellow bass)	--	1	T	--	--	--	--	--	--	--	1	T	1	T	1	T
Unspecified moronids (not *M. saxatilis*)	177	211	1.2	192	263	1.2	1,434	2,983	12.8	1,470	1,550	5.9	4,805	7.1	3,475	3.9
Unspecified moronids	103	124	0.7	36	26	0.2	826	1,053	5.5	364	271	1.2	2,106	3.1	697	0.8

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Table 9. (continued)

Taxa	Yr 1						Yr 2						Both Years Combined			
	Intake			Reservoir			Intake			Reservoir						
	Day	Night	%	Day	Night	%	Day	Night	%	Day	Night	%	Int.	%	Res.	%
Centrarchidae																
Unspecified *Lepomis* sp. (Sunfish)	382	343	2.2	155	178	0.9	84	349	1.3	369	116	0.9	1,158	1.7	818	0.9
Unspecified *Micropterus* sp. (Black bass)	--	--	--	--	--	--	--	--	--	--	1	T	--	T	1	T
Unspecified *Pomoxis* sp. (Crappie)	8	7	T	21	20	0.1	7	12	0.1	39	25	0.1	34	0.1	105	0.1
Percidae																
Perca flavescens (Yellow perch)	2	1	T	1	--	T	6	14	0.1	9	11	T	23	T	21	T
Percina caprodes (Logperch)	--	1	T	--	--	--	2	--	T	--	1	T	3	T	1	T
Sander canadensis (Sauger)	--	1	T	1	--	T	1	3	T	--	1	T	5	T	2	T
Unidentifiable darter (*Etheostoma* type)	1	--	T	--	--	--	--	--	--	--	--	--	1	T	--	T
Unidentifiable darter (*P. caprodes* type)	64	49	0.3	20	9	0.1	105	62	0.5	33	44	0.2	280	0.4	106	0.1
Unidentifiable darter	--	2	T	--	3	T	18	8	0.1	20	19	0.1	28	T	42	T
Sciaenidae																
Aplodinotus grunniens (Freshwater drum)	117	90	0.6	450	377	2.2	65	157	0.6	271	348	1.2	429	0.6	1,446	1.6
Unidentifiable Fish	47	40	0.3	5	3	T	25	8	0.1	15	16	0.1	120	0.2	39	T
Toal Larvae	**17,493**	**15,346**		**17,490**	**19,532**		**11,872**	**22,574**		**29,672**	**21,630**		**67,285**		**88,324**	
Total Taxa	**17**	**18**		**15**	**12**		**15**	**12**		**12**	**19**		**23**		**23**	

"--" denotes no fish eggs or larvae collected
T- trace or less than 0.05%

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Table 10. Estimated annual numbers (x 10^5) by sample period of all taxa entrained at the Browns Ferry Nuclear Plant's CCW intake from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

YEAR 1		Eggs						Larvae												
Sample Period	Sample Week/Month	Sciaenidae	Clupeidae	Moronidae	Unidentifiable	Atherinopsidae	Total	Clupeidae	Atherinopsidae	Moronidae	Centrarchidae	Sciaenidae	Cyprinidae	Catostomidae	Percidae	Unidentifiable	Ictaluridae	Fundulidae	Poeciliidae	Total	Total Eggs and Larvae
1	Feb 20-21, 2018																				
2	Feb 26-27									1					1					3	3
3	Mar 6-7													1	5					6	6
4	Mar 13-15										1				1					2	2
5	Mar 21-22													3	16					19	19
6	Mar 27-30													9	6					16	16
7	Apr 3-4									1				10	21					32	32
8	Apr 10-11			2		1	3			164	6			13	9					192	195
9	Apr 17-18		3	1			4	4		237	4			25	21					290	294
10	Apr 24-25							41	3	76	2			4	9					135	135
11	May 2-3		4		2	2	7	104	2	3				6	1					115	123
12	May 8-9	13	100				113	814	15	5	1	1		1						836	949
13	May 16	11	13		1		25	9,973	48	11	7	1			2	1		2		10,045	10,070
14	May 22-23	100	6				106	3,578	418	7	60	18	4			2				4,086	4,192
15	May 28-30	436			1		436	9,832	538	85	50	47	32		1	27	1			10,612	11,048
16	Jun 6							529	203	3	2	55	2			1				795	795
17	Jun 13-14	1					1	278	8		66	60	4			2				418	419
18	Jun 20-21							336	9		105		1			9				459	459
19	Jun 26-28							148	12		52					3				214	214
20	Jul 2-4	12					12	591	8	1	54		40			2	5			700	712
21	Jul 11-12							17	7		42					3				68	68
22	Jul 18-19							61	3		38		22			5	8			137	137
23	Jul 25-26							43			28					14				85	85
24	Aug 1-2	2					2	101	3		141		40			12	2		1	299	301
25	Aug 8-9							16	2		8									25	25
26	Aug 15-16	1					1	66	29		13		12			2	2			125	126
27	Aug 23-24	20					20	32			5		18							56	75
28	Sep 26-27							8												8	8
29	Oct 23-24																				
30	Nov 20-21																				
31	Dec 27-28																				

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Table 10. (continued)

Sample Period	YEAR 2 Sample Week/Month	Eggs						Larvae												Total Eggs and Larvae
		Sciaenidae	Clupeidae	Moronidae	Unidentifiable	Atherinopsidae	Total	Clupeidae	Atherinopsidae	Moronidae	Centrarchidae	Sciaenidae	Cyprinidae	Catostomidae	Percidae	Unidentifiable	Ictaluridae	Fundulidae	Poeciliidae	Total	
32	Jan 28-30, 2019																				
33	Feb 27	NS	NS	NS	NS	NS	NS														
34	Mar 6-7																				
35	Mar 12-13														8					8	8
36	Mar 19-21														15					15	15
37	Mar 26-28		1				1	5		9	3			3	18	1				40	40
38	Apr 2-4							5		152				12	8	3				180	180
39	Apr 9-11							155		2,206	3			40	41	8				2,452	2,452
40	Apr 16-18							933	1	326	4		1	42	12	3				1,320	1,320
41	Apr 24-26		2				2	2,782	1	1,496	1		2	23	31	10				4,346	4,348
42	Apr 30-May 2	29					29	1,152	3	742	2				25					1,923	1,951
43	May 8-9	1,199	1				1,200	3,937		744	1	32	2	1	12	3				4,731	5,931
44	May 14-16							5,644	11	88	5	45		1	8	1				5,803	5,803
45	May 21-23	97					97	679	6	6	3	34	3	1	2					734	831
46	May 28-30	384					384	7,033	98	7	72	66	5		1					7,281	7,665
47	Jun 4-6	11					11	1,549	84		274	21								1,928	1,939
48	Jun 11-13	3					3	210	5		7	2								224	226
49	Jun 18-20							2	1		2	1								5	5
50	Jun 25-27							2			3									5	5
51	Jul 2-4										5									5	5
52	Jul 9-11							2			9		29				1			42	42
53	Jul 16-18										3									3	3
54	Jul 23-25										4									4	4
55	Jul 30-Aug 1										3									3	3
56	Aug 6-8										2									2	2
57	Aug 13-15										4									4	4
58	Aug 20-22																				
59	Aug 27-29																				
60	Sep 17-19																				
61	Oct 28-30																				
62	Nov 25-27																				
63	Dec 17-19																				
Total	**Year 1**	**595**	**125**	**3**	**4**	**3**	**729**	**26,573**	**1,306**	**594**	**684**	**182**	**174**	**71**	**93**	**81**	**17**	**2**	**1**	**29,778**	**30,507**
Total	**Year 2**	**1,722**	**3**	**-**	**-**	**-**	**1,725**	**24,089**	**210**	**5,776**	**409**	**201**	**42**	**123**	**179**	**29**	**1**	**-**	**-**	**31,058**	**32,783**
Total	**Both Years**	**2,316**	**129**	**3**	**4**	**3**	**2,454**	**50,662**	**1,516**	**6,370**	**1,092**	**383**	**216**	**194**	**272**	**110**	**18**	**2**	**1**	**60,836**	**63,290**
Non-clupeid	**Both Years**	**2,316**	**-**	**3**	**4**	**2**	**2,325**	**-**	**1,516**	**6,370**	**1,092**	**383**	**216**	**194**	**272**	**110**	**18**	**2**	**1**	**10,174**	**12,499**

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Table 11. Average densities (number/1,000 m^3) of fish eggs and larvae by family collected in day and night ichthyoplankton samples at intake and river (TRM 294.5) transects from February 2018 December 2019

YEAR 1	Intake			Reservoir										
	Day	Night		Day					Night					
Family			Intake Average	RDB*	MC-Bottom to Middepth	MC-Middepth to Surface	LDB*	Day Average	RDB*	MC-Bottom to Middepth	MC-Middepth to Surface	LDB*	Night Average	River Average
EGGS														
Sciaenidae	22.7	26.6	24.7	3.7	83.0	54.7	64.3	51.4	1.4	92.2	73.8	54.4	55.6	53.5
Clupeidae	7.0	4.7	5.8	22.0	0.5	0.5	1.2	6.0	-	0.2	-	0.2	0.1	3.1
Moronidae	0.1	0.2	0.1	-	-	0.7	-	0.2	-	0.2	-	-	0.1	0.1
Unidentifiable	0.1	0.2	0.2	0.2	-	-	0.2	0.1	-	-	-	-	-	0.1
Atherinopsidae	0.2	-	0.1	T	-	0.2	-	0.1	-	-	-	-	-	T
Cyprinidae	-	-	-	-	-	-	-	-	-	-	0.2	-	0.1	T
LARVAE														
Clupeidae	1,241.5	1,034.7	1,136.6	942.3	668.2	1,122.9	1,051.2	946.1	1,711.0	844.6	738.6	961.7	1,062.9	1,004.5
Atherinopsidae	51.3	60.3	55.9	12.0	0.9	10.2	1.8	6.3	11.9	1.4	7.0	6.0	6.5	6.4
Moronidae	23.4	26.8	25.2	19.9	12.5	12.1	8.3	13.2	27.8	21.1	11.0	7.4	16.8	15.0
Centrarchidae	30.7	26.8	28.7	22.0	4.2	9.5	5.1	10.2	20.8	3.0	11.7	10.6	11.5	10.8
Sciaenidae	9.2	6.9	8.0	2.8	32.4	10.7	58.1	26.1	4.7	31.4	7.7	43.1	21.8	23.9
Cyprinidae	7.0	6.7	6.8	2.3	3.7	4.2	3.5	3.4	1.2	4.8	5.4	4.8	4.1	3.7
Catostomidae	3.2	3.4	3.3	13.4	1.9	0.9	4.1	5.1	17.7	3.7	3.5	1.2	6.5	5.8
Percidae	5.3	4.1	4.7	2.1	0.5	0.2	2.3	1.3	0.7	0.7	0.9	0.5	0.7	1.0
Unidentifiable	3.7	3.1	3.4	-	0.5	0.2	0.5	0.3	0.2	-	-	0.5	0.2	0.2
Ictaluridae	0.6	0.8	0.7	-	0.5	0.5	1.4	0.6	-	0.5	0.5	-	0.2	0.4
Fundulidae	0.2	-	0.1	-	-	-	-	-	-	-	-	-	-	-
Poeciliidae	0.1	-	T	-	-	-	-	-	-	-	-	-	-	-
EGGS Total	**30.0**	**31.7**	**30.9**	**25.9**	**83.4**	**56.1**	**65.7**	**57.8**	**1.4**	**92.7**	**74.1**	**54.6**	**55.8**	**56.8**
LARVAE Total	**1,376.1**	**1,173.7**	**1,273.4**	**1,016.8**	**725.2**	**1,171.5**	**1,136.2**	**1,012.5**	**1,795.9**	**911.1**	**786.3**	**1,035.7**	**1,131.2**	**1,071.8**

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Table 11. (continued)

YEAR 2	Intake			Reservoir										
	Day	Night		Day					Night					
Family			Intake Average	RDB**	MC**-Bottom to Middepth	MC-Middepth to Surface	LDB**	Day Average	RDB	MC-Bottom to Middepth	MC-Middepth to Surface	LDB	Night Average	River Average
EGGS														
Sciaenidae	9.6	133.5	71.6	3.9	20.8	24.4	62.1	27.9	11.8	375.5	227.2	203.0	204.8	116.5
Clupeidae	0.2	0.1	0.2	-	0.2	-	0.4	0.2	3.1	0.2	0.2	-	0.9	0.5
Percidae	-	-	-	-	0.8	-	-	0.2	-	-	-	-	-	0.1
Unidentifiable	-	-	-	-	-	-	-	-	-	-	-	0.2	0.1	T
LARVAE														
Clupeidae	702.1	1,343.7	1,023.3	4,572.3	629.4	448.4	401.3	1,500.3	2,546.0	890.8	521.6	215.4	1,044.4	1,271.9
Moronidae	173.0	308.4	240.7	215.5	93.3	76.9	27.7	102.9	242.0	66.1	74.3	25.2	102.0	102.4
Centrarchidae	7.0	27.5	17.3	62.1	10.4	7.6	11.8	22.8	22.5	4.0	3.3	1.8	7.9	15.4
Sciaenidae	5.0	12.0	8.5	7.0	16.6	9.2	27.7	15.2	3.3	30.1	19.8	24.3	19.4	17.3
Atherinopsidae	1.5	16.5	9.0	7.9	-	1.3	22.3	7.9	34.4	3.5	0.9	5.8	11.1	9.5
Catostomidae	6.0	4.6	5.3	3.2	6.6	6.1	9.2	6.3	9.1	5.7	16.2	23.8	13.7	10.0
Percidae	10.1	6.6	8.4	6.3	2.4	2.2	1.8	3.2	6.5	2.7	3.6	2.7	3.8	3.5
Cyprinidae	1.2	2.2	1.7	0.5	0.2	0.2	1.3	0.6	1.6	0.2	1.3	4.0	1.8	1.2
Unidentifiable	1.9	0.6	1.3	0.5	1.8	0.7	0.4	0.8	-	1.3	1.8	0.4	0.9	0.9
Ictaluridae	0.1	-	T	-	-	-	-	-	-	-	0.2	-	0.1	T
EGGS														
Total	**9.8**	**133.6**	**71.8**	**3.9**	**21.8**	**24.4**	**62.5**	**28.2**	**14.9**	**375.7**	**227.4**	**203.2**	**205.7**	**117.2**
LARVAE														
Total	**907.9**	**1,722.1**	**1,315.5**	**4,875.4**	**760.8**	**552.7**	**503.6**	**1,660.0**	**2,865.4**	**1,004.4**	**643.1**	**303.5**	**1,205.0**	**1,432.0**

***Intake densities are averages of two samples; T-trace, or value less than 0.05.**
****MC – Mid-channel, RDB – right descending bank, LDB – left descending bank**

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Table 12. Relative abundance (%) and catch rates of fish species collected by electrofishing and gill netting at areas upstream (TRM 295.9) and downstream (TRM 292.5) of Browns Ferry Nuclear Plant during spring and autumn 2007

		Proportion (%)						Catch Per Unit Effort	
		Spring			Autumn				
Common Name	Trophic level*	TRM 292.5	TRM 295.9	Total	TRM 292.5	TRM 295.9	Total	Spring	Autumn
Black crappie	TC	--	--	--	--	0.3	0.2	--	0.3
Black redhorse	BI	0.9	0.3	0.6	0.1	0.1	0.1	0.9	0.1
Blue catfish	OM	1.6	4.0	2.8	0.9	0.3	0.5	4.3	0.9
Bluegill	IN	24.8	17.1	21.0	5.7	18.2	13.1	31.8	22.6
Bullhead minnow	IN	--	--	--	--	0.2	0.1	--	0.2
Channel catfish	OM	8.7	7.8	8.2	3.7	3.3	3.5	12.5	6.0
Common carp	OM	0.2	0.3	0.2	0.1	--	0.0	0.3	0.1
Emerald shiner	IN	--	0.1	0.0	--	0.1	0.1	0.1	0.1
Flathead catfish	TC	0.5	0.3	0.4	0.9	0.5	0.6	0.6	1.1
Freshwater drum	BI	2.0	1.7	1.9	4.3	3.4	3.8	2.8	6.5
Gizzard shad	OM	4.2	7.4	5.7	35.7	28.6	31.5	8.7	54.3
Golden redhorse	BI	1.6	--	0.8	0.1	--	0.0	1.2	0.1
Golden shiner	IN	--	--	--	0.1	1.8	1.1	--	1.9
Green sunfish	IN	0.5	0.6	0.6	0.6	0.8	0.7	0.9	1.3
Largemouth bass	TC	16.9	9.9	13.5	2.1	11.4	7.6	20.3	13.1
Largescale stoneroller	HB	--	--	--	--	0.1	0.0	--	0.1
Logperch	BI	0.3	--	0.1	0.1	0.3	0.2	0.2	0.3
Longear sunfish	IN	6.9	2.6	4.8	2.9	2.9	2.9	7.2	4.9
Mississippi silverside	IN	6.1	2.3	4.2	29.4	9.0	17.3	6.4	29.7
Northern hog sucker	BI	0.1	--	0.0	--	--	--	0.1	--
Redbreast sunfish	IN	--	0.1	0.0	--	0.2	0.1	0.1	0.2
Redear sunfish	IN	1.8	1.1	1.5	1.8	3.0	2.5	2.2	4.3
River redhorse	BI	0.3	--	0.1	--	--	--	0.2	--
Sauger	TC	0.3	0.7	0.5	0.1	0.4	0.3	0.8	0.5
Silver redhorse	BI	0.8	--	0.4	--	--	--	0.6	--
Skipjack herring	TC	3.0	2.9	3.0	3.4	3.8	3.6	4.5	6.3
Smallmouth bass	TC	3.4	1.1	2.2	1.3	0.6	0.9	3.4	1.5
Smallmouth buffalo	OM	0.7	1.3	1.0	1.7	1.4	1.5	1.5	2.6
Spotfin shiner	IN	1.6	0.1	0.8	0.6	0.5	0.5	1.3	0.9
Spotted bass	TC	2.4	1.7	2.1	0.4	1.7	1.2	3.1	2.0
Spotted gar	TC	0.3	0.7	0.5	0.4	0.3	0.3	0.8	0.6
Spotted sucker	BI	4.5	0.9	2.7	0.5	1.2	0.9	4.1	1.5
Striped bass	TC	0.9	--	0.4	--	0.1	0.1	0.7	0.1
Striped shiner	IN	--	--	--	--	0.3	0.2	--	0.3
Threadfin shad	PK	1.3	33.1	16.9	0.3	0.1	0.2	25.6	0.3
Warmouth	IN	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.2
White bass	TC	0.6	0.4	0.5	0.2	0.5	0.3	0.7	0.6
White crappie	TC	0.3	--	0.1	--	--	--	0.2	--
Yellow bass	TC	2.4	1.6	2.0	2.7	4.5	3.8	3.1	6.5
Yellow perch	IN	--	--	--	--	0.3	0.2	--	0.3
Total		**32**	**28**		**27**	**34**		**151.4**	**172.3**

***Trophic level: benthic invertivore (BI), insectivore (IN), omnivore (OM), planktivore (PK), herbivore (HB), top carnivore (TC); T – trace or less than 0.05%**

****Shaded species represent six of top eight species proportionally that are same between sites**

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Table 13. Proportions and numbers of species of each trophic guild observed during spring and autumn 2007 monitoring in Wheeler Reservoir at Browns Ferry Nuclear Plant

	Observed Downstream of BFN (TRM 292.5)				Observed Upstream of BFN (TRM 295.9)				Sites Combined			
	Proportion (%)		Number of Species		Proportion (%)		Number of Species		Proportion (%)		Number of Species	
Trophic Guild	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Benthic Invertivore	10.3	5.1	8	5	2.9	4.9	3	4	6.7	5.0	8	5
Insectivore	41.8	41.1	7	7	24.1	35.3	9	11	33.1	37.9	9	11
Top Carnivore	31.2	11.4	11	9	19.2	24.0	9	11	25.3	18.8	11	11
Omnivore	15.4	42.1	5	6	20.7	35.7	5	6	18.0	38.1	5	7
Planktivore	1.3	0.3	1	1	33.1	0.1	1	1	16.9	0.2	1	1

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Table 14. Records of federal and state-listed aquatic animal species known within a 10-mile radius of Browns Ferry Nuclear Plant (TRM 294)[1]

Scientific Name	Common Name	Element Rank[2]	Federal Status[3]	State Status[3]	State Rank[4]
FISH					
Hybopsis amblops	Bigeye Chub	E		TRKD	S3
Hemitremia flammea	Flame Chub	BC		TRKD	S3
Polyodon spathula	Paddlefish	H		PROT	S3
Etheostoma rufilineatum	Redline Darter	E		TRKD	S3
Moxostoma anisurum	Silver Redhorse	E		TRKD	S2
Typhlichthys subterraneus	Southern Cavefish	E		PROT	S3
Elassoma alabamae	Spring Pygmy Sunfish	A?	LT	PROT	S1
Elassoma alabamae	Spring Pygmy Sunfish	E	LT	PROT	S1
Phenacobius uranops	Stargazing Minnow	E		TRKD	S1
Etheostoma tuscumbia	Tuscumbia Darter	E		PROT	S2
AMPHIBIANS					
Cryptobranchus alleganiensis	Hellbender	E	PS	PROT	S2
MUSSELS					
Epioblasma haysiana	Acornshell	H		EXTI	SH
Lemiox rimosus	Birdwing Pearlymussel	X	LE	PROT	SX
Hemistena lata	Cracking Pearlymussel	X	LE	PROT	SX
Epioblasma brevidens	Cumberlandian Combshell	H	LE	PROT	S1
Dromus dromas	Dromedary Pearlymussel	X	LE	PROT	S1
Ptychobranchus subtentum	Fluted Kidneyshell	H	LE	PROT	SX
Toxolasma parvum	Lilliput	H		TRKD	S3
Pleurobema cordatum	Ohio Pigtoe	E		TRKD	S2
Lampsilis abrupta	Pink Mucket	E	LE	PROT	S1
Potamilus ohiensis	Pink Papershell	E		TRKD	S3
Toxolasma lividus	Purple Lilliput	E		TRKD	S2
Obovaria retusa	Ring Pink	X	LE	PROT	S1
Pleurobema plenum	Rough Pigtoe	E	LE	PROT	S1
Cumberlandia monodonta	Spectaclecase	E	LE	PROT	S1
Epioblasma torulosa torulosa	Tuberculed Blossom Pearlymussel	X	LE	PROT	SX
Lasmigona complanata	White Heelsplitter	H		TRKD	S2S3
SNAILS					
Elimia nassula	Round-rib Elimia	E		TRKD	S1
Pleurocera pyrenella	Skirted Hornsnail	E		TRKD	S2
Lithasia lima	Warty Rocksnail	H		HIST	SH
Campeloma decampi	Slender Campeloma	E	LE	PROT	S1

[1] Source: TVA Natural Heritage Database, queried on 03/29/2021

[2] Heritage Element Occurrence Rank: E=Verified extant (viability not assessed); BC=Good or fair estimated viability; A?=Possibly excellent estimated viability; H = historical record ≥25years old; X=Extirpated; Xr=Extirpated but reintroduction underway from outside of state (Georgia).

[3] Status Codes: LE or END = Listed Endangered; R = Rare, Not State-listed; D = Deemed in Need of Management; PS=Partial status (population has federal status but entire species does not-status is only in a portion of the species rang); PROT=State Protected; TRKD=Not protected by State, but tracked; EXTI=Extirpated; HIST=Historical record

[4] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; SH = Of Historical occurrence in Tennessee; SX=Presumed extirpated.

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Table 15. Estimated storage volumes of Wheeler Reservoir by month, averaged from 1994 to 2014, and estimates of the maximum proportion of the storage volume withdrawn monthly by Browns Ferry Nuclear Plant

	Minimum monthly storage		Maximum monthly storage		Mean monthly storage	Estimated proportion of mean monthly storage volume withdrawn
Month	Year	Volume	Year	Volume	Volume	%
Jan	2000	400.3	2012	489.1	444.3	1.1
Feb	2007	403.3	2003	510.3	444.4	1.1
Mar	2005	411.9	1997	501.1	448.0	1.1
Apr	1995	469.7	1998	533.7	507.6	1.0
May	2000	509.0	2003	581.5	524.3	0.9
Jun	2000	500.5	1997	541.1	518.0	0.9
Jul	2007	499.9	2013	547.4	517.2	1.0
Aug	1995	484.1	2013	523.1	507.4	1.0
Sep	1998	453.4	2004	514.2	483.7	1.0
Oct	1998	424.3	2009	478.6	448.7	1.1
Nov	1999	402.6	2004	477.3	428.7	1.1
Dec	1999	395.9	2004	506.6	435.7	1.1
Estimated monthly volume of raw water used by Browns Ferry Nuclear Plant at design maximum withdrawal rate:						149.5

Note: All volumes are given in thousands of day-second-feet (dsf)
1 dsf = 86,400 cu. ft.

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Table 16. Average volume of water stored each month in Wheeler Reservoir from 1994 through 2014, determined from TVA's Reservoir Management Database

	Average Storage Volume											
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1994	13,862	14,067	14,383	15,971	16,046	15,535	16,124	15,358	13,926	13,603	12,796	12,753
1995	12,914	12,209	13,955	14,092	15,930	15,357	16,011	15,006	13,699	13,930	13,349	12,884
1996	14,258	13,102	14,567	15,316	16,059	15,425	16,018	15,617	14,117	13,395	13,262	14,686
1997	14,686	12,450	15,535	14,483	16,477	16,232	15,978	15,531	13,889	13,909	12,568	12,501
1998	13,744	12,494	14,097	16,010	16,209	15,574	15,986	15,374	13,602	13,154	12,187	12,576
1999	13,940	11,416	13,640	14,591	16,329	15,518	16,263	15,394	13,757	13,181	12,078	12,272
2000	12,408	11,935	13,665	15,794	15,780	15,563	16,116	15,455	13,990	13,315	12,253	12,583
2001	13,171	12,925	13,848	15,095	15,833	15,512	16,047	15,681	14,156	14,495	12,727	13,958
2002	14,000	11,926	13,793	15,361	16,238	15,484	16,130	15,958	14,077	13,853	13,918	14,053
2003	12,735	14,289	14,189	15,057	18,027	15,708	16,234	15,676	13,984	13,292	12,653	13,138
2004	12,999	13,958	13,610	14,113	16,055	15,579	16,083	16,032	15,425	14,299	14,319	15,706
2005	13,413	12,214	12,769	15,575	15,938	15,267	15,794	15,590	14,764	13,834	12,263	12,578
2006	13,692	11,729	12,798	15,199	16,081	15,385	15,760	15,666	14,894	14,071	13,275	12,572
2007	13,763	11,293	12,912	14,801	16,072	15,016	15,496	15,539	14,679	13,693	12,393	12,474
2008	12,777	12,482	13,993	15,468	16,207	15,522	15,627	15,799	14,919	14,021	12,531	14,493
2009	14,348	11,714	14,025	15,739	16,514	15,482	16,133	16,014	15,161	14,835	13,610	15,090
2010	14,017	12,939	13,439	15,466	16,230	15,370	15,821	16,058	15,060	14,074	12,848	13,591
2011	13,939	11,838	15,462	15,855	15,991	15,610	16,198	16,036	15,135	14,227	13,000	15,065
2012	15,161	12,660	13,743	15,199	16,063	15,528	15,828	16,151	15,135	14,355	12,892	13,475
2013	15,147	12,807	13,929	15,453	16,966	15,823	16,968	16,215	15,232	14,220	12,404	14,213
2014	14,232	13,074	13,280	15,143	16,252	15,832	16,115	16,179	15,117	14,355	12,730	12,978
Mean	**13,772**	**12,549**	**13,887**	**15,228**	**16,252**	**15,539**	**16,035**	**15,730**	**14,510**	**13,910**	**12,860**	**13,507**
Minimum	**12,408**	**11,293**	**12,769**	**14,092**	**15,780**	**15,016**	**15,496**	**15,006**	**13,602**	**13,154**	**12,078**	**12,272**
Maximum	**15,161**	**14,289**	**15,535**	**16,010**	**18,027**	**16,232**	**16,968**	**16,215**	**15,425**	**14,835**	**14,319**	**15,706**

Note: All volumes are given in thousands of day-second-feet (dsf); 1 dsf = 86,400 cu. ft.

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Table 17. Condenser passage effects on larval fish following entrainment at Fort Calhoun Station, June 1 through July 13, 1977 (King 1977)

		Intake			Discharge			Differential Percent Mortality[a]	
		Percent	Percent Dead		Percent	Percent Dead			
Date	Species	Live	Opaque	Transparent	Live	Opaque	Transparent		
June 1	Freshwater drum	45.6	29.1	25.3	5.9	76.5	17.6	39.7	47.4
	Total larvae	46.9	29.6	23.5	12.5	66.7	20.8	34.4	34.1
June 6	Freshwater drum	34.2	35.0	30.8	3.6	85.7	10.7	30.6	50.7
	Total larvae	36.2	34.9	28.8	5.0	83.3	11.7	31.2	48.4
June 15	Freshwater drum	22.6	30.7	46.7	1.3	81.5	17.2	21.3	50.8
	Total larvae	22.7	31.2	46.1	1.9	79.9	18.2	20.8	48.7
June 23	Freshwater drum	48.6	20.6	30.8	14.3	64.3	21.4	34.3	43.7
	Total larvae	52.5	19.6	27.9	42.3	42.3	15.4	10.2	22.7
June 30	Freshwater drum	57.8	16.0	26.2	14.3	71.4	14.3	43.5	55.4
	Total larvae	58.5	17.7	23.8	19.4	54.8	25.8	39.1	37.1
July 6	Freshwater drum	56.5	16.7	26.8	6.2	81.2	12.5	50.2	64.5
	Total larvae	56.2	16.6	27.2	16.7	72.2	11.1	39.6	55.6
July 13	Freshwater drum	57.1	14.1	28.8	23.1	15.4	61.5	34.0	1.3
	Total larvae	56.0	14.1	29.9	20.0	26.7	53.3	36.0	12.6

[a] **Differences between intake and discharge mortalities are based on percent live (Column 1) and percent dead (opaque; Column 2)**

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Table 18. List of upgrades to BFN's units resulting from the extended power uprate in 2017

Description	Unit 1	Unit 2	Unit 3
Maximum Extended Load Line Limit Analysis Plus (MELLLA+)	TBI	TBI	TBI
Condensate Phase Separator Upgrade	TBI	TBI	TBI
500 kV Breaker Failure Relays	TBI	TBI	TBI
Self-Excited Excitation System	TBI	TBI	TBI
Keylock Hand Switches to Inhibit MSIV Closure	TBI	TBI	TBI
Condensate Pump Trip / Power Run Back	TBI	TBI	TBI
Piping Vibration Monitoring Components	TBI	TBI	TBI
Pipe Supports for Flow Induced Vibration	TBI	TBI	TBI
Automated Generator Hydrogen Make-Up and Monitoring	TBI	TBI	TBI
VFD Heat Exchangers	TBI	TBI	TBI
Condenser Pressure Transmitters	TBI	TBI	TBI
Raw Water Cooling Demineralizer Integrated Flow Diffusers, Septa, and Slow Pressurization	TBI	TBI	TBI
#4 Feedwater Heater Tube Bundle Replacement	TBI	TBI	TBI
Visco-Elastic Dampers for Main Steam System	TBI	TBI	TBI
EHC Software Changes	TBI	TBI	TBI
High Pressure Turbine	TBI	TBI	TBI
Main Steam Line Strain Gauges	TBI	TBI	TBI
Condensate Demineralizer Integrated Flow Diffusers	TBI	TBI	TBI
Replacement Steam Dryer	TBI	TBI	TBI
Rod Worth Minimizer	TBI	TBI	TBI
Generator Hydrogen	TBI	TBI	TBI
Main Steam Line High Flow Instruments	TBI	TBI	TBI
APRM Flow Biased & Setdown Instruments	TBI	TBI	TBI
Recirculation Pump & Motor Uprate	TBI	TBI	TBI
Pass Partition Plate Reinforcements	TBI	TBI	TBI
Turbine First Stage Pressure Setpoints	TBI	TBI	TBI
Raw Cooling Water Piping and Booster Pumps	X	X	TBI
Recirculation Piping Vibration Monitoring Components	X	X	TBI
Reduce Reactor Feedwater Pumps Run-out Flow	X	X	TBI
Generator Uprate	X	TBI	X
Condensate Booster Pumps & Motors	X	X	TBI
5-Ton Crane	X	N/A	N/A
Unit #3 Feedwater Heater Upper Shell Replacement	N/A	X	X
Main Steam & Feedwater Piping Vibration Monitoring	X	X	X
Feedwater Pump Replacement	X	X	X
Feedwater Heater Pass Partition Plates	X	X	X
Feedwater Heater Nozzles/Shell Relief Valves	X	X	X
Steam Seal & Main Steam Instruments	X	X	X
Condensate Pumps & Condensate Booster Pumps Area Ventilation	X	X	X
Torus Attached Piping	N/A	X	X

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Table 18 (continued).

Description	Unit 1	Unit 2	Unit 3
Feedwater Control System	X	X	X
BOP Instrument Respan	X	X	X
SJAE Condenser Condensate Pressure Switches	X	X	X
Condensate Pump Impellers & Motors	X	X	X
Condensate Demineralizer Control Panel Upgrade	X	X	X
Condensate Demineralizer Tie-In	X	X	X
Condensate Demineralizer Isolation Valves	X	X	X
Condensate Demineralizer Vessel Addition	X	X	X
Steam Packing Exhauster Bypass	X	X	X
Main Steam Supports	X	X	X
Condenser Instrumentation	X	X	X
Unit #3 Feedwater Heater Nozzle Relocation	X	X	X
Moisture Separator Internals	X	X	X
Moisture Separator Drain Pump Bypass	X	X	X
Isophase Bus Cooling	X	X	X
MSIV Poppets	X	X	X
Jet Pump Sensing Line Clamps	X	X	X
EHC Software	X	X	X
Feedwater Heater Units 1, 2 & 3 Level Instrumentation	X	X	X
Main Steam Acoustic Vibration Suppressors	X	X	X
Hardened Containment Vent System	X	X	TBI

***TBI-to be implemented; X-fully implemented**

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Appendix A – Documentation of consultation with U.S. Fish and Wildlife Service

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Appendix A-1. Letter 1 from USFWS to NRC which include lists of protected species in the vicinity of BFN for 2016-2017 Extended Power Uprate Project

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Alabama Ecological Services Field Office
1208 B MAIN STREET
DAPHNE, AL 36526
PHONE: (251)441-5181 FAX: (251)441-6222

Consultation Code: 04EA1000-2016-SLI-0106 February 01, 2016
Event Code: 04EA1000-2016-E-00921
Project Name: Browns Ferry Nuclear Plant - Proposed Extended Power Uprate

Subject: Updated list of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

The Alabama Ecological Services Field Office will provide an official species list for projects within the State upon receipt of a project description and map location, received at the following mail address:

US Fish and Wildlife Service

1208 Main Street

Daphne, AL 36526

Note that due to the volume of emails received by our office, we cannot accept project consultation requests by email.

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be

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completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF

Please be aware that bald and golden eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 *et seq.*), and projects affecting these species may require development of an eagle conservation plan (http://www.fws.gov/windenergy/eagle_guidance.html). Additionally, wind energy projects should follow the wind energy guidelines (http://www.fws.gov/windenergy/) for minimizing impacts to migratory birds and bats.

Guidance for minimizing impacts to migratory birds for projects including communications towers (e.g., cellular, digital television, radio, and emergency broadcast) can be found at: http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/towers.htm; http://www.towerkill.com; and http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/comtow.html.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Tracking Number in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

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United States Department of Interior
Fish and Wildlife Service

Project name: Browns Ferry Nuclear Plant - Proposed Extended Power Uprate

Preliminary Species list

Provided by:

Alabama Ecological Services Field Office
1208 B MAIN STREET
DAPHNE, AL 36526
(251) 441-5181

Consultation Code: 04EA1000-2016-SLI-0106
Event Code: 04EA1000-2016-E-00921

Project Type: POWER GENERATION

Project Name: Browns Ferry Nuclear Plant - Proposed Extended Power Uprate
Project Description: NRC is reviewing an application from Tennessee Valley Authority requesting issuance of amendments to the Browns Ferry Nuclear Plant operating licenses that would increase the maximum licensed thermal power level for each of the three reactors to 3,952 MWt (an increase of approximately 14.3 percent above the current licensed thermal power level).

Please Note: The FWS office may have modified the Project Name and/or Project Description, so it may be different from what was submitted in your previous request. If the Consultation Code matches, the FWS considers this to be the same project. Contact the office in the 'Provided by' section of your previous Official Species list if you have any questions or concerns.

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Project Location Map:



Project Coordinates: MULTIPOLYGON (((-87.12755498854676 34.71563762420765, -87.12322439969284 34.71698444781209, -87.12041559250792 34.71666379438044, -87.11862087249756 34.715349066354854, -87.11628026794642 34.7112438914227, -87.11752867646283 34.709640499464925, -87.11386113020126 34.70726728223421, -87.11101326858625 34.70495785452516, -87.10843834793195 34.70351451627673, -87.10761909547728 34.70200694200368, -87.11050600890303 34.69918435476035, -87.11553869216003 34.695239275029394, -87.12673573347274 34.70345030547559, -87.13013377273455 34.70974280732633, -87.13138218125096 34.71447950794253, -87.12755498854676 34.71563762420765)))

Project Counties: Lawrence, AL | Limestone, AL

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Endangered Species Act Species List

There are a total of 31 threatened, endangered, or candidate species on your species list. Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. Critical habitats listed under the **Has Critical Habitat** column may or may not lie within your project area. See the **Critical habitats within your project area** section further below for critical habitat that lies within your project. Please contact the designated FWS office if you have questions.

Amphibians	**Status**	**Has Critical Habitat**	**Condition(s)**
Black Warrior Waterdog *(Necturus alabamensis)*	Candidate		
Clams			
Alabama moccasinshell *(Medionidus acutissimus)*	Threatened	Final designated	
Cracking pearlymussel *(Hemistena lata)* Population: Wherever found; Except where listed as Experimental Populations	Endangered		
Dark pigtoe *(Pleurobema furvum)*	Endangered	Final designated	
fanshell *(Cyprogenia stegaria)*	Endangered		
Littlewing pearlymussel *(Pegias fabula)* Population: Entire	Endangered		
Orangenacre mucket *(Lampsilis perovalis)*	Threatened	Final designated	
Ovate clubshell *(Pleurobema perovatum)*	Endangered	Final designated	

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Pink mucket *(Lampsilis abrupta)* Population: Entire	Endangered		
Rough pigtoe *(Pleurobema plenum)*	Endangered		
Sheepnose Mussel *(Plethobasus cyphyus)*	Endangered		
Snuffbox mussel *(Epioblasma triquetra)*	Endangered		
Spectaclecase (mussel) *(Cumberlandia monodonta)*	Endangered		
Triangular Kidneyshell *(Ptychobranchus greenii)*	Endangered	Final designated	
Ferns and Allies			
Alabama streak-sorus fern *(Thelypteris pilosa var. alabamensis)*	Threatened		
Fishes			
Boulder darter *(Etheostoma wapiti)* Population: Entire	Endangered		
Rush Darter *(Etheostoma phytophilum)* Population: Entire	Endangered	Final designated	
Slackwater darter *(Etheostoma boschungi)* Population: Entire	Threatened	Final designated	
Spring Pygmy sunfish *(Elassoma alabamae)*	Threatened		
Flowering Plants			
Fleshy-fruit gladecress	Endangered	Final designated	

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(Leavenworthia crassa)			
Kral's water-plantain *(Sagittaria secundifolia)*	Threatened		
Leafy prairie-clover *(Dalea foliosa)*	Endangered		
lyrate bladderpod *(Lesquerella lyrata)*	Threatened		
Price's potato-bean *(Apios priceana)*	Threatened		
Mammals			
Gray bat *(Myotis grisescens)* Population: Entire	Endangered		
Indiana bat *(Myotis sodalis)* Population: Entire	Endangered		
Northern long-eared Bat *(Myotis septentrionalis)*	Threatened		
Reptiles			
Flattened Musk turtle *(Sternotherus depressus)* Population: Black Warrior R. system upstream from Bankhead Dam	Threatened		
Snails			
Anthony's riversnail *(Athearnia anthonyi)* Population: Wherever found; Except where listed as Experimental Populations	Endangered		
Armored snail *(Pyrgulopsis (=marstonia) pachyta)* Population: Entire	Endangered		
Slender campeloma *(Campeloma*	Endangered		

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decampi) Population: Entire			

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Critical habitats that lie within your project area

There are no critical habitats within your project area.

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Appendix A-2. Letter 2 from USFWS to NRC which include lists of protected species in the vicinity of BFN for 2016-2017 Extended Power Uprate Project

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Alabama Ecological Services Field Office
1208 B Main Street
Daphne, AL 36526-4419
Phone: (251) 441-5181 Fax: (251) 441-6222

In Reply Refer To: March 30, 2017
Consultation Code: 04EA1000-2017-SLI-0530
Event Code: 04EA1000-2017-E-01836
Project Name: Browns Ferry Nuclear Plant, Units 1, 2, and 3, Extended Power Uprate

Subject: List of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. Please note that new information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.).

Note that due to the volume of emails received by our office, we cannot accept project consultation requests by email.

Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Also note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the process and consultation under the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

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A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF

Please be aware that bald and golden eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 et seq.), and projects affecting these species may require development of an eagle conservation plan (http://www.fws.gov/windenergy/eagle_guidance.html). Additionally, wind energy projects should follow the wind energy guidelines (http://www.fws.gov/windenergy/) for minimizing impacts to migratory birds and bats.

Guidance for minimizing impacts to migratory birds for projects including communications towers (e.g., cellular, digital television, radio, and emergency broadcast) can be found at:

http://www.fws.gov/migratorybirds/pdf/management/usfwscommunicationtowerguidance.pdf

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Tracking Number in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

We can be reached at:

US Fish and Wildlife Service

1208 Main Street

Daphne, AL 36526

Attachment(s):

- Official Species List

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Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Alabama Ecological Services Field Office
1208 B Main Street
Daphne, AL 36526-4419
(251) 441-5181

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Project Summary

Consultation Code: 04EA1000-2017-SLI-0530

Event Code: 04EA1000-2017-E-01836

Project Name: Browns Ferry Nuclear Plant, Units 1, 2, and 3, Extended Power Uprate

Project Type: POWER GENERATION

Project Description: The U.S. Nuclear Regulatory Commission (NRC) is reviewing an application from the Tennessee Valley Authority (TVA) requesting issuance of amendments to the existing Browns Ferry Nuclear Plant operating licenses that would increase the maximum licensed thermal power level for each of the three reactors to 3,952 MWt (an increase of approximately 15 percent above the current licensed thermal power level).

The uprate would require modifications and upgrades to existing balance-of-plant equipment, all of which would occur within industrial areas of the site. No changes to existing onsite land uses or disturbance of any natural areas or habitats are expected. Following the necessary equipment modifications and upgrades, operation of Browns Ferry at the uprate power level would increase the steam flow to the plant's steam turbines, which would in turn increase the amount of waste heat that must be dissipated. TVA would increase the use of its cooling towers to dissipate some of the additional heat. The remaining heat would be discharged to Wheeler Reservoir in accordance with the limitations set forth in TVA's National Pollutant Discharge Elimination System (NPDES) permit. For years with warm summers, TVA predicts that the temperature of water exiting the diffusers and entering Wheeler Reservoir (assuming all three Browns Ferry units are operating at the full uprate power level) would be 2.6 °F (1.4 °C) warmer on average than current operations. The river temperature at the National Pollutant Discharge Elimination System (NPDES) compliance depth at the downstream end of the mixing zone would be 0.6 °F (0.3 °C) warmer on average. TVA predicts that it would operate the cooling towers in helper mode an additional 22 days per year on average (88 days total) and that the most extreme years could result in an additional 39 days per year of cooling tower helper mode operation (121 days total).

The uprate would also require several upgrades to the transmission system and the Browns Ferry main generator excitation system to ensure transmission system stability at EPU power levels. However, TVA (NRC's applicant), as a federal entity, would be responsible for consulting with the U.S. Fish and Wildlife Service separately prior to implementing

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those upgrades because the NRC has no authority over or permitting role related to power transmission systems.

The NRC issued a draft Environmental Assessment related to the proposed uprate on December 1, 2017, in the Federal Register (81 FR 86732).

Project Location:

Approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/place/34.70304044306785N87.111589758369W



Counties: Limestone, AL

Endangered Species Act Species

There is a total of 6 threatened, endangered, or candidate species on your species list. Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area. Please contact the designated FWS office if you have questions.

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Mammals

NAME	STATUS
Gray Bat *(Myotis grisescens)* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/6329	Endangered
Indiana Bat *(Myotis sodalis)* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/5949	Endangered
Northern Long-eared Bat *(Myotis septentrionalis)* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9045	Threatened

Clams

NAME	STATUS
Pink Mucket (pearlymussel) *(Lampsilis abrupta)* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/7829	Endangered
Rough Pigtoe *(Pleurobema plenum)* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/6894	Endangered
Snuffbox Mussel *(Epioblasma triquetra)* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/4135	Endangered

Critical habitats

There are no critical habitats within your project area.

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§ 122.21(r)(9)
Entrainment Characterization Study
for the
Browns Ferry Nuclear Plant



TENNESSEE VALLEY AUTHORITY

River and Reservoir Compliance Monitoring Program

2020

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Revisions from original version (02/16/2021)

Two sample periods were included in the original data analysis that did not occur. This caused some sample volumes to be shifted ahead in time, and therefore, these sample volumes did not match up with corresponding ichthyoplankton collection data. As a result, the following values were inaccurate in the original report:

- Some density values listed in Table 5 and Table 6 and illustrated in Figures 4 through 14,
- Some estimated entrainment values listed in Table 8 and Table 9,
- Some percent entrainment values listed in Table 10, and
- River flow totals for some sample periods.

Additionally, some intake flows listed in Table 7 and Table 12 were inaccurate due to incorrect units of the original data.

Revisions to correct these inaccuracies are outlined below.

- Dates for sample periods 28 and 29 (Aug 29-30 and Sep 5-6, resp.) were mistakenly included in the original report. After omission of these, the total number of sample periods was reduced from 65 to 63. Tables 5, 7, 8, and 9 were revised to reflect this.

- Table 1
  - Three unspecified percid eggs were moved from Year 1 to Year 2.

- Table 5
  - "YR 1 Average Density", "YR 2 Average Density", and "Average Density – Years Combined" were calculated as simple averages by sample period in the original report, which was not consistent with other density calculations. These were recalculated using total numbers and total sample volumes.
  - During sample period 33, no intake samples were collected. However, this was not denoted in the original report with "NS".
  - The general pattern of densities for each family during Year 2 did not change in this table with the omission of sample periods 28 and 29, but was shifted ahead two sample periods. When shifted, sample volumes were slightly different from those used in original report, and therefore, some densities changed slightly.

- Table 6
  - Some densities changed slightly with updated sample volumes.

- Table 7
  - "River Flow ($x10^6$)" during sample periods 27, 28, and 29 were reallocated to reflect omitted sample periods and corresponding data.
  - "CCW Intake Flow ($x10^6$)" during Year 2 were not accurate in the original report. Year 2 intake flow values "On Sample Date" and "Totals for Sample Week/Month" have been

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updated using corrected values. "Percent Water Entrained" values have been updated due to corrected intake flow values.

- Table 8
  - "Numbers Entrained", "Numbers Transported Past BFN", and "Percent Entrainment" were updated using corrected densities, intake flows, and river flows.

- Table 9
  - Estimated annual numbers entrained were updated using corrected densities and intake flows.

- Table 10
  - Percent entrainment by diel period was updated using corrected estimated annual numbers entrained and estimated numbers passing BFN.

- Table 12
  - Total CCW intake flows by month were updated with accurate values.

- Figure 15
  - Year 2 flow during the January sample period was added to the chart. This value was unintentionally omitted in the original report.

These revisions did not change the original conclusion regarding entrainment by the BFN plant: The BFN plant entrains a low percentage of a small portion of the ichthyoplankton of Wheeler Reservoir and is not judged to be a significant adverse impact on the fisheries resources of Wheeler Reservoir.

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Introduction

Section (§) 316(b) of the Clean Water Act provides that the location, design, construction, and capacity of cooling water intake structures (CWIS) reflect the best technology available (BTA) for minimizing adverse environmental impact (i.e., impingement and entrainment of aquatic species). The U.S. Environmental Protection Agency (EPA) issued a final § 316(b) rule effective October 2014 for existing power generating and industrial facilities. Under the rule, the Browns Ferry Nuclear Plant (BFN) facility is required, as an existing facility that withdraws more than 125 million gallons of cooling water per day (actual intake flow), to provide an Entrainment Characterization Study (§ 122.21(r)(9)) that includes a minimum of two years of entrainment data collection and the following components:

- Entrainment Data Collection Method (122.21(r)(9)(i)),
- Biological Entrainment Characterization (122.21(r)(9)(ii)), and
- Analysis and Supporting Documentation (122.21(r)(9)(iii)).

In the document that follows, TVA has included information required of the BFN facility as specified in the § 316(b) rule at § 122.21 under paragraph (r)(9).

Location and General Site Characteristics

Wheeler Reservoir (Tennessee River) is the cooling water source water body for BFN (Figures 1 and 2). The reservoir covers a surface area of 67,070 acres, has a volume of 1.05 million acre-ft, has a hydraulic retention time of 10.7 days, and extends approximately 74 river miles upstream from Wheeler Dam at Tennessee River mile (TRM) 274.9 to Guntersville Dam at TRM 349 (Figure 1). The width of Wheeler Reservoir in the vicinity of BFN ranges from 1 to 1.5 miles (Figure 2) and is relatively shallow, with an average depth of 15 ft and maximum depth of 60 ft. A minimum of 11 feet depth is maintained in a channel for navigation of commercial traffic. Normal summer pool elevation is 556 ft above mean sea level, with a minimum level of 550 ft. Average daily flows of the Tennessee River past BFN are approximately 47,600 cubic feet per

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second (cfs). During the period from February 2018 to December 2019, average daily river flow was approximately 71,200 cfs.

Plant Description

BFN is a three-unit nuclear-fueled facility with a total generating capacity of 3,300 megawatts. Unit One, which remained idle for several years, returned to service June 2007. Current operation utilizes a once-through condenser cooling water (CCW) system, withdrawing water from the Tennessee River through an intake structure at TRM 294.3 and discharging the water through a multi-port diffuser located downstream from the plant at TRM 293.6 (Figure 2). Maximum flow rate of the CCW is approximately 3,171 million gallons per day (TVA 2003a).

Condenser Circulating Water System

Wheeler Reservoir on the Tennessee River is the source for cooling water systems for BFN. The intake forebay is separated from Wheeler Reservoir by a gate structure with three bays that are each 12 m (40 ft) wide by about 7.3 m (24 ft) high (TVA 1972). Each bay includes a 6-m (20-ft)-high gate that can be raised or lowered depending on the operational requirements of the plant. The flow velocity through the openings varies depending on the gate position.

When the gates are in their full open position and the plant is operated in either the "open" or "helper modes", the average flow velocity through the openings is about 0.2 m/s (0.6 fps) for the operation of one unit, 0.34 m/s (1.1 fps) for the operation of two units, and 0.52 m/s (1.7 fps) for the operation of all three units (TVA 2003a). These flow velocities are based on an intake flow per unit of about 734,000 gallons per minute (gpm), which is 46.3 m^3/s or 1,635 cfs.

The intake pumping station includes 18 bays (i.e., six bays per reactor unit), each with a traveling screen. Each bay has a net opening size of about 2.6 m by 6 m (8.5 ft by 20 ft). The maximum average flow velocity through each bay is about 0.49 m/s (1.6 fps) and is independent of the reservoir surface elevation. The maximum average velocity through a clean screen with net openings of 0.95 cm by 0.95 cm (3/8 in. by 3/8 in.) is about 0.64 m/s (2.1 fps) (TVA 2003a).

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Flow velocities through the intake pump station bays and traveling screens are independent of the number of units in operation and the reservoir elevation.

The BFN units are normally cooled by pumping water from Wheeler Reservoir into the turbine generator condensers and discharging it back to the reservoir via three large submerged diffuser pipes that are perforated to maximize uniform mixing into the flow stream. These pipes range in diameter from 5.2 m to 6.2 m (17 ft to 20.5 ft). The flow exits each discharge pipe through 7,800 5-cm (2-in.) ports (TVA 2003b). This straight-through flow path is known as "open cycle" or "open mode" operation. As originally designed, the maximum thermal discharge from the once-through cooling water system is directed into the Wheeler Reservoir, with a temperature increase across the intake and discharge of 13.9°C (25°F) (TVA 1972). The flow exits the diffusers and mixes with the reservoir flow. At the edge of the discharge mixing zone, the water temperature is required to be less than 5.6°C (10°F) above ambient (ADEM 2003).

Through various gates, some of this cooling water can also be directed through cooling towers to reduce its temperature as necessary to comply with environmental regulations. This flow path is known as the "helper mode."

The capacity also exists to recycle cooling water from the cooling towers directly back to the intake structure without being discharged to the reservoir. This flow path, known as the "closed mode" of operation, has not been used since the restart of Units 2 and 3 because of difficulties in achieving temperature limits in summer months and problems with equipment reliability. TVA does not anticipate using this mode in the future, and no procedures for operating in this mode currently exist.

In recent years, only Units 2 and 3 have been operated, but because of a combination of system upgrades and improved flow calibrations, the measured total per-unit condenser, circulating water (CCW) flow rate in open mode (with three CCW water pumps per unit) has increased. The condenser tubes were replaced with stainless steel tubing that has a larger internal diameter and lower flow resistance. This modification increased flow through the condenser by

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approximately 6 percent. TVA estimates total intake for three-unit operation in "open mode" to be 3,171 mgd (139 m^3/s or 4,907 cfs) (TVA 2003a).

Because of various system limitations, BFN cannot pass all the CCW through the cooling towers when operating in the "helper mode". The fraction of cooling water that cannot be passed through the cooling towers is routed directly to the river. Almost all of the cooling water that passes through the cooling towers is returned to the river, but a small amount is lost to the atmosphere during operation. If cooling tower capacity is increased during the license renewal term, this consumptive use could increase proportionately. The cooling towers are only operated when necessary to meet thermal discharge temperature limits specified in the National Pollutant Discharge Elimination System (NPDES) permit issued by the Alabama Department of Environmental Management (ADEM), typically a few weeks during the hottest part of the summer (typically July and August).

The "helper" cooling towers are operated only when necessary to meet thermal discharge temperature limits specified in the NPDES permit, typically a few months during the hottest part of the summer (usually July and August). During a recent 5-year period (2017-2021), helper mode operation was required between approximately 14.5 and 19.7 percent of a year. Increased thermal power proposed for Units 2 and 3 will result in an additional increase of approximately 2.2°C (4°F) in the circulating water temperature leaving the main condenser (for each operating unit) (Hopping 2004). This increase in water discharge temperature would result in increased use of the cooling towers during summer periods to maintain compliance with discharge limitations. No changes to the plant intake system or to the individual unit intake flow rates are expected to be required as a result of the Unit 2 and 3 EPU project, and operations will continue to meet regulatory limits established in the existing NPDES permit.

Entrainment Data Collection Method § 122.21(r)(9)(i)

a.) The study should identify and document the data collection period and frequency.

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Ichthyoplankton sampling was conducted for two years from February 20-21, 2018 through December 17-19, 2019. Samples were collected weekly during February through August (expected period of fish spawning) then monthly from September through January. Samples were collected during day and night at all sampling locations.

Data collection locations for intake and river samples are illustrated in Figure 2. To determine the numbers and taxonomic identity of fish eggs and larvae entrained by the BFN intake, samples were taken immediately outside the CCW intake channel located at TRM 294.3. Samples were also taken from three equidistant locations along a river transect, which was located at TRM 294.5 in Wheeler Reservoir immediately upstream from the CCW intake and perpendicular to the river flow (Figure 2). Collections from the river transect were used to determine the number of fish eggs and larvae available for entrainment.

b.) The study should identify and document organisms collected to the lowest taxon possible of all life stages of fish and shellfish that are in the vicinity of the cooling water intake structure(s) and are susceptible to entrainment, including any organisms identified by the Director, and any species protected under Federal, State, or Tribal law, including threatened or endangered species with a habitat range that includes waters in the vicinity of the cooling water intake structure.

Fish eggs and larvae were identified to the lowest possible taxon, counted and measured (larvae) to the nearest millimeter total length following procedures outlined in TVA's Quality Assurance/ Quality Control Program procedure for Ichthyoplankton Sample Processing (TVA 2010a; Appendix A). Taxonomic decisions were based on TVA's identification guide for larval fishes in the Tennessee River (Hogue et al. 1976) and other pertinent literature (Wallus et al. 1990; Kay et al. 1994; Simon and Wallus 2003; Simon and Wallus 2006; Wallus and Simon 2006; and Wallus and Simon 2008).

Some specimens could not be identified to species. The term "unidentifiable fish larvae" applies to specimens too damaged or mutilated to identify, while "unspecified" before a taxon implies a level of taxonomic resolution (e.g., "unspecified clupeids" designates larvae within the family Clupeidae that cannot be identified to a lower taxon). The category "unidentifiable fish eggs"

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applies to specimens that cannot be identified due to damage or lack of taxonomic knowledge. Taxonomic refinement is a function of specimen size and developmental stage.

No entrainable shellfish occur in the vicinity of the BFN intake; therefore, this study is limited to entrainable life stages of fish. Table 1 lists numbers and taxa of fish eggs and larvae collected in the vicinity of the BFN cooling water intake structure (CWIS) located at Tennessee River mile 294.3 (Figure 2) during the two-year Entrainment Characterization Study (ECS). Fish eggs and larvae comprised twelve families—Clupeidae, Moronidae, Centrarchidae, Atherinopsidae, Sciaenidae, Cyprinidae, Catostomidae, Percidae, Ictaluridae, Fundulidae, and Poeciliidae; the remaining fish eggs and larvae were unidentifiable.

No species were collected that are currently protected under Federal, State, or Tribal law, or threatened or endangered with a habitat range that includes waters in the vicinity of the BFN CWIS. The following is discussed in § 122.21(r)(4). The TVA's Regional Natural Heritage Database (queried 19 October 2020) indicated records of thirty aquatic species that currently occur or historically occurred within a ten-mile radius of BFN (Table 2), which included nine mussels federally listed as endangered (crackling pearlymussel, Cumberlandian combshell, dromedary pearlymussel, fluter kidneyshell, lilliput, pink papershell, rough pigtoe, spectaclecase, and tuberculed blossom pearlymussel) and two snails (round-rib Elimia and warty rocksnail); one fish as threatened (spring pygmy sunfish); and eight fishes, one salamander, five mussels, and two snails tracked or listed at only the state level (bigeye chub, flame chub, paddlefish, redline darter, silver redhorse, southern cavefish, stargazing minnow, Tuscumbia darter, hellbender, acornshell, Ohio pigtoe, pink mucket, purple lilliput, ring pink, skirted hornsnail, and slender campeloma). TVA also queried the Alabama Department of Conservation and Natural Resources (ADCNR) internet resource page that included listed species reports; however, these query results are by state and therefore likely includes species that do not occur near BFN. In addition to the aforementioned species, the ADCNR website lists nineteen additional federally listed species—lake sturgeon, shovelnose sturgeon, slackwater darter, boulder darter, fanshell, oyster mussel, fine-rayed pigtoe, littlewing pearlymussel, orangefoot pimpleback, sheepnose mussel, round pigtoe, pyramid pigtoe, slabside pearlymussel, rabbitsfoot, Cumberland monkeyface, pale lilliput, armored snail and Anthony's river snail.

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One mussel species (birdwing pearlymussel) is considered extirpated and one (white heelsplitter) is based on historical (> 25 years old) or possibly historical records (Table 2). In collections by TVA during the twenty-one years (since 1993) of sampling in the vicinity of BFN, four fish species, of the thirteen federally or state-listed species, have been collected by TVA. Paddlefish (2019), lake sturgeon (2019), and bigeye chub (2006) have been collected during only one year and silver redhorse during most (17 of 21) years. Given that shovelnose sturgeon is likely extirpated from Alabama and the other eight species utilize habitat different from that found in Wheeler Reservoir, it is unlikely these nine species still occur in Wheeler Reservoir.

Additionally, TVA queried the U.S. Fish and Wildlife Service (USFWS) Environmental Conservation Online System (ECOS) and the USFWS Information for Planning and Consultation (IPAC) (queried 19 October 2020) to supplement information on rare aquatic species and designated potentially occurring near BFN. The ECOS and IPAC systems utilize known federally listed species by county. These data inherently search broader areas than the TVA Database queries and, consequently, listed additional federally listed species as potentially occurring near the BFN project (Table 2). While TVA recognizes these additional species may occur or have occurred in Limestone County, Alabama, we have determined that they would not be affected by BFN since they are either no longer occurring in the Tennessee River near BFN or occur in habitats outside of the affected BFN project area within Limestone County.

The ECOS system showed designated critical habitat for the federally threatened fluted kidneyshell and slabside pearlymussel in the vicinity of the BFN CWIS's area of hydraulic influence. Critical habitat includes specific areas (occupied or unoccupied by the species) on which are found physical or biological features essential to the conservation of the species (constituent elements) and may require special management. The constituent elements for the fluted kidneyshell and slabside pearlymussel critical habitat include: geomorphically stable river channels and banks; a hydrologic flow regime necessary to maintain benthic habitats where the species is found; water and sediment quality necessary to sustain natural physiological processes; the presence and abundance of fish hosts; and either little or no competitive or predaceous invasive species.

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c.) Biological data collection must be representative of the entrainment at the intakes

The fish eggs and larvae collected were representative of entrainment at the BFN intake. To support this, entrainment data collected during the two-year ECS was compared to data collected by TVA at the BFN intake during the periods, (1971-1979 and 2008-2009) (TVA 1978; TVA 1980; TVA 2012). Eleven of 16 families (Esocidae, Hiodontidae, Lepisosteidae, Polyodontidae and Petromyzontidae were not) collected during the previous ichthyoplankton monitoring in 1971-1979 and 2008-2009 were collected during 2018 and 2019. Relative abundances of the five families not collected in 2018 and 2019 were low (trace amounts). Numbers of total (distinct) ichthyoplankton taxa collected in intake and river samples were similar among years, ranging from 9 to 12 taxa. During all years historical and present, larval collections in intake samples were dominated (greater or equal to 74%) by Clupeidae (Table 3).

Additionally, the methods used to collect and analyze ichthyoplankton samples during the two-year study were representative of entrainment in that methods were similar to those used in the historical monitoring. The method differences between the two studies are discussed below. This section provides an overview of the sampling methods used during monitoring, while more detailed procedures are outlined in TVA's Quality Assurance/ Quality Control Program procedure for Ichthyoplankton Sample Collection (TVA 2010b; Appendix B).

During February 2018 through December 2019, samples were taken with a beam net (0.75 m circular, 3.75 m long, with 363-micron "nitex" mesh netting) towed into the current at a speed of 1.0 m/s to filter approximately 150 m^3 of water per sample. The volume of water filtered through the net was measured with a large-vaned General Oceanics Inc.® flowmeter suspended in the mouth of the net. Using a net with diameter of 0.75 m, flowmeter counts of approximately 12,500 (Appendix B) resulted in the target volume of 150 m^3. Sample volume was calculated using the equation:

$$Volume\ (m^3) = \left(\frac{3.14(Net\ Diameter^2)}{4}\right)x\left(\frac{26{,}873(Difference\ in\ Start\ and\ End\ Counts)}{999{,}999}\right).$$

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TVA was not able to collect ichthyoplankton inside the BFN intake channel (Figure 2) due to security reasons. TVA believes the sample locations, schedule, and use of full-stratum tows as discussed below allowed the most representative sample collection spatially and temporally.

At the intake, six net samples were taken on each sampling period, three each day and night, by towing the net immediately in front of and away from the skimmer wall (Figure 2). Intake samples were collected from the depth of the skimmer wall opening. The duplicate net samples were combined to yield one day and one night sample. At the river transect, one net sample was taken at each of the four stations in the day and at night (8 samples). Full-stratum samples were taken at either shoreline and at a mid-channel station; two samples were taken from the mid-channel station, one from river bottom to mid-depth and one from mid-depth to surface. The full-depth stratum was sampled by lowering the net to the river bottom and raising it in equally timed increments to mid-depth, and lowering to mid-depth and raising to surface, while propelling the boat at a speed of 1.0 m/s for approximately 10 minutes or until 150 m^3 of water was filtered (sections 5.4.3 through 5.4.12 of Appendix A).

To ensure sample collections were not biased towards a particular day and/or night period, sampling events were alternated weekly between four six-hour periods—two day (06:00–12:00; 12:00–18:00) and two night (18:00–0:00; 0:00–06:00). For example, during one week the day samples would be collected in the period 06:00–12:00, and the next week 12:00–18:00.

Method Differences between Studies

In the historical studies, stationary intake samples were collected behind the skimmer wall in the CCW intake channel. Due to security reasons, sampling during the current study was not allowed within the intake channel. Therefore, sampling was conducted immediately outside of the skimmer wall. Given the restrictions, this was deemed as the location most representative of entrainment at the BFN intake.

Another method difference was the size of net frame and mesh used. As stated above, the two years of monitoring used a 0.75-m circular beam net with a 363-micron "nitex" mesh netting, compared to a 0.5-m square beam net with a 790-micron mesh in the historical monitoring. To

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account for the different net frame size, the duration of each sampling effort in the current monitoring was adjusted so that 150 m^3 of water was filtered. It is assumed the smaller mesh size used in the current monitoring (363 microns) did not allow capture of any additional taxa collected or numbers because both mesh sizes were fine enough to capture the eggs and larvae of all fishes likely to be encountered at BFN.

d.) The owner or operator of the facility must identify and document how the location of the cooling water intake structure in the waterbody and the water column are accounted for by the data collection locations

Locations for data collections were selected to represent likely entrainment in the intake structure and organisms in the river/reservoir passing the facility (Figure 2). To determine the numbers and taxonomic identity of fish eggs and larvae entrained by the BFN intake, samples were taken within the BFN CWIS's area of influence immediately outside the intake channel located at TRM 293.2. Samples were also taken from three equidistant locations [near right descending bank (RDB), mid-channel] along a river transect, which was located at TRM 293.4 in Wheeler Reservoir (Tennessee River) immediately upstream from the CCW intake and perpendicular to the river flow (Figure 2). Collections from the river transect were used to determine the number of fish eggs and larvae available for entrainment. This will provide information relative to § 125.98(f)(3)(i) on impacts of entrainment on the waterbody that is one of the factors the ACDNR may consider in making the entrainment BTA determination.

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Biological Entrainment Characterization § 122.21(r)(9)(ii)

a.) Characterization of all life stages of fish, shellfish, and any species protected under Federal, State, or Tribal law (including threatened or endangered species), including a description of their abundance and their temporal and spatial characteristics in the vicinity of the cooling water intake structure(s), based on sufficient data to characterize annual, seasonal, and diel variations in entrainment, including but not limited to variations related to climate and weather differences, spawning, feeding, and water column migration. This characterization may include historical data that are representative of the current operation of the facility and of biological conditions at the site. Identification of all life stages of fish and shellfish must include identification of any surrogate species used, and identification of data representing both motile and non-motile life-stages of organisms;

The families, life stages and abundance of organisms sampled in the two-year entrainment characterization study (ECS) are presented in several tables. Table 1 lists by location and diel period numbers and relative abundance of fish eggs and larvae collected in the vicinity of the BFN intake. Table 4 lists relative abundance by family and location (intake/river). Average densities (number per 1,000 m^3) of families collected are listed in Tables 5 (by sample period) and 6 (by diel period and location). This characterization includes recent data from this two-year study rather than historical data, and is therefore representative of the current operation of BFN and of biological conditions at the site. No surrogate species were used.

Eggs and larvae were collected between February and September during 2018 and February and August during 2019. Percidae, Moronidae, and Catostomidae larvae were the first taxa to be collected during both years (Figure 3).

Fish Egg and Larval Densities

Fish Eggs

Totals of 2,758 and 6,076 fish eggs were collected from the intake and river transects combined during Years 1 and 2, respectively (Table 1). Of these totals, 796 fish eggs (28.9%) were collected in intake samples during Year 1 and 1,879 (30.9%) during Year 2. Fish eggs comprised five families (Sciaenidae, Cyprinidae, Clupeidae, Atherinopsidae, and Moronidae) during Year 1 and three families (Sciaenidae, Clupeidae, and Percidae) during Year 2. Total fish eggs collected in intake samples for both years combined were dominated by freshwater drum at 93.9% and clupeids at 5.8% (Table 4).

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Densities of fish eggs in both intake and river samples peaked in late May during Year 1. During Year 2, intake densities peaked during early May and river densities during late May (Table 5). During the first year, the highest density recorded in intake samples was 553/1,000 m^3 and in river samples was 823/1,000 m^3, both during May 28-30. Peak fish egg densities during the second year occurred three weeks earlier in intake samples (1,485/ 1,000 m^3; May 8-9) than river samples (2,486/ 1,000 m^3; May 28-30). The duration and timing of fish egg collection in intake samples was longer the first year (20 sample periods from April 10-11 to August 23-24) than the second year (12 sample periods from March 26-28 to June 11-13) (Figure 4; Table 5).

When comparing between diel periods and collection locations, average fish egg densities were highly similar between day and night time in both intake and reservoir samples during Year 1. During Year 2, fish eggs densities were higher during night than day in both intake and river samples. At stations along the river transect, fish egg densities (mostly freshwater drum) tended to be lowest along the RDB (right descending bank) and highest at the mid-channel station during both years (Table 6).

Water temperatures when fish egg collections began were slightly higher during Year 1 (59°F) than Year 2 (56°F). At peak fish egg densities, water temperatures were 79°F during the first year and 74°F and 84°F during the two peaks of the second year (Figure 4; Table 7).

Fish Larvae

Total area-combined numbers of fish larvae collected were lower during the first year (69,861) than second (85,748). However, total distinct taxa were similar between years—26 during Year 1 and 20 during Year 2 (Table 1). Fish larvae comprised eleven families during the first year including Clupeidae, Atherinopsidae, Moronidae, Centrarchidae, Sciaenidae, Cyprinidae, Catostomidae, Percidae, Ictaluridae, Fundulidae, and Poeciliidae; and nine the second year (aforementioned, less Fundulidae and Poeciliidae). Clupeidae larvae were the most abundant taxon collected during both years, making up 87.6% of the combined sample, followed by Moronidae at 7.2%, Atherinopsidae at 1.4%, Centrarchidae at 1.4%, and Sciaenidae at 1.2%. All

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other families (Cyprinidae, Catostomidae, Percidae, Ictaluridae, Fundulidae, and Poeciliidae) were represented by less than one percent of the total sample for both years combined (Table 4).

Durations of fish larvae collections were longer during the first year (late February to late September) than the second (mid-March to mid-August; Table 4). Larval percids and moronids were the earliest taxa collected during both years (Figure 5; Table 5). Densities of total fish larvae during Year 1 peaked twice in intake samples, once during the May 16 sample period and another two weeks later during May 28-30. Average densities of the two peaks were 13,182/1,000 m^3 and 13,440/1,000 m^3. Average densities in the river samples peaked at 14,296/1,000 m^3 during the May 22-23 sample period when the water temperature was 81°F. During Year 2, peak densities in both intake (9,791/1,000 m^3) and river (11,987/1,000 m^3) samples were slightly less than Year 1, and occurred during the May 28-30 sample period when water temperatures were 84°F (Figure 5; Tables 5 and 7).

Average larval densities were similar between intake and river samples during both years, but were slightly higher at both locations during Year 2. In intake samples during Year 2, night time densities were higher than day time; no other diel differences were observed. Along the river transect, average densities were generally highest at the shoreline stations (Table 6). This was to be expected given that river samples consisted mostly of clupeids which utilize shallower overbank areas for spawning.

Clupeidae

Larval clupeids comprised four taxa during both years—skipjack herring, gizzard shad, threadfin shad, and unspecified clupeids (Table 1). Total collections were dominated by clupeids during both years, making up a slightly higher proportion of the total sample during the first year (91.6%) than the second (84.4%) (Table 4). In the first year, clupeid larvae were first collected during mid-April when the water temperature was 59°F, and during late March the second year when the water temperature was 56°F. Collections spanned roughly four months (20 sample periods) during both years and continued through late September during Year 1 and August during Year 2. Intake densities peaked twice and river samples once during May of both years when water temperatures ranged from 71 to 84°F (Figure 6; Table 7). Average densities of

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larval clupeids were similar between intake and river samples during both years, and with the exception of intake samples during Year 2, were generally similar between diel periods. Higher densities of clupeid larvae at the two shoreline stations (primarily the right descending bank; Table 6) indicated greater spawning activity in the shallower (overbank) areas of the river.

Moronidae

Larval moronid taxa were made up of white bass, yellow bass, and primarily unspecified moronids (Table 1). Moronids composed a higher proportion during Year 2 (11.6%) than Year 1 (1.7%). Proportions were similar between intake and river samples during the first year but were higher in intake samples during the second year (Table 4). Larval moronid collections began in late February during the first year and late March the second year, continuing for 10 to 14 sample periods through late May/ early June. Peak moronid densities in intake and river samples during the first year occurred in mid-April. Densities were higher the second year, peaking about ten times higher than the highest first year densities. Peaks during the second year were observed in April. During both years, moronid spawning began when water temperatures were 56 to 58°F, with peaks occurring at water temperatures of 59 to 65°F (Figure 7; Tables 5 and 7).

Average moronid densities were higher in intake samples during both years, but more so during the second year. When compared among stations along the river transect, the right descending bank showed highest densities (Table 6). Based on these data, most moronid spawning activity in the vicinity of the BFN intake was likely occurring along the right descending bank upstream of the intake and the river transect.

Centrarchidae

Larval centrarchid composition was similar between years at 1.6% and 1.2% (Table 4), and were composed of three taxa—unspecified *Lepomis* spp., unspecified *Micropterus* spp., and unspecified *Pomoxis* spp. Centrarchid larvae were first collected in mid- to late March, when water temperatures were 51-56°F, and continued for approximately 21 sample periods through late August during both years. Peak densities were recorded in early August during Year 1 and early June during Year 2 (Figure 8; Tables 5 and 7). Average densities between intake and river samples and between diel periods were similar during both years. Centrarchid densities were

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consistently highest at the station nearest the right descending bank, indicating higher spawning activity along the right shoreline (Table 6).

Atherinopsidae

Larval atherinopsid (silverside) taxa were made up of the non-indigenous Mississippi silverside and unspecified atherinopsids (Table 1). Atherinopsids composed similar proportions between Year 1 and Year 2 at 2.4% and 0.7%, respectively (Table 4). Collections started in April during both years, continuing into August the first year and July the second. Peak densities occurred during late May during both years when temperatures ranged from 79 to 84°F (Figure 9; Table 5 and 7). No trends were observed between locations and diel periods (Table 6).

Incidental Families Collected

Larvae representing eight additional families—Sciaenidae (Figure 10), Catostomidae (Figure 11), Cyprinidae (Figure 12), Percidae (Figure 13), Ictaluridae (Figure 14), Fundulidae, and Poeciliidae—were collected, all comprising less than one percent of the total catch during both years (Tables 1 and 4).

Hydraulic Entrainment

In this context, hydraulic entrainment is the proportion of BFN withdrawal flow to total flow past the plant. River flows past BFN were obtained from TVA's Reservoir Operations database and CCW intake flow data from the BFN plant.

Hydraulic entrainment by BFN during the 31 sampling periods of Year 1 (February 20-21 to December 27-28, 2018) averaged 9.6% with a range of 1.2 to 18.1%. Peak hydraulic entrainment occurred during the sample period of July 18-19, when river flow was low. The lowest hydraulic entrainment was recorded during the first and second sample periods of February 20-21 and February 27 when weekly total river flow was highest at ~540 and 722 x 10^6 m^3/ day, respectively (Figure 15; Table 7).

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During Year 2, annual total river flow past BFN and mean flow were similar to those of Year 1, resulting in a similar annual hydraulic entrainment rate (10.3%) to that of Year 1. The range of percent entrainment during Year 2 was similar to that of Year 1 at 1.3 to 20.5% (Figure 15; Table 7).

Entrainment Relative to River Densities

Estimated annual numbers of eggs and larvae entrained at BFN were low compared to river transport (Table 8) and had similar family composition (Tables 9 and 10). Annual entrainment for the two-year study was 6.4% for fish eggs and 10.6% for fish larvae, based on estimates of transported populations (past BFN) of approximately 4.8 billion fish eggs and 57.1 billion fish larvae and total entrainment at the BFN CWIS of approximately 0.2 billion fish eggs and 6.0 billion fish larvae (Tables 8 and 9).

The total annual percent of all taxa of fish eggs and larvae in the river that were entrained at BFN's CCW intake is presented by diel period in Table 10, and was similar between day (fish eggs 1.8%; larvae 4.2%) and night time (fish eggs 4.2%; larvae 6.6%) during both years combined.

Conclusions

The two years of sampling results demonstrate variability in the occurrence and spatial-temporal distribution of larval fish in Wheeler Reservoir near BFN. This variability can translate into significant fluctuation in the entrainment rates associated with plant operation. Factors contributing to these fluctuations include:

- Proximity of intake to spawning and nursery areas, which differs from the river as a whole
- Seasonality and period of occurrence
- Vertical distribution/movement
- Cross-sectional or horizontal distribution
- Diel distribution

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- Life-stage/swimming ability
- Growth rate
- Physical parameters and operation of Wheeler Reservoir in the vicinity of BFN

In calculating entrainment estimates, one or two species usually comprise a high percentage of the total composition, as is the case with clupeids (mostly shad) and freshwater drum eggs in the vicinity of BFN. Freshwater drum spawn in open water while clupeids spawn near shore, and each female can produce thousands of eggs, creating areas in the river with high densities of fish eggs and early larvae. As these high-density pulses of eggs and larvae drift downstream, their occurrence within a sampling area (either near the plant intake or in the open river) may significantly affect individual entrainment estimates. Entrainment data demonstrate annual variations in the relative abundance and spatial-temporal distribution of fish and fluctuations in river flow are common in the vicinity of BFN. Life history aspects and dynamics of drifting larvae and fluctuation in river flow past BFN are significant factors influencing variations observed in the annual entrainment estimates.

The BFN plant is estimated to entrain a low percentage of the larval fish population transported past the site (Table 8). This entrainment affects only a small portion of the river since larvae spawned below the plant are not exposed to entrainment and many of those spawned above the plant become nonplanktonic before reaching the plant intake. Hence, the BFN plant entrains a low percentage of a small portion of the ichthyoplankton of Wheeler Reservoir. For this reason, entrainment of fish eggs and larvae by BFN is not judged to be a significant adverse impact on the fisheries resources of Wheeler Reservoir.

Summary of Head Capsule Measurements

For comparative analyses of alternative intake screening technologies [r(10)], it is necessary to know the sizes of larvae that would be prevented from passing through a screen's mesh size. Head capsules are generally the firmest part of a fish larva and the most useful body part for estimating passage through, or retention by, the screen. Summary statistics (mean, maximum, minimum, and median dimensions) and standard deviations of each taxon measured are listed in

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Table 11. Using the March 2015 through September 2015 dataset, a total of 1,762 larvae representing 25 taxa was measured. Freshwater drum larvae were collected most often (21 sample periods) followed by clupeids (13) and *Lepomis* larvae (9). Threadfin shad were the largest larvae measured with a mean TL of 28.0 mm, and freshwater drum and *Morone* (not striped bass) the smallest with mean TLs of 4.4 mm. Mean HD ranged from 0.6 to 5.1 mm; the range of HW was not as large, spanning from 0.6 to 3.4 mm (Table 11)

Analysis and Supporting Documentation § 122.21(r)(9)(iii)

a.) Documentation of the current entrainment of all life stages of fish, shellfish, and any species protected under Federal, State, or Tribal law (including threatened or endangered species). The documentation may include historical data that are representative of the current operation of the facility and of biological conditions at the site.

Documentation of the current entrainment of all life stages of fish and shellfish at the BFN intake is presented above. The entrainment data presented in this document are representative of the current operation of the facility and of biological conditions at the site. No fish species collected in entrainment samples at the BFN intake are currently protected under Federal, State, or Tribal law (including threatened or endangered species).

b.) Entrainment data to support the facility's calculations must be collected during periods of representative operational flows for the cooling water intake structure, and the flows associated with the data collection must be documented.

Flows associated with the BFN cooling water intake structure for each sample period from February 2018 to December 2019 are presented in Table 7. Using an Analysis of Variance (ANOVA) test, average monthly intake flows observed during the study (2018 and 2019) were not significantly different (P=0.25) to monthly averages of those observed during the previous four years (2014–2017) of BFN operation (Table 12), and therefore, are representative of BFN operation. During both years, entrainment samples were collected weekly during February through August (expected period of fish spawning) then monthly from September through January (December during the second year). Samples were collected during day and night at all

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sampling locations. Therefore, entrainment data were collected during diel, seasonal, and annual periods representative of operational flows.

c.) The method used to determine latent mortality along with data for specific organism mortality or survival that is applied to other life-stages or species must be identified.

For the purposes of satisfying the requirements of § 122.21(r)(9), TVA has assumed 100% mortality of all fish eggs and larvae that enter the plant; therefore, no method for latent mortality identification was used.

d.) The owner or operator of the facility must identify and document all assumptions and calculations used to determine the total entrainment for that facility together with all methods and quality assurance/quality control procedures for data collection and data analysis. The proposed data collection and data analysis methods must be appropriate for a quantitative survey.

Methods and Assumptions for Data Collection

Ichthyoplankton data collection and sample processing were conducted by following the detailed procedures and quality control criteria outlined in TVA's Quality Assurance/ Quality Control Program procedures for Ichthyoplankton Sample Collection and Ichthyoplankton Sample Processing (TVA 2010a and 2010b; Appendices A and B). The collection method involved oblique towing of a 0.75-m circular beam net through vertically integrated strata at approximately 1.0 m/s for approximately 7 minutes (or enough time to sample approximately 150 m^3 of water) to sample spatial distributions of ichthyoplankton. The procedure, developed by TVA personnel, is recognized by other biologists as a fully adequate sampling method for the types of large rivers, reservoirs and habitats found in the Tennessee River Valley. The 0.75-m circular beam net was towed and sampling procedures adopted so that habitats would be sampled consistently, yielding more comparable and readily interpretable data. Advantages of these collection methods include ability to sample all open water and near shoreline habitats, vertical integration of the entire water column, no net harness turbulence, high filtration efficiency, and control of sampling speed (Appendix B). Since sampling could not be conducted in the intake channel, it was assumed that, at the collection location immediately outside the skimmer wall, all collected species would have been entrained.

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Methods and Assumptions for Calculation of Entrainment Estimates

Taxa-specific fish egg and larvae entrainment estimates were calculated for each week/month of sampling. These estimates were based upon the average densities of each taxon collected in intake and river samples, which were calculated from the intake and river samples collected during each sample period (weekly during February through August and monthly September through January). It is assumed that filtering 150 m^3 of water per sample was adequate to determine representative densities. Density was expressed as numbers per 1,000 m^3 and was calculated by dividing the number of each taxon collected in a sample by the volume of water filtered through the sampling net for that particular sample.

$$Density = \frac{1{,}000(Number\ fish\ eggs\ or\ larvae\ collected)}{Sample\ volume}$$

Entrainment estimates for sample weeks or months were calculated by multiplying a taxon's density in intake samples during a given sample period by the total volume of water withdrawn by BFN CCW intake for that particular week (daily flow summed for 7 days) or month (daily flow summed for number of days in the month). Daily CCW intake flows were provided by the BFN facility. Weekly or monthly estimates of fish eggs and larvae available for entrainment were calculated in the same manner, except using densities in river samples and weekly or monthly total river flow past BFN. Daily river flows were obtained from TVA's Reservoir Operations database and summed for each sample week/month. Estimated numbers entrained or available for entrainment were calculated using the formula:

$$Estimated\ numbers\ entrained\ or\ available\ for\ entrainment = \frac{\sum Density\ x\ Flow}{1{,}000}$$

Weekly and monthly estimates were based on the assumption that the density based on one sample per week or month is representative for that particular sample week/month (i.e., density on sample date is used for remaining days of sample week/month). These extrapolations to large numbers from small densities are justified. The estimated weekly or monthly entrainment for each taxon was then summed for the entire sample year to determine estimated annual numbers of fish entrained and available for entrainment.

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The percent of fish eggs and larvae in the river that were entrained at BFN CCW intake during a sample week or month was estimated using the formula:

$$Percent\ entrainment = \frac{100(Estimated\ numbers\ entrained)}{(Estimated\ numbers\ available\ for\ entrainment)}$$

The annual percent of total fish eggs and larvae entrained was determined using the above formula with annual totals of numbers entrained and numbers available for entrainment.

Head Capsule Measurements

Head capsules of fish larvae were measured in this study in order to estimate passage through different mesh screen dimensions of modified traveling screen to support analysis of § 122.21(r)(10). Estimates were based on the taxonomic composition and measured length distributions of larvae collected during the entrainment monitoring conducted at Sequoyah Nuclear Plant (Tennessee River) from March 2015 through September 2015. Up to thirty (30) individuals of each taxa per sample period were measured with the assumption that this number was representative of sizes present in each week of sampling. Measurements of total length (TL), head depth (HD), and head width (HW) were recorded for each individual using a microscope equipped with an ocular micrometer. Measurements were taken to the nearest 0.1 mm.

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Figures

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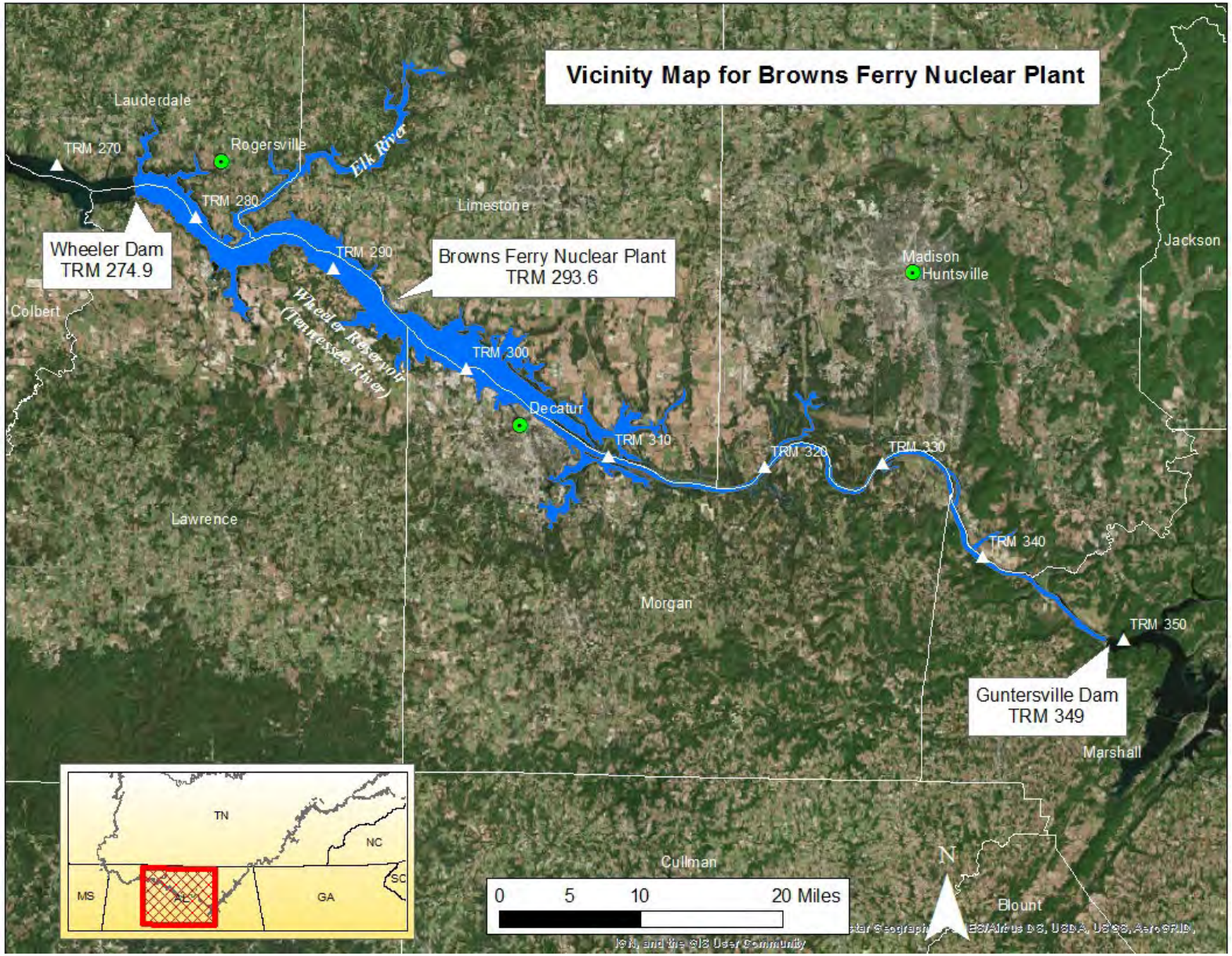
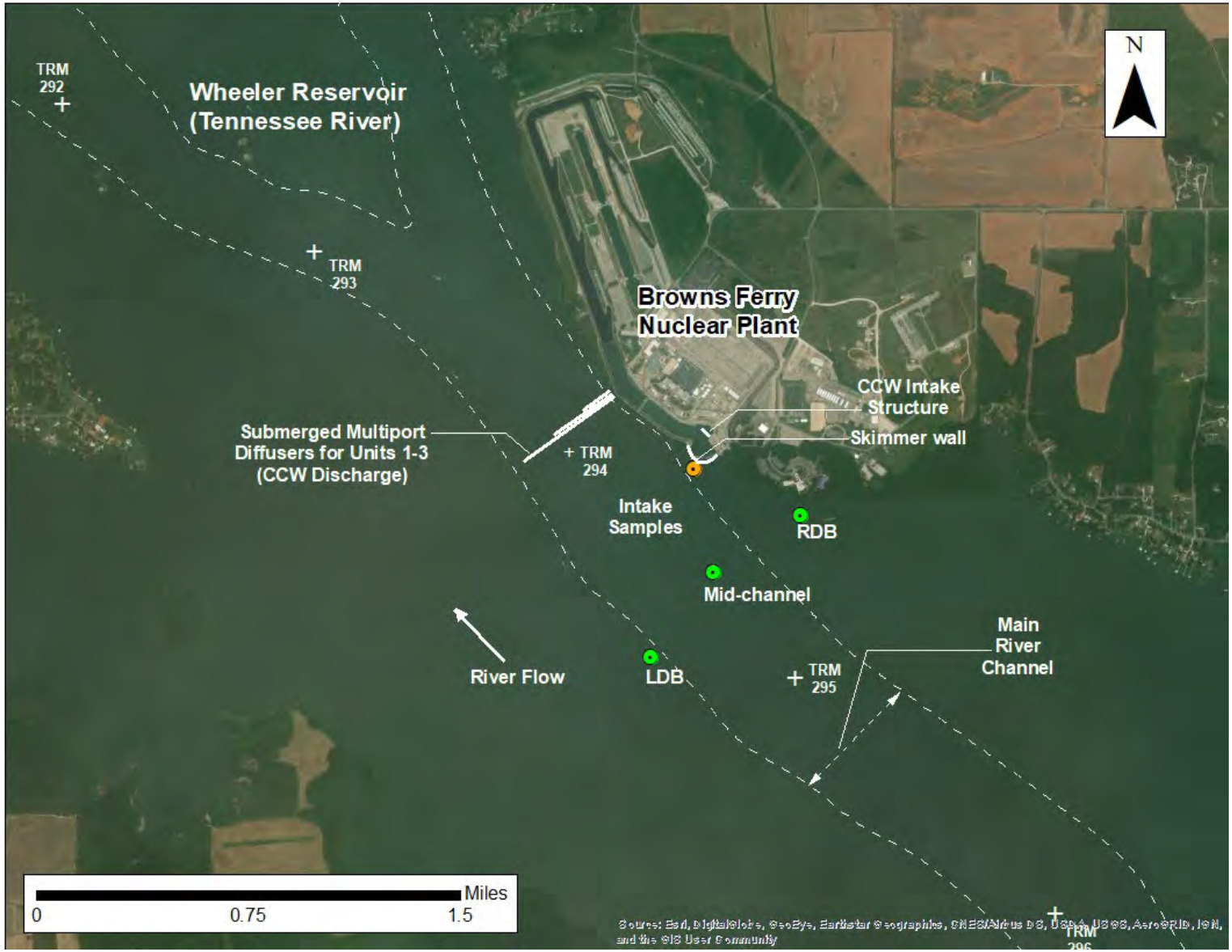


Figure 1. Location of Browns Ferry Nuclear Plant on Wheeler Reservoir of the Tennessee River, depicting location of dams upstream (Guntersville Dam) and downstream (Wheeler Dam) from the plant

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*RDB-right descending bank; LDB-left descending bank; TRM-Tennessee River mile

Figure 2. Ichthyoplankton sampling locations (intake and river transects) at Browns Ferry Nuclear Plant, showing skimmer wall, condenser cooling water (CCW) intake structure, and submerged multiport diffusers (CCW discharge)

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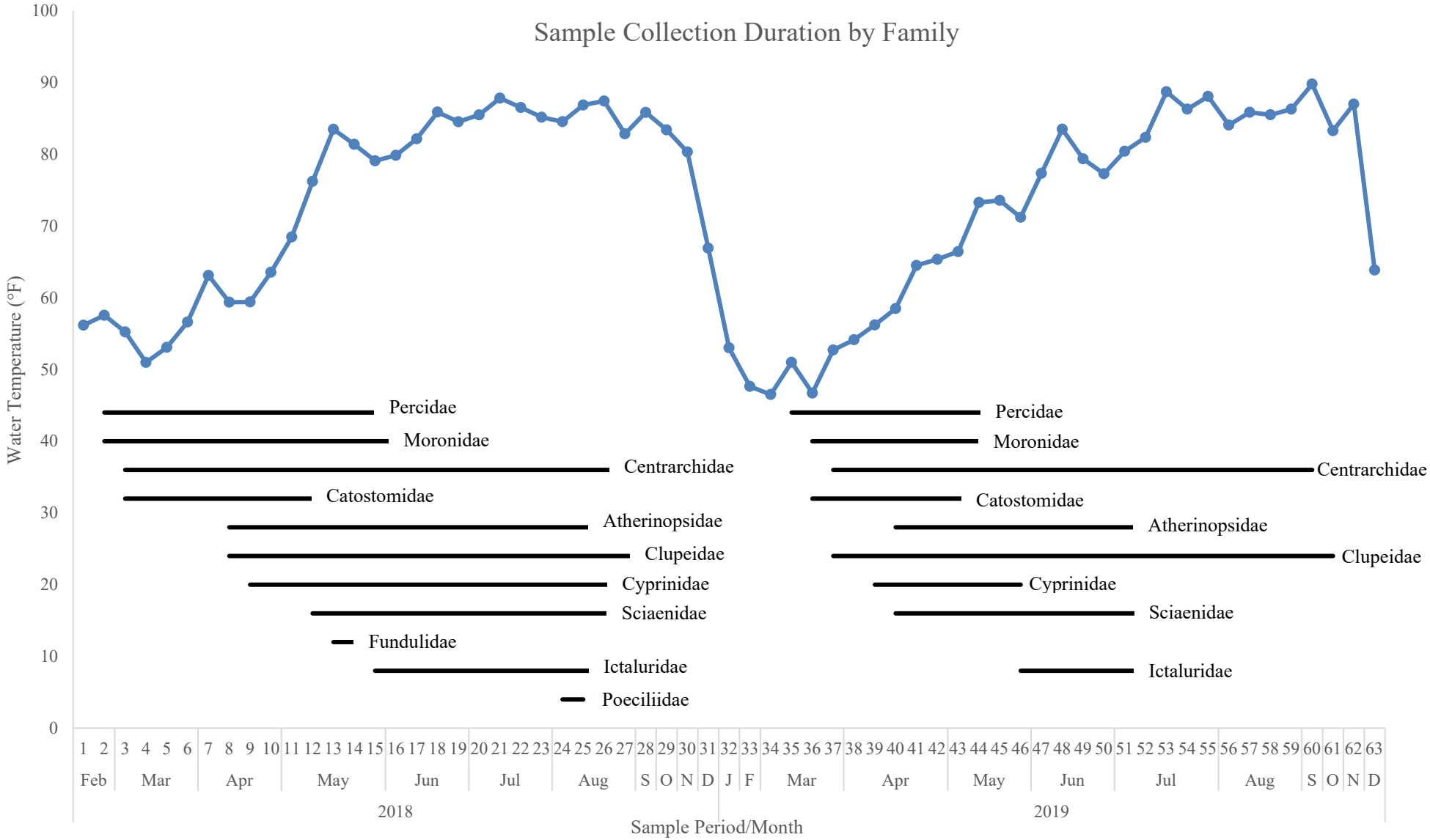


Figure 3. Occurrence of fish eggs and larvae by family collected at intake (outside skimmer wall) and river (TRM 294.5) transects near Browns Ferry Nuclear Plant from February 2018 to January 2019 (Year 1) and February 2019 to December 2019 (Year 2)

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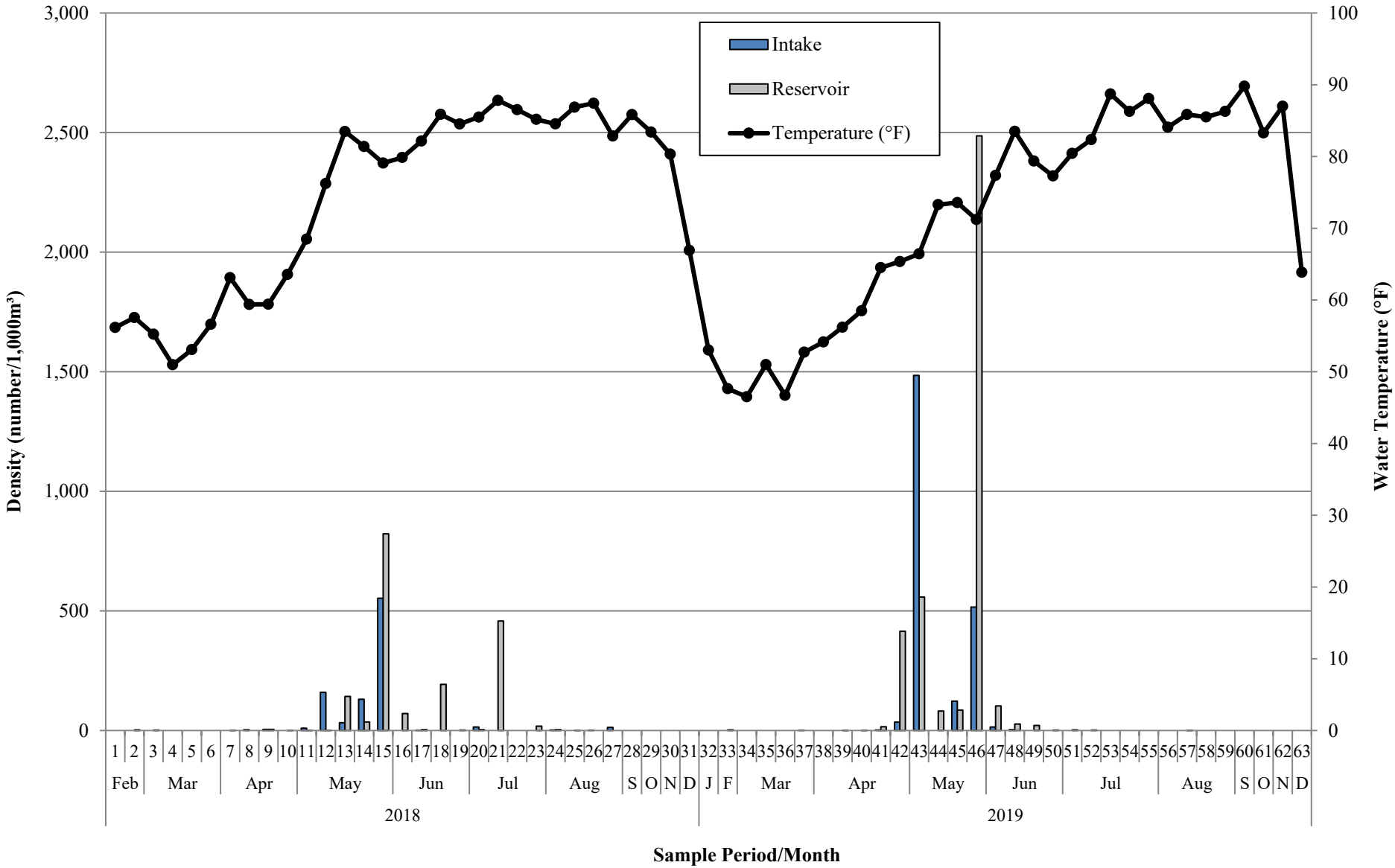


Figure 4. Average densities of fish eggs and water temperature collected at intake (outside skimmer wall) and river (TRM 294.5) transects near Browns Ferry Nuclear Plant from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

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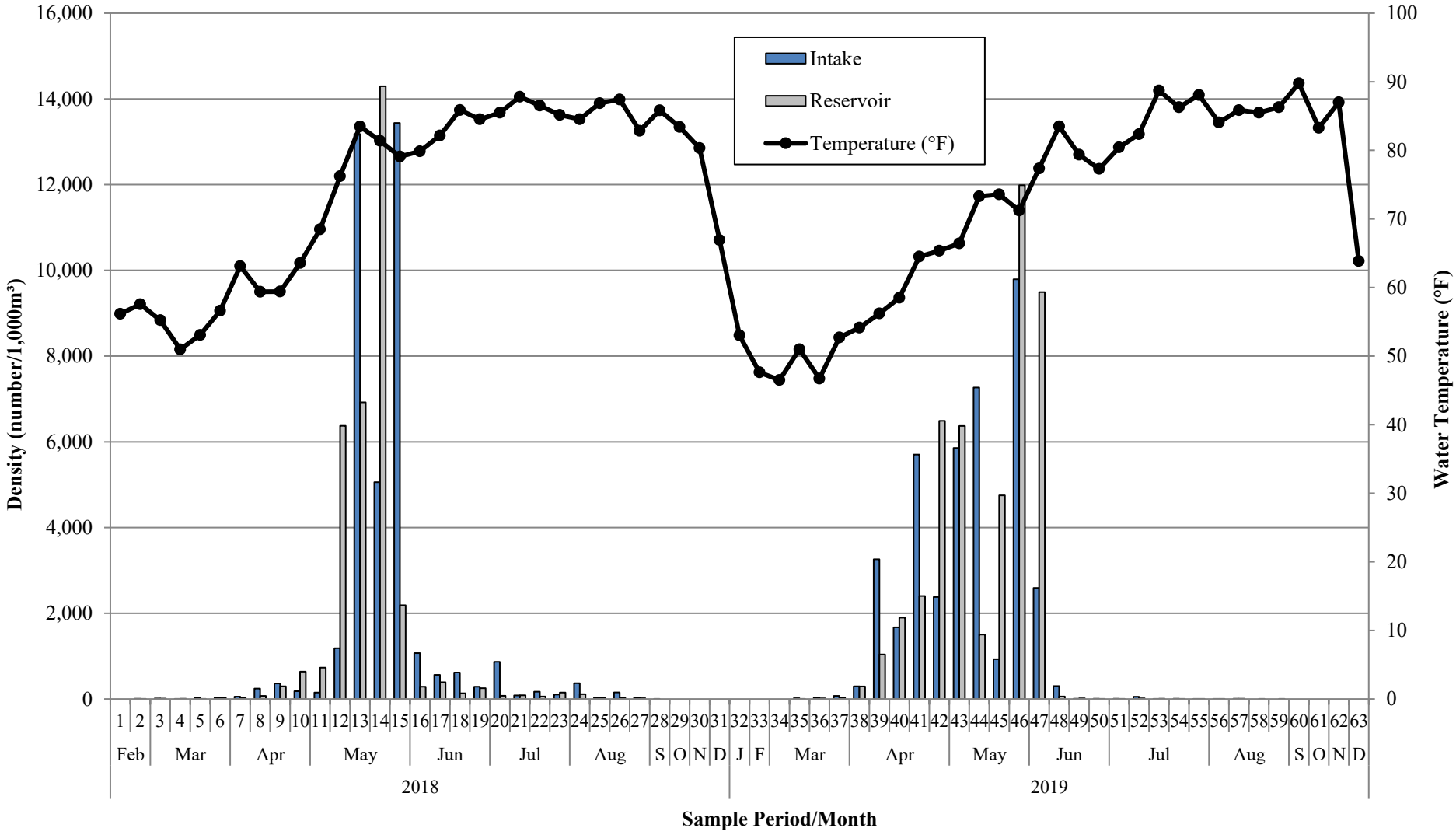


Figure 5. Average densities of fish larvae and water temperature collected at intake (outside skimmer wall) and river (TRM 294.5) transects near Browns Ferry Nuclear Plant from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

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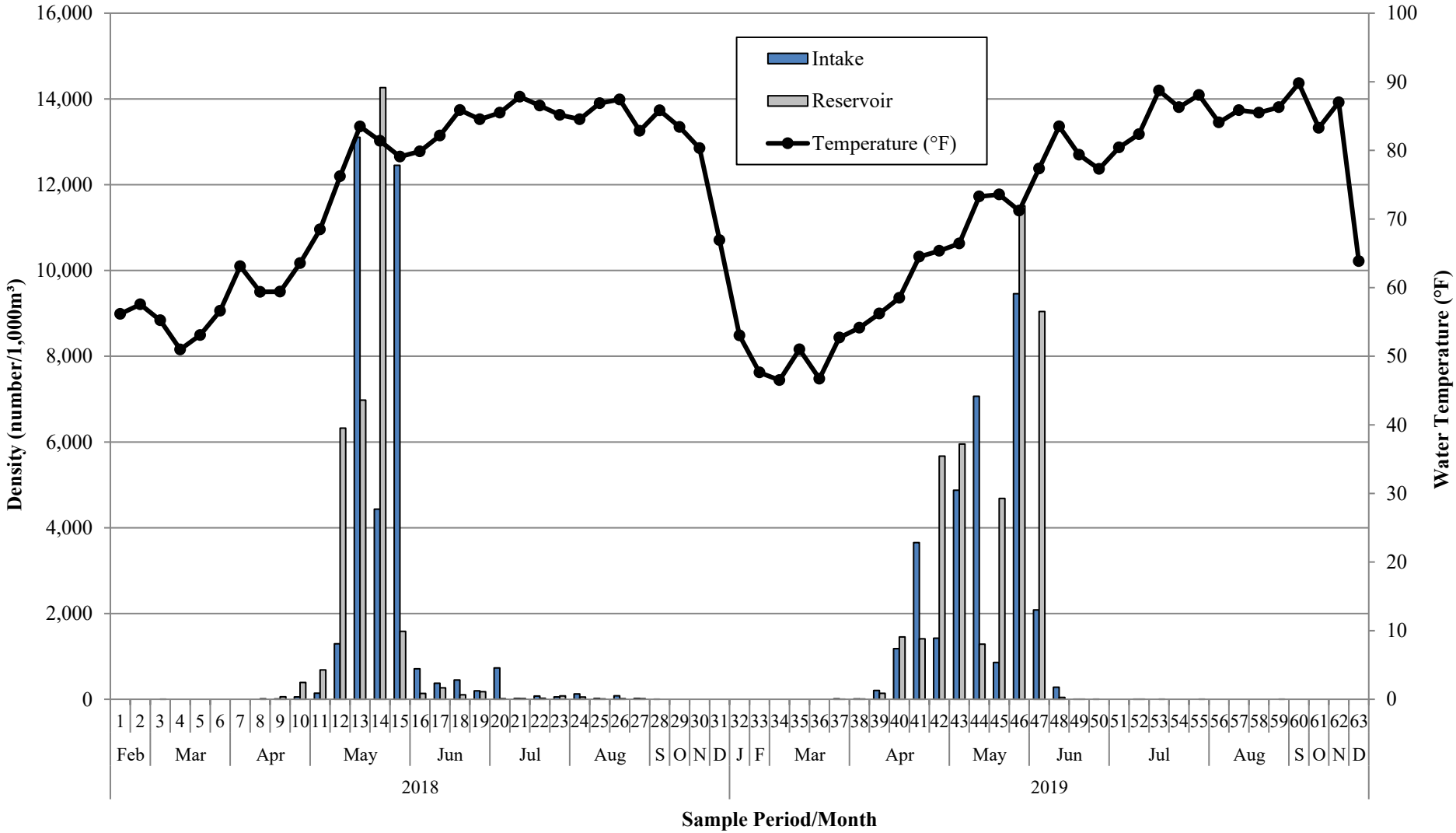


Figure 6. Average densities of Clupeidae fish eggs and larvae and water temperature collected at intake (outside skimmer wall) and river (TRM 294.5) transects near Browns Ferry Nuclear Plant from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

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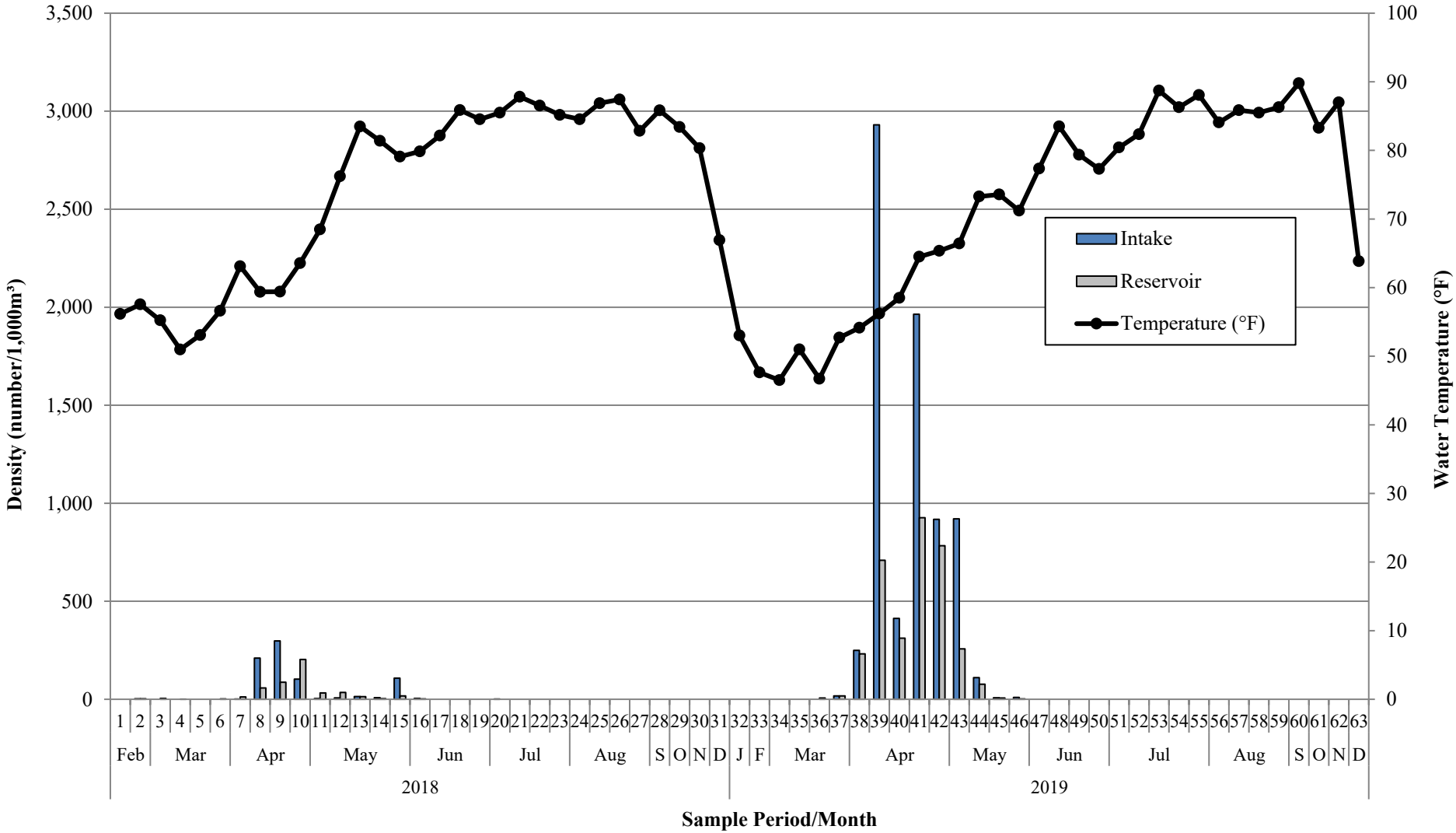


Figure 7. Average densities of Moronidae fish larvae and water temperature collected at intake (outside skimmer wall) and river (TRM 294.5) transects near Browns Ferry Nuclear Plant from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

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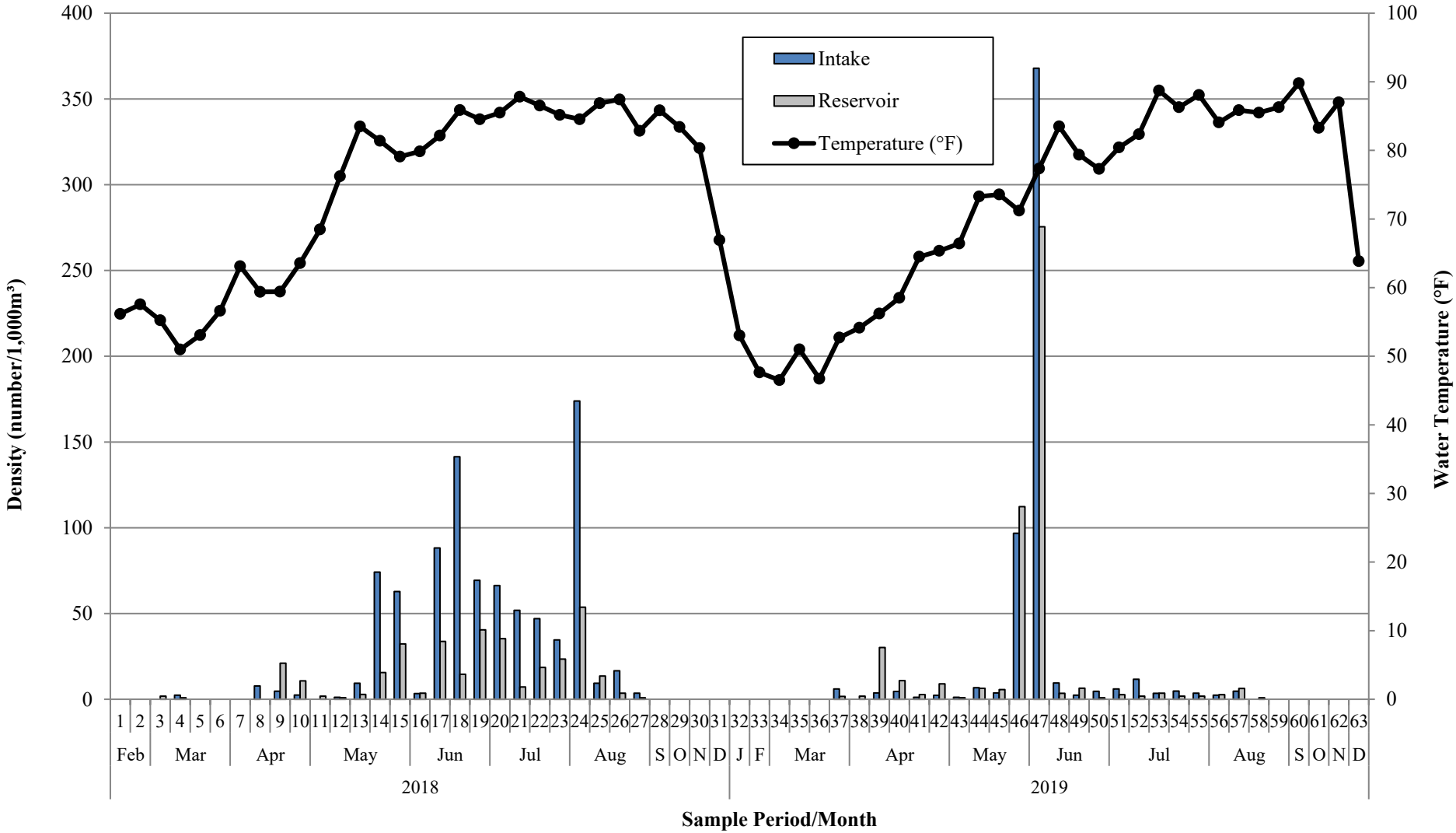


Figure 8. Average densities of Centrarchidae fish larvae and water temperature collected at intake (outside skimmer wall) and river (TRM 294.5) transects near Browns Ferry Nuclear Plant from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

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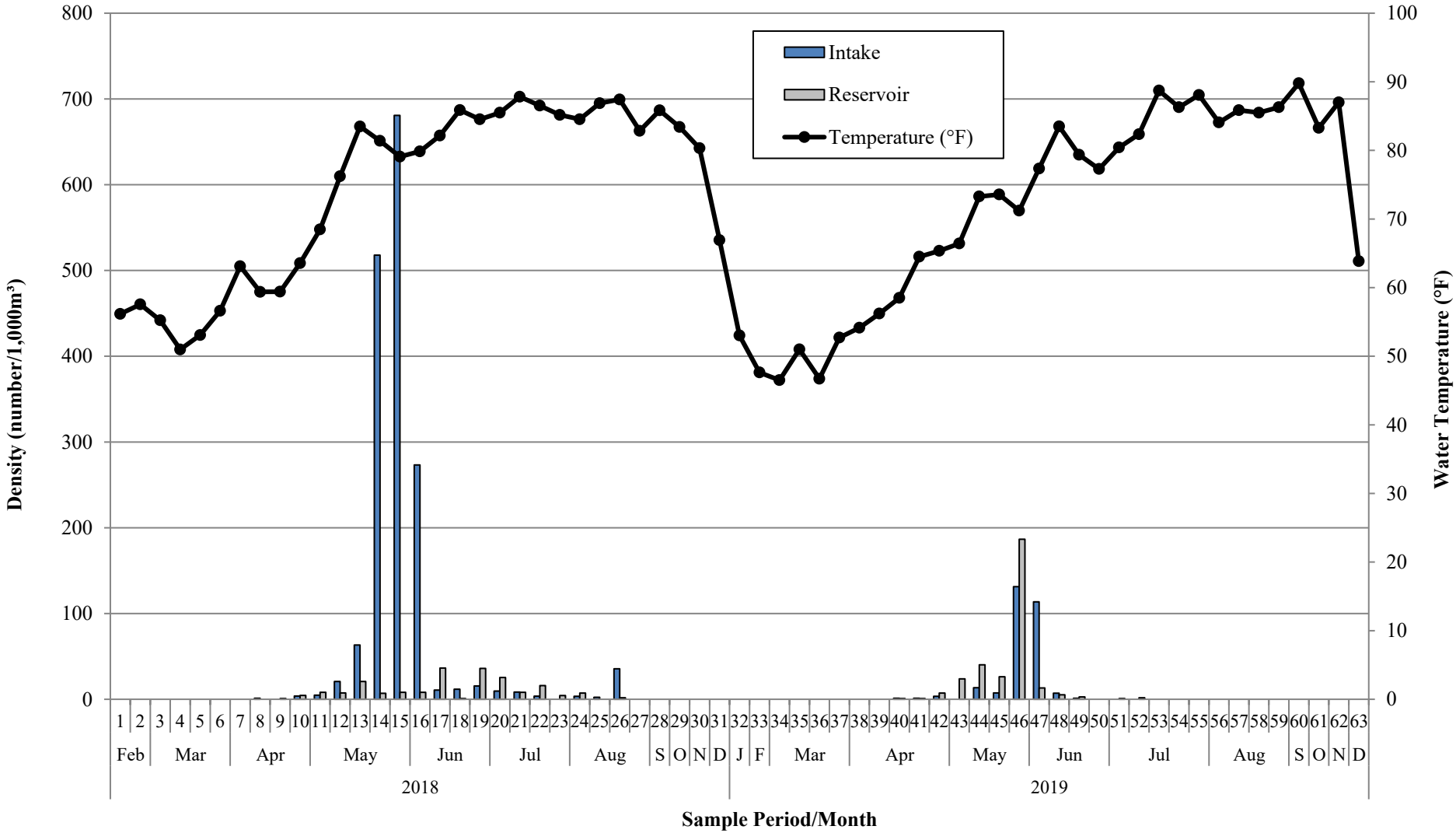


Figure 9. Average densities of Atherinopsidae fish eggs and larvae and water temperature collected at intake (outside skimmer wall) and river (TRM 294.5) transects near Browns Ferry Nuclear Plant from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

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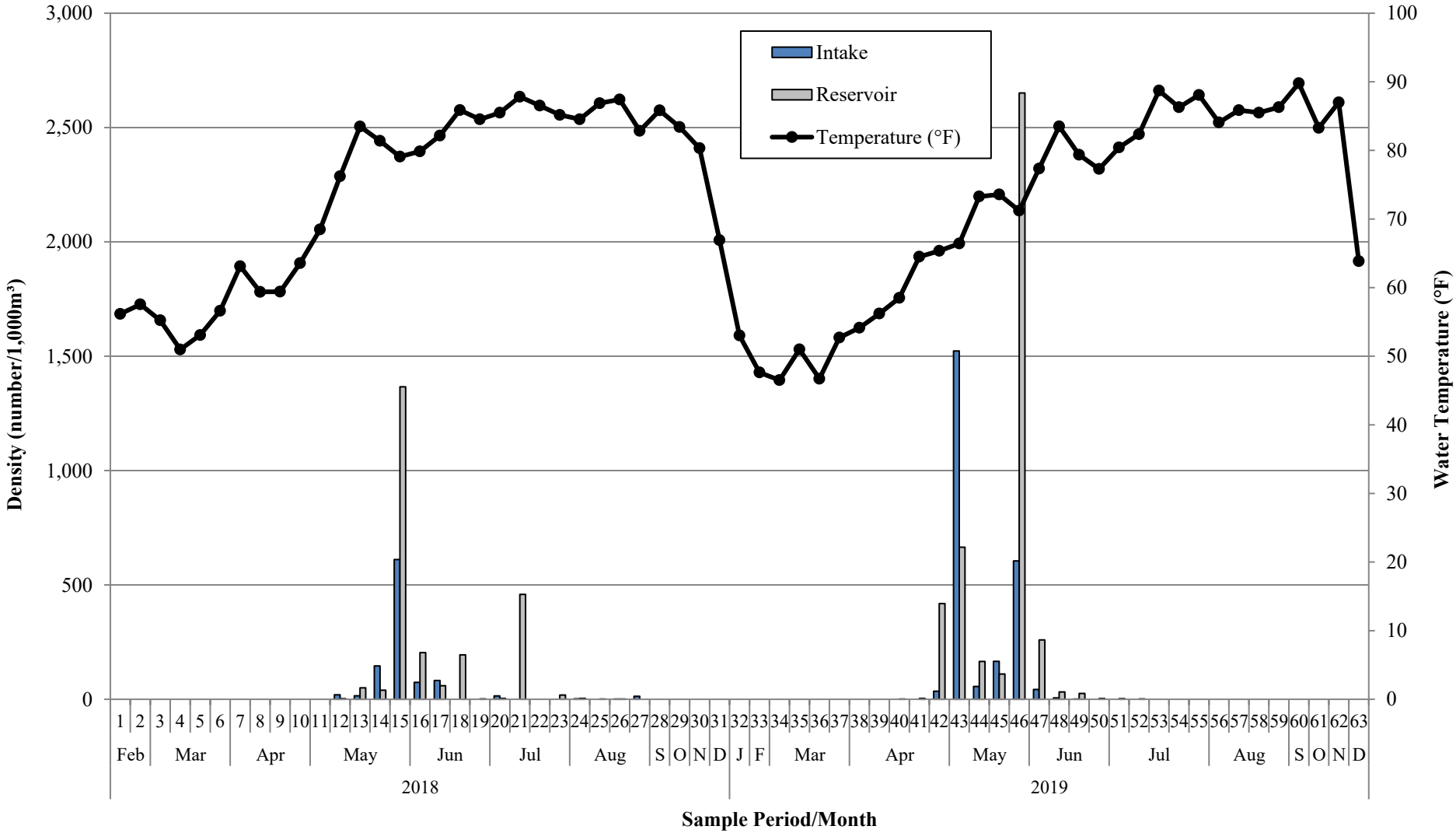


Figure 10. Average densities of Sciaenidae fish eggs and larvae and water temperature collected at intake (outside skimmer wall) and river (TRM 294.5) transects near Browns Ferry Nuclear Plant from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

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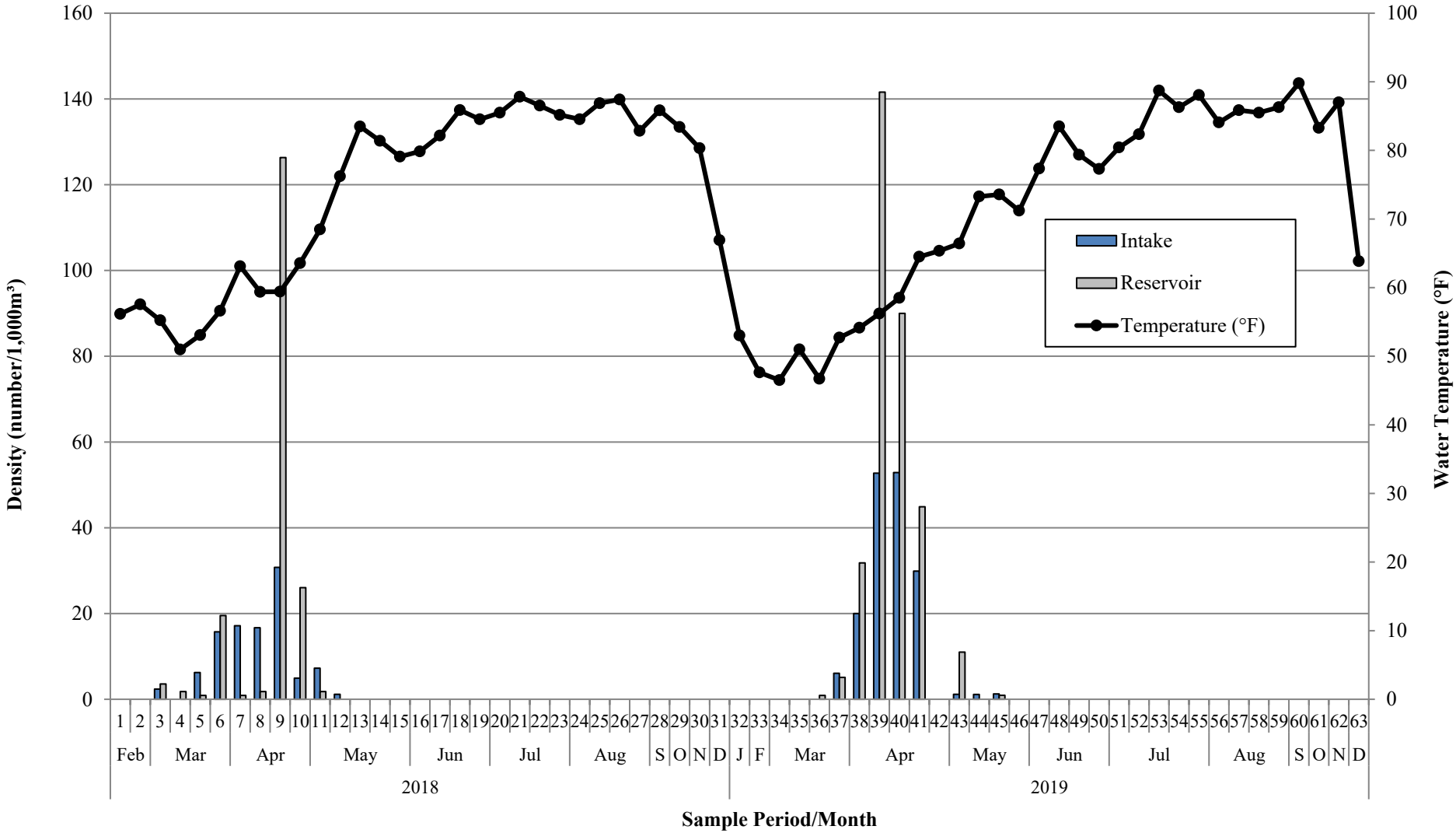


Figure 11. Average densities of Catostomidae fish larvae and water temperature collected at intake (outside skimmer wall) and river (TRM 294.5) transects near Browns Ferry Nuclear Plant from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

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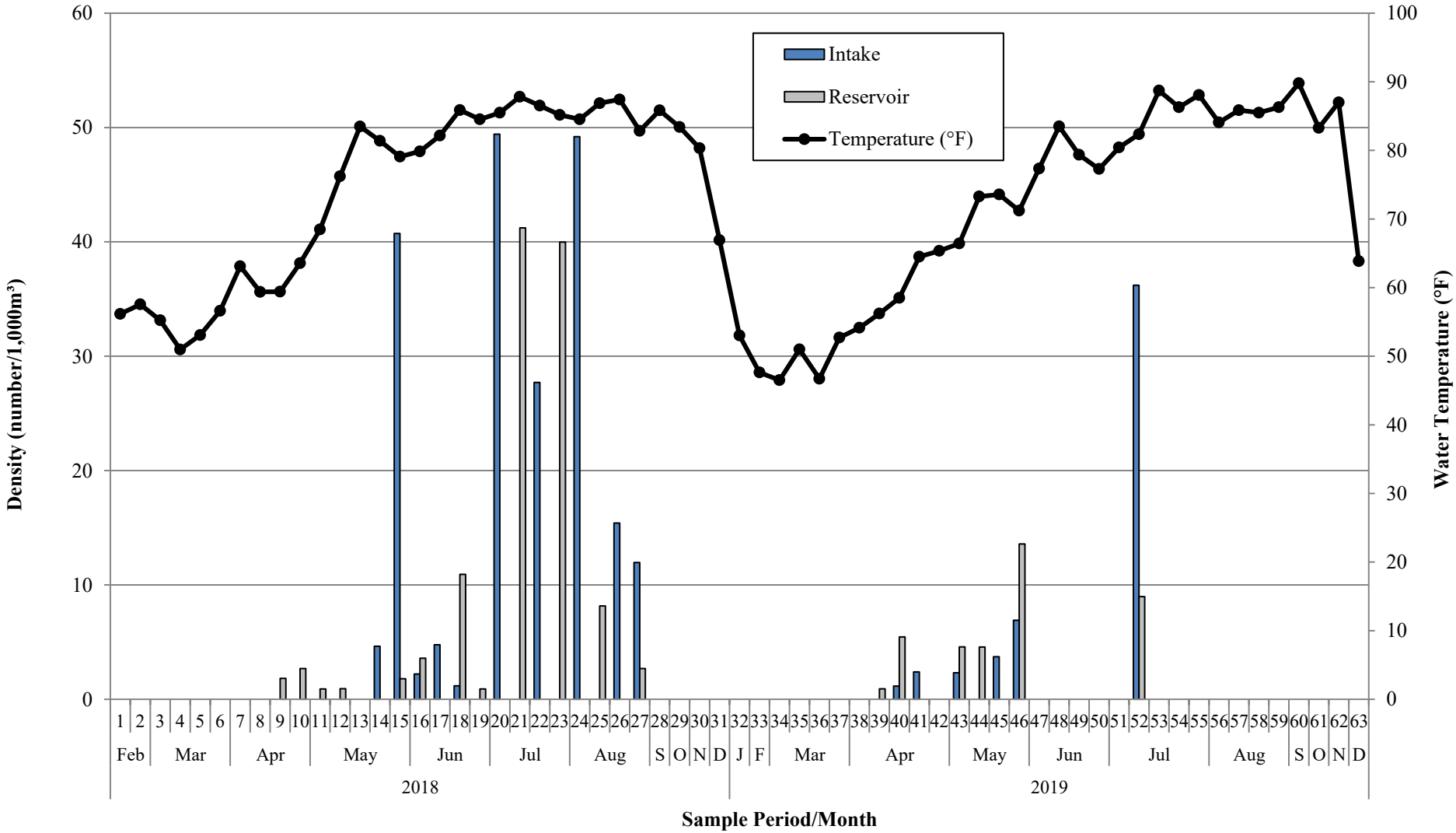


Figure 12. Average densities of Cyprinidae fish larvae and water temperature collected at intake (outside skimmer wall) and river (TRM 294.5) transects near Browns Ferry Nuclear Plant from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

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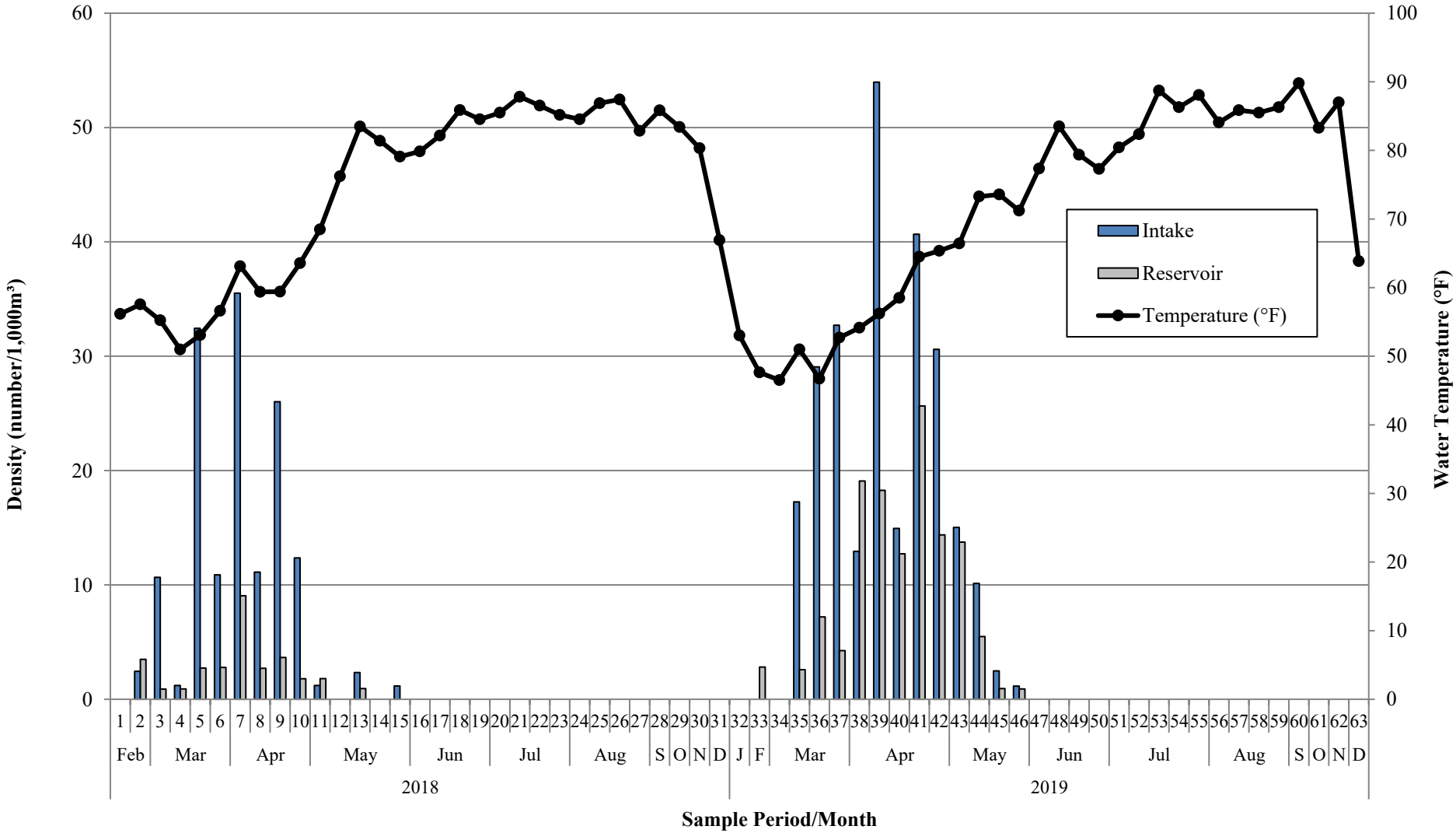


Figure 13. Average densities of Percidae fish larvae and water temperature collected at intake (outside skimmer wall) and river (TRM 294.5) transects near Browns Ferry Nuclear Plant from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

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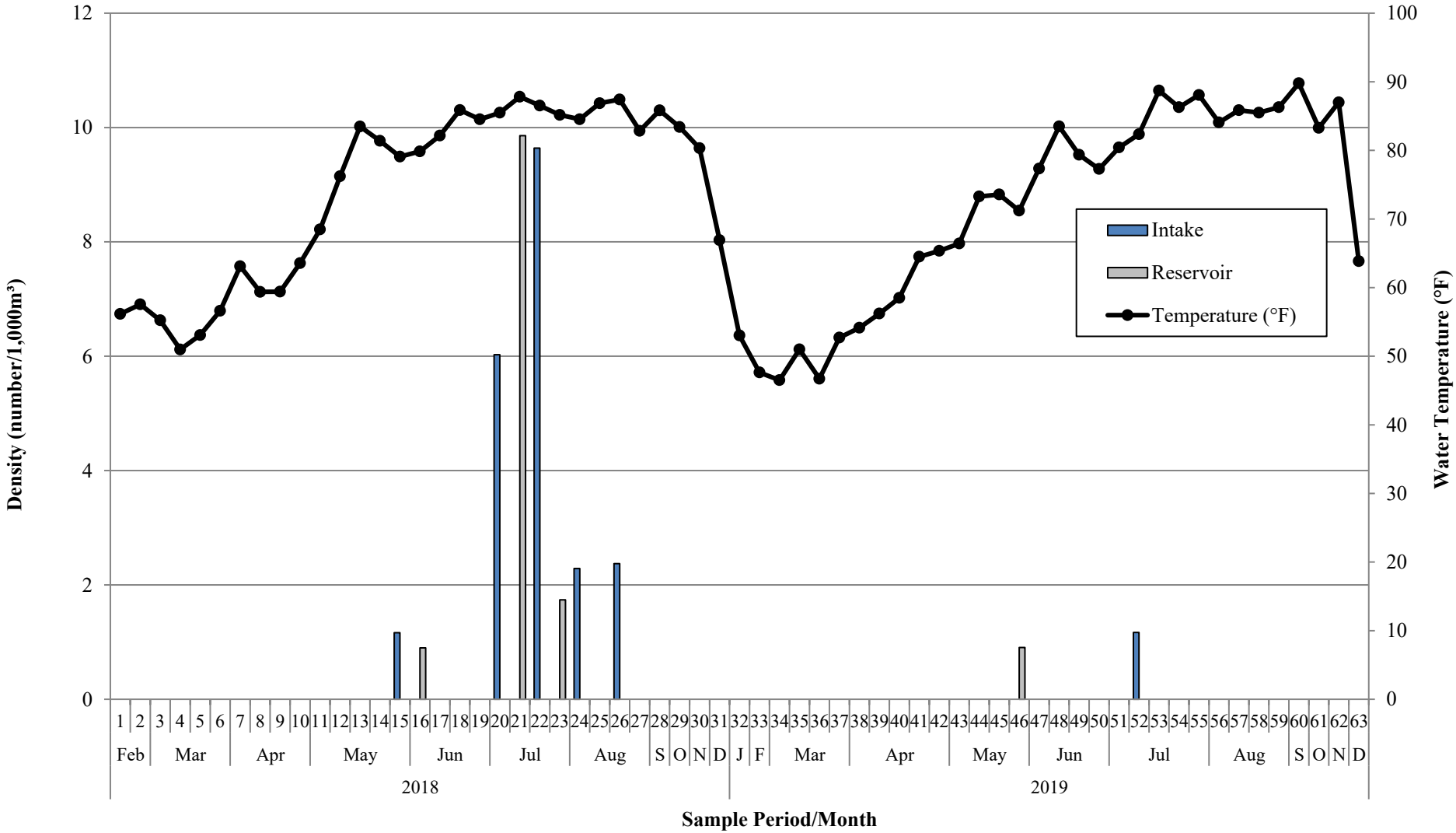


Figure 14. Average densities of Ictaluridae fish larvae and water temperature collected at intake (outside skimmer wall) and river (TRM 294.5) transects near Browns Ferry Nuclear Plant from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

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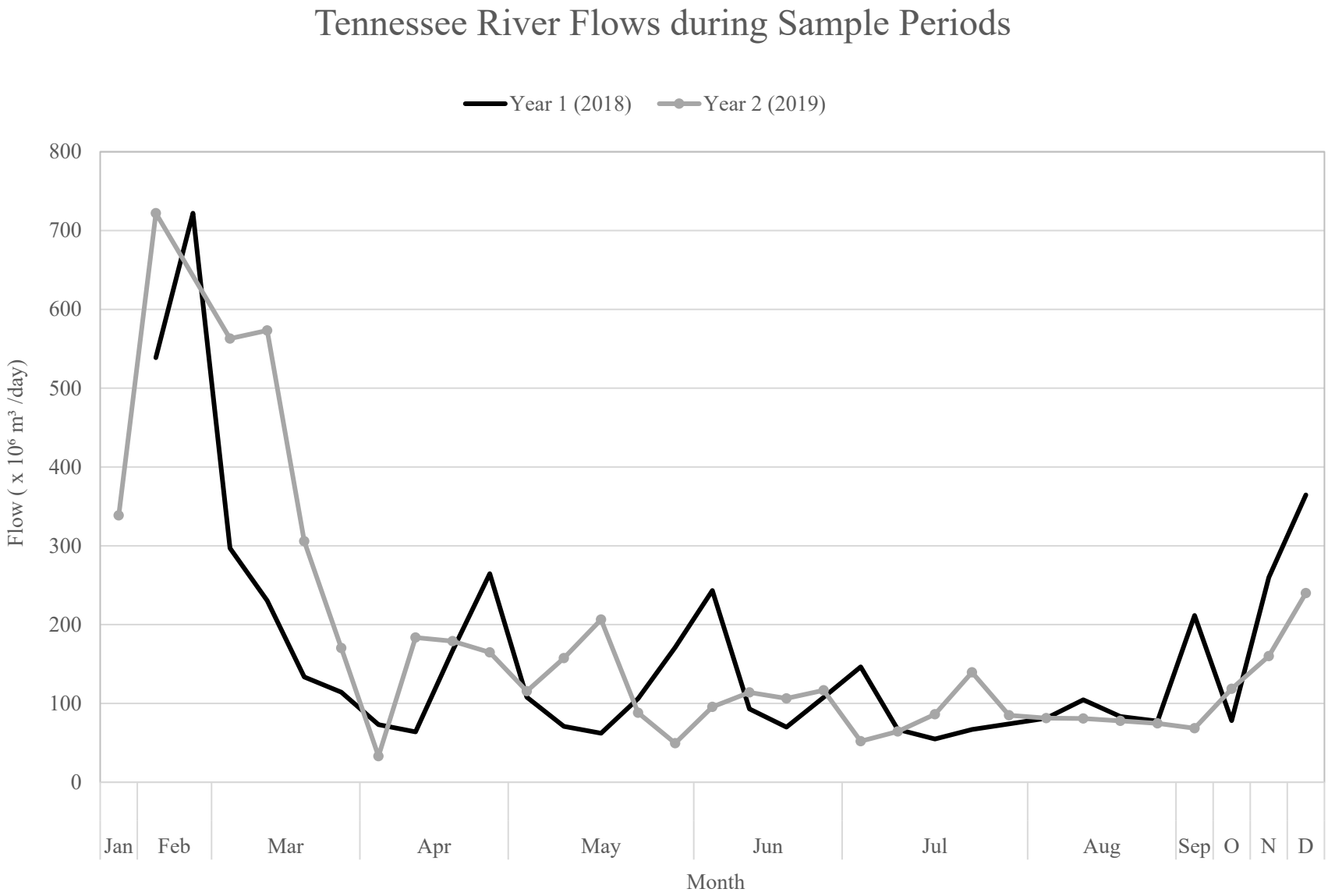


Figure 15. River flows recorded during each sample period at Browns Ferry Nuclear Plant February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

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Tables

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Table 1. Actual numbers and relative abundance (%) of fish eggs and larvae collected in ichthyoplankton samples at intake (outside skimmer wall) and river (TRM 294.5) transects* from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2) in the vicinity of Browns Ferry Nuclear Plant

***RDB–right descending bank; LDB–left descending bank; MC–Mid-channel; Riv. Total–total of day and night samples at five river stations; Int/Riv Comb. Total–Total numbers during day and night of intake and river samples;**

YEAR 1	Intake				River											
	Day	Night			Day				Night							
Taxon			Intake Total	%	RDB*	MC-Bottom to Middepth	MC-Middepth to Surface	LDB*	RDB*	MC-Bottom to Middepth	MC-Middepth to Surface	LDB*	Riv. Total*	%	Int/Riv Comb. Total*	%
EGGS																
Clupeidae																
Alosa chrysochloris (skipjack herring) eggs	-	-	-	-	-	-	-	5	-	-	-	-	5	0.3	5	0.2
Unspecified clupeid eggs	89	61	150	18.8	95	2	2	-	-	1	-	1	101	5.1	251	9.1
Cyprinidae																
Unspecified cyprinid eggs	-	-	-	-	-	-	-	-	-	-	1	-	1	0.1	1	T
Atherinopsidae																
Unspecified atherinopsid eggs	3	-	3	0.4	-	-	1	-	-	-	-	-	1	0.1	4	0.1
Moronidae																
Unspecified moronid (not *M. saxatilis*) eggs	1	2	3	0.4	-	-	3	-	-	1	-	-	4	0.2	7	0.3
Sciaenidae																
Aplodinotus grunniens (freshwater drum) eggs	288	348	636	79.9	16	358	235	279	6	402	316	236	1,848	94.2	2,484	90.1
Unidentifiable Fish Eggs	1	3	4	0.5	1	-	-	1	-	-	-	-	2	0.1	6	0.2
TOTAL EGGS	**382**	**414**	**796**		**112**	**360**	**241**	**285**	**6**	**404**	**317**	**237**	**1,962**		**2,758**	
LARVAE																
Clupeidae																
Alosa chrysochloris (Skipjack herring)	-	-	-	-	1	-	-	1	-	-	-	-	2	-	2	T
Dorosoma cepedianum (Gizzard shad)	6	24	30	0.1	-	-	-	-	-	-	-	-	-	-	30	T
Dorosoma petenense (Threadfin shad)	376	380	756	2.3	5	-	-	4	11	4	5	12	41	0.1	797	1.1
Unspecified clupeids	15,400	13,125	28,525	86.9	4,066	2,883	4,828	4,556	7,326	3,678	3,156	4,161	34,654	93.6	63,179	90.4

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Table 1. (continued)

YEAR 1	Intake				River											
	Day	Night			Day				Night							
Taxon			Intake Total	%	RDB*	MC-Bottom to Middepth	MC-Middepth to Surface	LDB*	RDB*	MC-Bottom to Middepth	MC-Middepth to Surface	LDB*	Riv. Total*	%	Int/Riv Comb. Total*	%
Cyprinidae																
Ctenopharyngodon idella (Grass carp)	-	1	1	T	-	-	-	-	-	-	-	-	-	-	1	T
Cyprinus carpio (Common carp)	-	-	-	-	2	1	-	1	-	-	-	-	4	T	4	T
Unspecified cyprinids (*N. atherinoides* group)	1	1	2	T	-	-	-	-	-	-	-	-	-	-	2	T
Unspecified cyprinids (*Pimephales* group)	72	76	148	0.5	6	14	18	11	5	21	23	14	112	0.3	260	0.4
Unspecified cyprinids	16	9	25	0.1	2	1	-	3	-	-	-	7	13	T	38	0.1
Catostomidae																
Minytrema melanops (Spotted sucker)	3	-	3	T	5	1	-	2	13	-	1	-	22	0.1	25	T
Ictiobinae (Buffalofish or carpsucker)	38	45	83	0.3	53	7	4	16	63	16	14	5	178	0.5	261	0.4
Ictaluridae																
Ictalurus furcatus (Blue catfish)	-	1	1	T	-	1	-	1	-	1	-	-	3	T	4	T
Ictalurus punctatus (Channel catfish)	7	10	17	0.1	-	1	2	4	-	1	2	-	10	T	27	T
Pylodictus olivaris (Flathead catfish)	-	-	-	-	-	-	-	1	-	-	-	-	1	T	1	T
Fundulidae																
Unspecified fundulids	2	-	2	T	-	-	-	-	-	-	-	-	-	-	2	T
Poeciliidae																
Gambusia affinis (Western mosquitofish)	1	-	1	T	-	-	-	-	-	-	-	-	-	-	1	T
Atherinopsidae																
Menidia audens (Mississippi silverside)	145	96	241	0.7	-	-	-	-	-	-	-	1	1	T	242	0.3
Unspecified silversides	507	693	1,200	3.7	52	4	44	8	51	6	30	25	220	0.6	1,420	2.0

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Table 1. (continued)

YEAR 1	Intake				River											
	Day	Night			Day				Night							
Taxon			Intake Total	%	RDB*	MC-Bottom to Middepth	MC-Middepth to Surface	LDB*	RDB*	MC-Bottom to Middepth	MC-Middepth to Surface	LDB*	Riv. Total*	%	Int/Riv Comb. Total*	%
Moronidae																
Morone chrysops (White bass)	18	15	33	0.1	-	-	-	-	-	-	-	1	1	T	34	T
Morone mississippiensis (Yellow bass)	-	1	1	T	-	-	-	-	-	-	-	-	-	-	1	T
Unspecified moronids	280	335	615	1.9	86	54	52	36	119	92	47	31	517	1.4	1,132	1.6
Centrarchidae																
Unspecified *Lepomis* sp. (Sunfish)	382	343	725	2.2	87	12	38	18	85	5	46	42	333	0.9	1,058	1.5
Unspecified *Pomoxis* sp. (Crappie)	8	7	15	T	8	6	3	4	4	8	4	4	41	0.1	56	0.1
Percidae																
Perca flavescens (Yellow perch)	2	1	3	T	-	-	-	1	-	-	-	-	1	T	4	T
Percina caprodes (Logperch)	-	1	1	T	-	-	-	-	-	-	-	-	-	-	1	T
Sander canadensis (Sauger)	-	1	1	T	-	1	-	-	-	-	-	-	1	T	2	T
Unidentifiable darter (*Etheostoma* type)	1	-	1	T	-	-	-	-	-	-	-	-	-	-	1	T
Unidentifiable darter (*P. caprodes* type)	64	49	113	0.3	9	1	1	9	2	2	3	2	29	0.1	142	0.2
Unidentifiable darter	-	2	2	T	-	-	-	-	1	1	1	-	3	T	5	T
Sciaenidae																
Aplodinotus grunniens (Freshwater drum)	117	90	207	0.6	12	140	46	252	20	137	33	187	827	2.2	1,034	1.5
Unidentifiable fish larvae	47	40	87	0.3	-	2	1	2	1	-	-	2	8	T	95	0.1
TOTAL LARVAE	**17,493**	**15,346**	**32,839**		**4,394**	**3,129**	**5,037**	**4,930**	**7,701**	**3,972**	**3,365**	**4,494**	**37,022**		**69,861**	
TOTAL DISTINCT TAXA	**17**	**19**	**23**		**10**	**11**	**7**	**14**	**9**	**10**	**10**	**9**	**18**		**26**	

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Table 1. (continued)

YEAR 2	Intake				River											
	Day	Night			Day				Night							
Taxon			Intake Total	%	RDB*	MC-Bottom to Middepth	MC-Middepth to Surface	LDB*	RDB*	MC-Bottom to Middepth	MC-Middepth to Surface	LDB*	Riv. Total*	%	Int/Riv Comb. Total*	%
EGGS																
Clupeidae																
Alosa chrysochloris (skipjack herring) eggs	-	1	1	0.1	-	1	-	-	-	-	-	-	1	T	2	T
Unspecified clupeid eggs	3	-	3	0.2	-	-	-	2	14	1	1	-	18	0.4	21	0.3
Percidae																
Unspecified percid eggs	-	-	-	-	-	3	-	-	-	-	-	-	3	0.1	3	T
Sciaenidae																
Aplodinotus grunniens (freshwater drum) eggs	125	1,750	1,875	99.8	17	94	109	278	53	1,699	1,021	903	4,174	99.5	6,049	99.6
Unidentifiable Fish Eggs	-	-	-	-	-	-	-	-	-	-	-	1	1	T	1	T
TOTAL EGGS	**128**	**1,751**	**1,879**		**17**	**98**	**109**	**280**	**67**	**1,700**	**1,022**	**904**	**4,197**		**6,076**	
LARVAE																
Clupeidae																
Dorosoma cepedianum (Gizzard shad)	-	-	-	-	-	-	-	-	4	-	-	-	4	T	4	T
Dorosoma petenense (Threadfin shad)	2	1	3	T	-	-	-	1	1	-	-	1	3	T	6	T
Unspecified clupeids	9,179	17,613	26,792	77.8	20,173	2,847	2,001	1,796	11,408	4,031	2,344	957	45,557	88.8	72,349	84.4
Cyprinidae																
Cyprinus carpio (Common carp)	3	1	4	T	1	1	-	1	-	-	2	2	7	T	11	T
Unspecified cyprinids (*N. atherinoides* group)	1	-	1	T	-	-	-	-	2	-	-	-	2	T	3	T
Unspecified cyprinids (*Cyprinella* group)	-	-	-	-	-	-	-	1	-	-	-	-	1	T	1	T
Unspecified cyprinids (*Pimephales* group)	10	21	31	0.1	-	-	-	4	4	1	4	15	28	0.1	59	0.1
Unspecified cyprinids	2	7	9	T	1	-	1	-	1	-	-	1	4	T	13	T

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Table 1. (continued)

YEAR 2	Intake				River											
	Day	Night			Day				Night							
Taxon			Intake Total	%	RDB*	MC-Bottom to Middepth	MC-Middepth to Surface	LDB*	RDB*	MC-Bottom to Middepth	MC-Middepth to Surface	LDB*	Riv. Total*	%	Int/Riv Comb. Total*	%
Catostomidae																
Minytrema melanops (Spotted sucker)	2	-	2	T	-	1	-	1	1	-	1	1	5	T	7	T
Ictiobinae (Buffalofish or carpsucker)	77	60	137	0.4	14	29	27	40	40	26	72	105	353	0.7	490	0.6
Ictaluridae																
Ictalurus punctatus (Channel catfish)	1	-	1	T	-	-	-	-	-	-	1	-	1	T	2	T
Atherinopsidae																
Menidia audens (Mississippi silverside)	-	2	2	T	-	-	-	-	45	3	-	-	48	0.1	50	0.1
Unspecified silversides	20	214	234	0.7	35	-	6	100	109	13	4	26	293	0.6	527	0.6
Moronidae																
Morone chrysops (White bass)	2	6	8	T	1	-	-	-	-	-	1	-	2	T	10	T
Morone mississippiensis (Yellow bass)	-	-	-	-	-	-	-	-	1	-	-	-	1	T	1	T
Unspecified moronids	2,260	4,036	6,296	18.3	949	421	342	122	1,083	296	330	112	3,655	7.1	9,951	11.6
Centrarchidae																
Unspecified *Lepomis* sp. (Sunfish)	84	349	433	1.3	272	36	26	35	89	15	8	4	485	0.9	918	1.1
Unspecified *Micropterus* sp. (Black bass)	-	-	-	-	-	-	-	-	-	-	-	1	1	T	1	T
Unspecified *Pomoxis* sp. (Crappie)	7	12	19	0.1	2	11	8	18	12	3	7	3	64	0.1	83	0.1
Percidae																
Perca flavescens (Yellow perch)	6	14	20	0.1	2	2	2	3	2	3	5	1	20	T	40	T
Percina caprodes (Logperch)	2	-	2	T	-	-	-	-	1	-	-	-	1	T	3	T
Sander canadensis (Sauger)	1	3	4	T	-	-	-	-	-	-	1	-	1	T	5	T
Unidentifiable darter (*P. caprodes* type)	105	62	167	0.5	18	7	7	1	20	6	10	8	77	0.2	244	0.3
Unidentifiable darter	18	8	26	0.1	9	3	2	6	7	6	3	3	39	0.1	65	0.1

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Table 1. (continued)

YEAR 2	Intake				River											
	Day	Night			Day				Night							
Taxon			Intake Total	%	RDB*	MC-Bottom to Middepth	MC-Middepth to Surface	LDB*	RDB*	MC-Bottom to Middepth	MC-Middepth to Surface	LDB*	Riv. Total*	%	Int/Riv Comb. Total*	%
Sciaenidae																
Aplodinotus grunniens (Freshwater drum)	65	157	222	0.6	31	75	41	124	15	136	89	108	619	1.2	841	1.0
Unidentifiable fish larvae	25	8	33	0.1	2	8	3	2	-	6	8	2	31	0.1	64	0.1
TOTAL LARVAE	**11,872**	**22,574**	**34,446**		**21,510**	**3,441**	**2,466**	**2,255**	**12,845**	**4,545**	**2,890**	**1,350**	**51,302**		**85,748**	
TOTAL DISTINCT TAXA	**14**	**12**	**16**		**7**	**8**	**5**	**10**	**13**	**7**	**11**	**10**	**20**		**20**	

T–trace, value less than 0.05

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Table 2. Records of federal and State-listed (Alabama) aquatic animal species in the vicinity[1,2,3] of the Browns Ferry Nuclear Plant CCW intake (TRM 294.2)[1]

Source	Common Name	Scientific Name	Element Rank[4]	Federal Status[5]	State Status[5]	State Rank[6]
TVA Natural Heritage Database[1]	**FISH**					
	Bigeye Chub	*Hybopsis amblops*	E		TRKD	S3
	Flame Chub	*Hemitremia flammea*			TRKD	S3
	Hellbender	*Cryptobranchus alleganiensis*	E	PS	PROT	S2
	Paddlefish	*Polyodon spathula*	H		PROT	S3
	Redline Darter	*Etheostoma rufilineatum*	E		TRKD	S3
	Silver Redhorse	*Moxostoma anisurum*	E		TRKD	S2
	Southern Cavefish	*Typhlichthys subterraneus*	E		PROT	S3
	Spring Pygmy Sunfish	*Elassoma alabamae*	E	LT	PROT	S1
	Stargazing Minnow	*Phenacobius uranops*	E		TRKD	S1
	Tuscumbia Darter	*Etheostoma tuscumbia*	E		PROT	S2
	MUSSELS					
	Acornshell	*Epioblasma haysiana*	H		TRKD	S3
	Birdwing Pearlymussel	*Lemiox rimosus*	X		EXTI	SH
	Cracking Pearlymussel	*Hemistena lata*	X	LE	PROT	SX
	Cumberlandian Combshell	*Epioblasma brevidens*	H	LE	PROT	SX
	Dromedary Pearlymussel	*Dromus dromas*	X	LE	PROT	S1
	Fluted Kidneyshell	*Ptychobranchus subtentum*	H	LE	PROT	S1
	Lilliput	*Toxolasma parvum*	H	LE	PROT	SX
	Ohio Pigtoe	*Pleurobema cordatum*	E		TRKD	S3
	Pink Mucket	*Lampsilis abrupta*	E		TRKD	S2
	Pink Papershell	*Potamilus ohiensis*	E	LE	PROT	S1
	Purple Lilliput	*Toxolasma lividus*	E		TRKD	S3
	Ring Pink	*Obovaria retusa*	X		TRKD	S2
	Rough Pigtoe	*Pleurobema plenum*	E	LE	PROT	S1
	Spectaclecase	*Cumberlandia monodonta*	E	LE	PROT	S1
	Tuberculed Blossom Pearlymussel	*Epioblasma torulosa torulosa*	X	LE	PROT	S1
	White Heelsplitter	*Lasmigona complanata*	H		HIST	SH

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Table 2. (continued)

Source	Common Name	Scientific Name	Element Rank[4]	Federal Status[5]	State Status[5]	State Rank[6]
TVA Natural Heritage Database[1] (continued)	**SNAILS**					
	Round-rib Elimia	*Elimia nassula*	E	LE	PROT	S1
	Skirted Hornsnail	*Pleurocera pyrenella*	E		TRKD	S1
	Slender Campeloma	*Campeloma decampi*	E		TRKD	S2
	Warty Rocksnail	*Lithasia lima*	H	LE	PROT	SX
ADCNR[2]	**FISH**					
	Lake Sturgeon	*Acipenser fulvescens*		LT	PROT	S1
	Shovelnose Sturgeon	*Scaphirhynchus platorynchus*		LT (S/A)	PROT	SX
	Paddlefish	*Polyodon spathula*			PROT	S3
	Southern Cavefish	*Typhlichthys subterraneus*	E		PROT	S3
	Slackwater darter	*Etheostoma boschungi*		LT	PROT	S1
	Tuscumbia Darter	*Etheostoma tuscumbia*	E		PROT	S2
	Boulder darter	*Etheostoma wapiti*		LE	PROT	S1
	MUSSELS					
	Spectaclecase (mussel)	*Cumberlandia monodonta*		LE	PROT	S1
	Fanshell	*Cyprogenia stegaria*		LE	PROT	S1
	Dromedary Pearlymussel	*Dromus dromas*	X	LE	PROT	SX
	Oyster Mussel	*Epioblasma capsaeformis*	X	LE	PROT	SX
	Fine-rayed Pigtoe	*Fusconaia cuneolus*				
	Cracking pearlymussel	*Hemistena lata*		LE	PROT	S1
	Pink mucket	*Lampsilis abrupta*		LE	PROT	S1
	Ring Pink	*Obovaria retusa*	X	LE	PROT	SX
	Littlewing pearlymussel	*Pegias fabula*		LE	PROT	SX
	Orangefoot pimpleback (pearlymussel)	*Plethobasus cooperianus*		LE	PROT	SX
	Sheepnose mussel	*Plethobasus cyphyus*		LE	PROT	S1
	Rough Pigtoe	*Pleurobema plenum*	E	LE	PROT	S1
	Round Pigtoe	*Pleurobema sintoxia*			PROT	S1
	Pyramid Pigtoe	*Pleurobema rubrum*			PROT	S1
	Slabside pearlymussel	*Pleuronaia dolabelloides*		LE	PROT	S1

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Table 2. (continued)

Source	Common Name	Scientific Name	Element Rank[4]	Federal Status[5]	State Status[5]	State Rank[6]
ADCNR[2] (continued)	Fluted kidneyshell	*Ptychobranchus subtentus*		LE	PROT	SX
	Rabbitsfoot	*Quadrula cylindrica cylindrica*		LT	PROT	S1
	Cumberland monkeyface	*Quadrula intermedia*		LE	PROT	SX
	Pale lilliput	*Toxolasma cylindrellus*		LE	PROT	S1
	SNAILS					
	Slender Campoloma	*Campeloma decampi*		LE	PROT	S1
	Armored snail	*Pyrgulopsis (Marstonia) pachyta*		LE	PROT	S1
	Anthony's riversnail	*Athearnia anthonyi*		LE	PROT	S1
ECOS/IPAC[3]	**MUSSELS**					
	Cracking pearlymussel	*Hemistena lata*		LE		
	Littlewing pearlymussel	*Pegias fabula*		LE		
	Pink mucket (pearlymussel)	*Lampsilis abrupta*		LE		
	Rough pigtoe	*Pleurobema plenum*		LE		
	Sheepnose mussel	*Plethobasus cyphyus*		LE		
	Snuffbox mussel	*Epioblasma triquetra*		LE		
	Spectaclecase (mussel)	*Cumberlandia monodonta*		LE		
	SNAILS					
	Anthony's riversnail	*Athearnia anthonyi*		LE		
	Armored snail	*Pyrgulopsis (Marstonia) pachyta*		LE		
	Slender campeloma	*Campeloma decampi*		LE		
	CRUSTACEANS					
	Alabama cave shrimp	*Palaemonias alabamae*		LE		

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Table 2. (continued)

Source	Common Name	Scientific Name	Element Rank[4]	Federal Status[5]	State Status[5]	State Rank[6]
ECOS/IPAC[3] (continued)	**FISHES**					
	Boulder darter	*Etheostoma wapiti*		LE		
	Slackwater darter	*Etheostoma boschungi*		LT		
	Snail darter	*Percina tanasi*		LT		
	Spring pygmy sunfish	*Elassoma alabamae*		LT		
	CRITCAL HABITAT					
	Fluted kidneyshell	*Ptychobranchus subtentum*				
	Slabside pearlymussel	*Pleuronaia dolabelloides*				
	Spring pygmy sunfish	*Elassoma alabamae*				

[1] TVA Natural Heritage Database returns records **within ten-mile radius** of the BFN intake and queried on 30 September 2020
[2] Alabama Department of Conservation and Natural Resources (ADCNR) website returns records **by state**
[3] U.S. Fish and Wildlife Service (USFWS) Environmental Conservation Online System (ECOS) and the Information for Planning and Consultation (IPAC) internet resource pages returns records **by county**
[4] Heritage Element Occurrence Rank: E = extant record ≤25 years old; H = historical record ≥25 years old; X = extirpated
[5] Status Codes: E, LE, or END = Listed Endangered; LT or THR - Listed Threatened; LT (S/A)=threatened due to similarity of appearance; S=Special concern; D or NMGT = Deemed in need of management; R = Rare, Not State Listed; TRKD = Tracked by state natural heritage program (no legal status); PROT = Protected
[6] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; SH=of historical occurrence in TN; SX = Extirpated

ADEM Watermark

Table 3. Occurrence and relative abundance (%) of fish eggs and larvae collected in intake and river samples near Browns Ferry Nuclear Plant's CCW intake during March through August 1971-1979, 2008-2009, and 2018-2019

Occurrence

	Intake													River											
Taxa	**'71**	**'72**	**'73**	**'74**	**'75**	**'76**	**'77**	**'78**	**'79**	**'08**	**'09**	**'18**	**'19**	**'71**	**'72**	**'73**	**'74**	**'75**	**'76**	**'77**	**'78**	**'79**	**'08**	**'09**	**'18**	**'19**
Petromyzontidae									X																	
Polyodontidae			X													X					X					
Lepisosteidae								X						X				X								
Clupeidae	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hiodontidae	X	X	X	X	X		X	X	X					X	X	X	X	X	X	X	X	X				
Esocidae					X														X							
Cyprinidae	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Catostomidae	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
Ictaluridae	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fundulidae						X						X														
Poeciliidae								X		X		X														
Atherinopsidae								X	X	X	X	X	X			X		X	X	X			X	X	X	X
Moronidae	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Centrarchidae	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Percidae	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sciaenidae	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Unidentifiable	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Total Fish Taxa:	**10**	**9**	**11**	**10**	**11**	**10**	**10**	**13**	**12**	**11**	**10**	**12**	**9**	**10**	**10**	**12**	**10**	**12**	**12**	**11**	**11**	**10**	**10**	**10**	**10**	**9**

Relative Abundance

	Intake													River											
Taxa	**'71**	**'72**	**'73**	**'74**	**'75**	**'76**	**'77**	**'78**	**'79**	**'08**	**'09**	**'18**	**'19**	**'71**	**'72**	**'73**	**'74**	**'75**	**'76**	**'77**	**'78**	**'79**	**'08**	**'09**	**'18**	**'19**
Petromyzontidae									T																	
Polyodontidae			T													T					T					
Lepisosteidae								T						T				T								
Clupeidae	97	97	88	81	97	96	95	95	88	94	92	88	74	98	98	93	86	92	95	95	96	92	96	93	89	82
Hiodontidae	T	T	T	T	T		T	T	T					T	T	T	T	T	T	T	T	T				
Esocidae					T														T							
Cyprinidae	1	2	T	2	1	T	T	T	1	T	T	1	T	T	T	1	4	5	1	1	T	1	T	T	T	T
Catostomidae	T	T	9	2	T	T	2	T	1	T	1	T	1		T	3	5	1	T	1	T	1	T	1	T	1
Ictaluridae	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Fundulidae						T						T														
Poeciliidae								T		T		T														
Atherinopsidae								T	T	2	1	4	1			T		T	T	T			T	T	1	1
Moronidae	T	T	T	3	T	1	1	3	4	2	3	2	17	T	T	T	1	1	2	1	1	3	2	3	1	7
Centrarchidae	T	T	T	T	T	T	T	T	1	1	2	2	1	T	T	T	T	T	T	T	1	T	1	1	1	1
Percidae	T		T	T	T	T	T	T	T	T	T	T	1	T	T	T	T	T	T	T	T	T	T	T	T	T
Sciaenidae	1	1	1	10	1	2	1	1	4	T	T	2	6	1	1	1	3	T	1	1	1	2	T	1	7	9
Unidentifiable	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T

T – trace, value less than 0.05

ADEM Watermark

Table 4. Relative abundance (percent) of families of fish eggs and larvae collected in ichthyoplankton samples at intake and river (ORM 945.7) transects in the vicinity of BFN from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

	Year 1			Year 2			Combined		
Family	**Intake**	**River**	**Total**	**Intake**	**River**	**Total**	**Intake**	**River**	**Total**
EGGS									
Sciaenidae	79.9	94.2	90.1	99.8	99.4	99.5	93.9	97.8	96.6
Clupeidae	18.8	5.4	9.3	0.2	0.5	0.4	5.8	2.0	3.2
Moronidae	0.4	0.2	0.3	-	-	-	0.1	0.1	0.1
Unidentifiable	0.5	0.1	0.2	-	T	T	0.1	T	0.1
Percidae	-	-	-	-	0.1	0.1	-	0.1	T
Atherinopsidae	0.4	0.1	0.1	-	-	-	0.1	T	T
Cyprinidae	-	0.1	T	-	-	-	-	T	T
LARVAE									
Clupeidae	89.3	93.7	91.6	77.8	88.8	84.4	83.4	90.9	87.6
Atherinopsidae	4.4	0.6	2.4	0.7	0.7	0.7	2.5	0.6	1.4
Moronidae	2.0	1.4	1.7	18.3	7.1	11.6	10.3	4.7	7.2
Centrarchidae	2.3	1.0	1.6	1.3	1.1	1.2	1.8	1.0	1.4
Sciaenidae	0.6	2.2	1.5	0.6	1.2	1.0	0.6	1.6	1.2
Cyprinidae	0.5	0.3	0.4	0.1	0.1	0.1	0.3	0.2	0.3
Catostomidae	0.3	0.5	0.4	0.4	0.7	0.6	0.3	0.6	0.5
Percidae	0.4	0.1	0.2	0.6	0.3	0.4	0.5	0.2	0.3
Unidentifiable	0.3	T	0.1	0.1	0.1	0.1	0.2	T	0.1
Ictaluridae	0.1	T	T	T	T	T	T	T	T
Fundulidae	T	-	T	-	-	-	T	-	T
Poeciliidae	T	-	T	-	-	-	T	-	T

T – trace, value less than 0.05

ADEM Watermark

Table 5. Average densities (number/1,000 m^3) during occurrence of fish eggs and larvae by sample period collected in ichthyoplankton samples at intake (outside skimmer wall) and river (TRM 294.5) transects from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

EGGS	YEAR 1	Intake						Reservoir							
Sample Period	Sample Date	Sciaenidae	Clupeidae	Unidentifiable	Atherinopsidae	Moronidae	Total	Sciaenidae	Clupeidae	Moronidae	Percidae	Unidentifiable	Atherinopsidae	Cyprinidae	Total
1	Feb 20-21, 2018														
2	Feb 26-27									2		1			3
3	Mar 6-7									2					2
4	Mar 13-15														
5	Mar 21-22														
6	Mar 27-30														
7	Apr 3-4											1			1
8	Apr 10-11				1	2	3								
9	Apr 17-18		4			1	5		5						5
10	Apr 24-25								1						1
11	May 2-3		5	2	2		10		1						1
12	May 8-9	18	141				159	1							1
13	May 16	14	18	1			33	49	93				1		143
14	May 22-23	124	7				131	35							35
15	May 28-30	552		1			553	822						1	823
16	Jun 6							71							71
17	Jun 13-14	1					1	4							4
18	Jun 20-21							193							193
19	Jun 26-28							2							2
20	Jul 2-4	14					14	4							4
21	Jul 11-12							458							458
22	Jul 18-19							0							
23	Jul 25-26							18							18
24	Aug 1-2	2					2	4							4
25	Aug 8-9							1							1
26	Aug 15-16	1					1								
27	Aug 23-24	13					13								
28	Sep 26-27														
29	Oct 23-24														
30	Nov 20-21														
31	Dec 27-28														
	YR 1 Average Density	**24.7**	**5.8**	**0.2**	**0.1**	**0.1**	**30.9**	**53.5**	**3.1**	**0.1**		**0.1**	**T**	**T**	**56.8**

ADEM Watermark

Table 5. (continued)

LARVAE	YEAR 1	Intake													Reservoir										
Sample Period	Sample Date	Clupeidae	Moronidae	Atherinopsidae	Centrarchidae	Sciaenidae	Percidae	Catostomidae	Cyprinidae	Unidentifiable	Ictaluridae	Fundulidae	Poeciliidae	Total	Clupeidae	Moronidae	Sciaenidae	Centrarchidae	Atherinopsidae	Catostomidae	Cyprinidae	Percidae	Unidentifiable	Ictaluridae	Total
1	Feb 20-21, 2018																								
2	Feb 26-27		2				2							5		1					3				4
3	Mar 6-7						11	2						13	1	3		2		4	1				10
4	Mar 13-15				2		1							4		1		1		2	1				5
5	Mar 21-22						32	6						39						1	3				4
6	Mar 27-30						11	16						27		2				20	3				24
7	Apr 3-4		1				36	17						54		12				1	9				22
8	Apr 10-11		208		8		11	17						244	11	58				2	3				73
9	Apr 17-18	5	297		5		26	31						363	55	87		21	1	126	4	2			296
10	Apr 24-25	56	103	4	2		12	5						182	390	203		11	4	26	2	3			638
11	May 2-3	137	4	2			1	7						151	683	32		2	8	2	2	1			730
12	May 8-9	1,152	7	21	1	1		1						1,183	6,324	35	2	1	7			1	1		6,372
13	May 16	13,088	14	63	9	1	2			1		2		13,182	6,883	13	1	3	20		1		1		6,921
14	May 22-23	4,428	8	518	74	22			5	2				5,058	14,265	3	4	16	7				1		14,296
15	May 28-30	12,452	108	681	63	59	1		41	34	1			13,440	1,584	17	545	32	8			1			2,187
16	Jun 6	711	4	273	3	74			2	1				1,070	136	2	133	4	8			4		1	286
17	Jun 13-14	374		11	88	81			5	2				562	266		56	34	36						392
18	Jun 20-21	451		12	141				1	12				617	106		1	15	1			11			133
19	Jun 26-28	199		16	69					4				287	176			40	36			1			254
20	Jul 2-4	732	1	10	66				49	2	6			867	14			35	25						75
21	Jul 11-12	20		8	52					4				84	19		1	7	8			41		10	86
22	Jul 18-19	76		4	47				28	6	10			170	22			19	16						57
23	Jul 25-26	54			35					17				105	78			23	4			40	4	2	152
24	Aug 1-2	125		3	174				49	15	2		1	370	52			54	7						113
25	Aug 8-9	20		2	9									31	9			14	0			8			31
26	Aug 15-16	82		36	17				15	2	2			154	14		1	4	2						20
27	Aug 23-24	22			4				12					37	14			1				3			18
28	Sep 26-27	2												2											
29	Oct 23-24																								
30	Nov 20-21																								
31	Dec 27-28																								
	YR 1 Average Density	**1,136.6**	**25.2**	**55.9**	**28.7**	**8.0**	**4.7**	**3.3**	**6.8**	**3.4**	**0.7**	**0.1**	**T**	**1,273.4**	**1,004.5**	**15.0**	**23.9**	**10.8**	**6.4**	**5.8**	**1.0**	**3.7**	**0.2**	**0.4**	**1,071.8**

ADEM Watermark

Table 5. (continued)

EGGS	YEAR 2	Intake						Reservoir							
Sample Period	Sample Date	Sciaenidae	Clupeidae	Unidentifiable	Atherinopsidae	Moronidae	Total	Sciaenidae	Clupeidae	Moronidae	Percidae	Unidentifiable	Atherinopsidae	Cyprinidae	Total
32	Jan 28-30, 2019														
33	Feb 27	NS	NS	NS	NS	NS	NS				3				3
34	Mar 6-7														
35	Mar 12-13														
36	Mar 19-21														
37	Mar 26-28		1				1								
38	Apr 2-4														
39	Apr 9-11								1						1
40	Apr 16-18							1							1
41	Apr 24-26		2				2	3	13						16
42	Apr 30-May 2	35					35	413	2						415
43	May 8-9	1,484	1				1,485	557	1						558
44	May 14-16							80	1						81
45	May 21-23	123					123	85							85
46	May 28-30	516					516	2,486							2,486
47	Jun 4-6	15					15	103							103
48	Jun 11-13	4					4	27							27
49	Jun 18-20							21							21
50	Jun 25-27							2							2
51	Jul 2-4							3							3
52	Jul 9-11							2							2
53	Jul 16-18														
54	Jul 23-25														
55	Jul 30-Aug 1														
56	Aug 6-8														
57	Aug 13-15											1			1
58	Aug 20-22														
59	Aug 27-29														
60	Sep 17-19														
61	Oct 28-30														
62	Nov 25-27														
63	Dec 17-19														
	YR 2 Average Density	**71.6**	**0.2**	**-**	**-**	**-**	**71.8**	**116.5**	**0.5**	**-**	**0.1**	**T**	**-**	**-**	**117.2**
	Average Density – Years Combined	**48.3**	**3.0**	**0.1**	**0.1**	**0.1**	**51.5**	**85.6**	**1.8**	**0.1**	**T**	**T**	**T**	**T**	**87.5**

ADEM Watermark

Table 5. (continued)

LARVAE	YEAR 2	Intake													Reservoir										
Sample Period	Sample Date	Clupeidae	Moronidae	Atherinopsidae	Centrarchidae	Sciaenidae	Percidae	Catostomidae	Cyprinidae	Unidentifiable	Ictaluridae	Fundulidae	Poeciliidae	Total	Clupeidae	Moronidae	Sciaenidae	Centrarchidae	Atherinopsidae	Catostomidae	Cyprinidae	Percidae	Unidentifiable	Ictaluridae	Total
32	Jan 28-30, 2019																								
33	Feb 27	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS											
34	Mar 6-7																								
35	Mar 12-13						17							17							3				3
36	Mar 19-21						29							29		6				1	7		1		15
37	Mar 26-28	10	17		6		33	6		2				74	3	17		2		5	4		1		32
38	Apr 2-4	8	249				13	20		5				295	5	232		2		32	19		5		294
39	Apr 9-11	206	2,930		4		54	53		11				3,258	138	709		30		142	18	1			1,038
40	Apr 16-18	1,181	413	1	5		15	53	1	3				1,672	1,453	312		11	1	90	13	5	14		1,899
41	Apr 24-26	3,652	1,964	1	1		41	30	2	13				5,704	1,397	926	1	3	1	45	26		4		2,402
42	Apr 30-May 2	1,425	918	4	2		31							2,380	5,670	783	5	9	7		14				6,490
43	May 8-9	4,873	921		1	39	15	1	2	3				5,856	5,951	257	108	1	24	11	14	5			6,371
44	May 14-16	7,066	110	14	7	56	10	1		1				7,266	1,285	77	85	6	40		5	5	1		1,504
45	May 21-23	860	7	7	4	43	2	1	4					929	4,685	7	25	6	26	1	1				4,751
46	May 28-30	9,457	9	131	97	89	1		7					9,791	11,506	2	165	112	187		1	14		1	11,987
47	Jun 4-6	2,083		114	368	28								2,593	9,044		157	275	13				4		9,493
48	Jun 11-13	282		7	9	2								301	44		5	3	5						58
49	Jun 18-20	2		1	2	1								7	1		5	6	3						15
50	Jun 25-27	2			5									7			2	1							3
51	Jul 2-4				6									6				3	1						4
52	Jul 9-11	2			12				36		1			51	3			2	2			9			15
53	Jul 16-18				3									3	1			4							4
54	Jul 23-25				5									5				2							2
55	Jul 30-Aug 1				4									4	1			2							3
56	Aug 6-8				2									2				3							3
57	Aug 13-15				5									5				6							6
58	Aug 20-22																	1							1
59	Aug 27-29														1										1
60	Sep 17-19																								
61	Oct 28-30																								
62	Nov 25-27																								
63	Dec 17-19																								
Year 2	**Average Density**	**1,023.3**	**240.7**	**9.0**	**17.3**	**8.5**	**8.4**	**5.3**	**1.7**	**1.3**	**T**	**-**	**-**	**1,315.5**	**1,271.9**	**102.1**	**17.3**	**15.4**	**9.5**	**10.0**	**3.9**	**1.2**	**0.9**	**T**	**1,432.0**
Years Combined	**Average Density**	**1,079.5**	**133.8**	**32.3**	**22.9**	**8.3**	**6.5**	**4.3**	**4.3**	**2.3**	**0.4**	**T**	**T**	**1,294.6**	**1,140.6**	**59.3**	**20.5**	**13.1**	**8.0**	**7.9**	**2.4**	**2.4**	**0.6**	**0.2**	**1,255.2**

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Table 6. Average densities (number/1,000 m^3) of fish eggs and larvae by family collected in day and night ichthyoplankton samples at intake and river (TRM 294.5) transects from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

YEAR 1	Intake			Reservoir										
	Day	Night		Day					Night					
Family			Intake Average	RDB*	MC-Bottom to Middepth	MC-Middepth to Surface	LDB*	Day Average	RDB*	MC-Bottom to Middepth	MC-Middepth to Surface	LDB*	Night Average	River Average
EGGS														
Sciaenidae	22.7	26.6	24.7	3.7	83.0	54.7	64.3	51.4	1.4	92.2	73.8	54.4	55.6	53.5
Clupeidae	7.0	4.7	5.8	22.0	0.5	0.5	1.2	6.0	-	0.2	-	0.2	0.1	3.1
Moronidae	0.1	0.2	0.1	-	-	0.7	-	0.2	-	0.2	-	-	0.1	0.1
Unidentifiable	0.1	0.2	0.2	0.2	-	-	0.2	0.1	-	-	-	-	-	0.1
Atherinopsidae	0.2	-	0.1	T	-	0.2	-	0.1	-	-	-	-	-	T
Cyprinidae	-	-	-	-	-	-	-	-	-	-	0.2	-	0.1	T
LARVAE														
Clupeidae	1,241.5	1,034.7	1,136.6	942.3	668.2	1,122.9	1,051.2	946.1	1,711.0	844.6	738.6	961.7	1,062.9	1,004.5
Atherinopsidae	51.3	60.3	55.9	12.0	0.9	10.2	1.8	6.3	11.9	1.4	7.0	6.0	6.5	6.4
Moronidae	23.4	26.8	25.2	19.9	12.5	12.1	8.3	13.2	27.8	21.1	11.0	7.4	16.8	15.0
Centrarchidae	30.7	26.8	28.7	22.0	4.2	9.5	5.1	10.2	20.8	3.0	11.7	10.6	11.5	10.8
Sciaenidae	9.2	6.9	8.0	2.8	32.4	10.7	58.1	26.1	4.7	31.4	7.7	43.1	21.8	23.9
Cyprinidae	7.0	6.7	6.8	2.3	3.7	4.2	3.5	3.4	1.2	4.8	5.4	4.8	4.1	3.7
Catostomidae	3.2	3.4	3.3	13.4	1.9	0.9	4.1	5.1	17.7	3.7	3.5	1.2	6.5	5.8
Percidae	5.3	4.1	4.7	2.1	0.5	0.2	2.3	1.3	0.7	0.7	0.9	0.5	0.7	1.0
Unidentifiable	3.7	3.1	3.4	-	0.5	0.2	0.5	0.3	0.2	-	-	0.5	0.2	0.2
Ictaluridae	0.6	0.8	0.7	-	0.5	0.5	1.4	0.6	-	0.5	0.5	-	0.2	0.4
Fundulidae	0.2	-	0.1	-	-	-	-	-	-	-	-	-	-	-
Poeciliidae	0.1	-	T	-	-	-	-	-	-	-	-	-	-	-
EGGS														
Total	**30.0**	**31.7**	**30.9**	**25.9**	**83.4**	**56.1**	**65.7**	**57.8**	**1.4**	**92.7**	**74.1**	**54.6**	**55.8**	**56.8**
LARVAE														
Total	**1,376.1**	**1,173.7**	**1,273.4**	**1,016.8**	**725.2**	**1,171.5**	**1,136.2**	**1,012.5**	**1,795.9**	**911.1**	**786.3**	**1,035.7**	**1,131.2**	**1,071.8**

ADEM Watermark

Table 6. (continued)

YEAR 2	Intake			Reservoir											
	Day	Night		Day					Night						
Family			Intake Average	RDB**	MC**-Bottom to Middepth	MC-Middepth to Surface	LDB**	Day Average	RDB	MC-Bottom to Middepth	MC-Middepth to Surface	LDB	Night Average	River Average
EGGS															
Sciaenidae	9.6	133.5	71.6	3.9	20.8	24.4	62.1	27.9	11.8	375.5	227.2	203.0	204.8	116.5
Clupeidae	0.2	0.1	0.2	-	0.2	-	0.4	0.2	3.1	0.2	0.2	-	0.9	0.5
Percidae	-	-	-	-	0.8	-	-	0.2	-	-	-	-	-	0.1
Unidentifiable	-	-	-	-	-	-	-	-	-	-	-	0.2	0.1	T
LARVAE															
Clupeidae	702.1	1,343.7	1,023.3	4,572.3	629.4	448.4	401.3	1,500.3	2,546.0	890.8	521.6	215.4	1,044.4	1,271.9
Moronidae	173.0	308.4	240.7	215.5	93.3	76.9	27.7	102.9	242.0	66.1	74.3	25.2	102.0	102.4
Centrarchidae	7.0	27.5	17.3	62.1	10.4	7.6	11.8	22.8	22.5	4.0	3.3	1.8	7.9	15.4
Sciaenidae	5.0	12.0	8.5	7.0	16.6	9.2	27.7	15.2	3.3	30.1	19.8	24.3	19.4	17.3
Atherinopsidae	1.5	16.5	9.0	7.9	-	1.3	22.3	7.9	34.4	3.5	0.9	5.8	11.1	9.5
Catostomidae	6.0	4.6	5.3	3.2	6.6	6.1	9.2	6.3	9.1	5.7	16.2	23.8	13.7	10.0
Percidae	10.1	6.6	8.4	6.3	2.4	2.2	1.8	3.2	6.5	2.7	3.6	2.7	3.8	3.5
Cyprinidae	1.2	2.2	1.7	0.5	0.2	0.2	1.3	0.6	1.6	0.2	1.3	4.0	1.8	1.2
Unidentifiable	1.9	0.6	1.3	0.5	1.8	0.7	0.4	0.8	-	1.3	1.8	0.4	0.9	0.9
Ictaluridae	0.1	-	T	-	-	-	-	-	-	-	0.2	-	0.1	T
EGGS															
Total	**9.8**	**133.6**	**71.8**	**3.9**	**21.8**	**24.4**	**62.5**	**28.2**	**14.9**	**375.7**	**227.4**	**203.2**	**205.7**	**117.2**
LARVAE															
Total	**907.9**	**1,722.1**	**1,315.5**	**4,875.4**	**760.8**	**552.7**	**503.6**	**1,660.0**	**2,865.4**	**1,004.4**	**643.1**	**303.5**	**1,205.0**	**1,432.0**

***Intake densities are averages of two samples; T-trace, or value less than 0.05.**
****MC – Mid-channel, RDB – right descending bank, LDB – left descending bank**

ADEM Watermark

Table 7. Flow* (m^3/day), hydraulic entrainment, and water temperatures on sample dates and total flow for each week/month at Browns Ferry Nuclear Plant from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

YEAR 1		On Sample Date			Totals for Sample Week/Month*		
Sample Period	Sample Date(s)	CCW Intake Flow (x 10^6)	River Flow (x 10^6)	Water Temperature (°F)	CCW Intake Flow (x 10^6)	River Flow (x 10^6)	Percent Water Entrained
1	Feb 20-21, 2018	7.2	538.7	56.2	51.1	4,250.0	1.2
2	Feb 26-27	7.7	722.0	57.6	52.9	4,345.6	1.2
3	Mar 6-7	6.8	297.0	55.2	47.4	2,288.5	2.1
4	Mar 13-15	6.8	230.5	51.0	47.4	1,546.3	3.1
5	Mar 21-22	6.8	133.5	53.1	49.3	925.8	5.3
6	Mar 27-30	9.0	114.3	56.6	59.1	754.0	7.8
7	Apr 3-4	9.7	73.1	63.1	59.1	550.2	10.7
8	Apr 10-11	11.5	63.9	59.4	79.0	511.4	15.4
9	Apr 17-18	11.5	167.0	59.4	79.9	1,178.2	6.8
10	Apr 24-25	10.6	264.7	63.6	74.4	1,663.1	4.5
11	May 2-3	11.5	107.9	68.5	76.2	949.1	8.0
12	May 8-9	9.7	70.8	76.2	70.7	432.5	16.3
13	May 16	10.6	62.2	83.5	76.2	544.9	14.0
14	May 22-23	11.5	106.1	81.4	80.8	743.7	10.9
15	May 28-30	11.5	171.0	79.1	79.0	1,334.9	5.9
16	Jun 6	10.6	243.2	79.9	74.4	1,414.9	5.3
17	Jun 13-14	10.6	93.0	82.2	74.4	696.5	10.7
18	Jun 20-21	10.6	69.9	85.9	74.4	466.9	15.9
19	Jun 26-28	10.6	107.7	84.5	74.4	907.5	8.2
20	Jul 2-4	11.5	146.4	85.5	80.8	907.2	8.9
21	Jul 11-12	11.5	66.9	87.8	80.8	487.1	16.6
22	Jul 18-19	11.5	54.8	86.5	80.8	447.1	18.1
23	Jul 25-26	11.5	66.9	85.2	80.8	462.7	17.5
24	Aug 1-2	11.5	81.1	84.5	80.8	507.8	15.9
25	Aug 8-9	11.5	104.5	86.9	80.8	651.9	12.4
26	Aug 15-16	11.5	83.3	87.4	80.8	596.0	13.6
27	Aug 23-24	11.5	77.6	82.9	150.1	979.1	15.3
28	Sep 26-27	11.5	211.6	80.3	346.3	3,744.5	9.2
29	Oct 23-24	6.0	78.1	66.9	273.9	3,511.8	7.8
30	Nov 20-21	9.1	259.9	53.0	262.9	6,049.1	4.3
31	Dec 27-28	11.5	364.6	47.6	353.2	9,227.1	3.8

ADEM Watermark

Table 7. (continued)

YEAR 2		On Sample Date			Totals for Sample Week/Month*		
Sample Period	Sample Date(s)	CCW Intake Flow (x 10^6)	River Flow (x 10^6)	Water Temperature (°F)	CCW Intake Flow (x 10^6)	River Flow (x 10^6)	Percent Water Entrained
32	Jan 28-30, 2019	9.7	338.5	46.5	349.6	10,958.5	3.2
33	Feb 27	10.6	722.0	51.0	292.9	11,747.7	2.5
34	Mar 6-7	6.8	563.0	46.7	59.9	4,109.3	1.5
35	Mar 12-13	6.8	573.2	52.7	47.4	3,744.3	1.3
36	Mar 19-21	7.7	305.9	54.1	50.2	2,535.1	2.0
37	Mar 26-28	7.7	170.3	56.2	53.9	1,403.9	3.8
38	Apr 2-4	10.1	33.0	58.5	61.1	479.1	12.8
39	Apr 9-11	10.6	183.5	64.5	75.3	800.1	9.4
40	Apr 16-18	11.5	179.0	65.4	79.0	1,289.5	6.1
41	Apr 24-26	10.9	164.8	66.4	76.2	1,265.3	6.0
42	Apr 30-May 2	11.5	115.5	73.3	80.8	792.9	10.2
43	May 8-9	11.5	157.5	73.6	80.8	960.6	8.4
44	May 14-16	11.5	206.3	71.2	79.9	1,357.3	5.9
45	May 21-23	10.9	88.0	77.4	79.0	893.9	8.8
46	May 28-30	10.6	49.5	83.5	74.4	396.4	18.8
47	Jun 4-6	10.6	95.5	79.4	74.4	486.4	15.3
48	Jun 11-13	10.6	113.9	77.3	74.4	782.5	9.5
49	Jun 18-20	10.6	106.3	80.4	74.4	664.0	11.2
50	Jun 25-27	10.6	116.6	82.4	74.4	798.0	9.3
51	Jul 2-4	11.5	52.0	88.7	77.1	489.2	15.8
52	Jul 9-11	11.5	64.3	86.3	80.8	394.2	20.5
53	Jul 16-18	11.5	86.2	88.1	80.8	618.7	13.1
54	Jul 23-25	11.5	139.5	84.1	80.8	757.1	10.7
55	Jul 30-Aug 1	11.5	84.9	85.9	80.8	663.9	12.2
56	Aug 6-8	11.5	81.3	85.5	80.8	581.5	13.9
57	Aug 13-15	11.5	80.8	86.3	80.8	567.2	14.2
58	Aug 20-22	11.5	77.8	89.8	80.8	490.0	16.5
59	Aug 27-29	11.5	74.6	83.3	103.9	644.7	16.1
60	Sep 17-19	11.5	68.5	87.0	312.5	1,905.3	16.4
61	Oct 28-30	11.5	118.5	63.9	357.9	1,901.6	18.8
62	Nov 25-27	10.9	159.9	52.2	338.0	3,570.9	9.5
63	Dec 17-19	10.6	239.9	49.5	342.2	7,649.5	4.5
YEAR 1	**Total**	**315.6**	**5,232.2**		**3,232.0**	**53,075.7**	
	Sample Period Average**	**10.2**	**168.8**	**72.0**	**104.3**	**1,712.1**	**9.6**
YEAR 2	**Total**	**339.7**	**5,610.2**		**3,934.9**	**65,698.4**	
	Sample Period Average	**10.6**	**175.3**	**72.7**	**123.0**	**2,053.1**	**10.3**

***Flows are totals for the sample period (weekly totals from March through September and monthly totals from October through February). River flows were obtained from TVA's Reservoir Operations database and CCW intake flows from BFN plant**

****Calculated by averaging totals for each sample period**

ADEM Watermark

Table 8. Estimated annual numbers entrained at the Browns Ferry Nuclear plant CCW intake, annual numbers transported past the plant, and percent of fish eggs and larvae in the river that are entrained at the plant's CCW intake from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

YEAR 1		Eggs			Larvae		
Sample Period	Sample Date	Numbers Entrained	Numbers Transported Past BFN	Percent Entrainment	Numbers Entrained	Numbers Transported Past BFN	Percent Entrainment
1	Feb 20-21, 2018	0	0	0.0	0	0	0.0
2	Feb 26-27	0	11,392,685	0.0	259,206	18,987,808	1.4
3	Mar 6-7	0	4,095,931	0.0	618,083	22,527,620	2.7
4	Mar 13-15	0	0	0.0	171,538	7,011,479	2.4
5	Mar 21-22	0	0	0.0	1,905,790	3,374,721	56.5
6	Mar 27-30	0	0	0.0	1,573,570	18,225,689	8.6
7	Apr 3-4	0	498,116	0.0	3,186,438	11,954,792	26.7
8	Apr 10-11	263,523	0	*	19,237,206	37,367,514	51.5
9	Apr 17-18	377,869	5,392,853	7.0	29,001,413	348,378,331	8.3
10	Apr 24-25	0	1,493,163	0.0	13,519,464	1,061,638,873	1.3
11	May 2-3	737,610	856,722	86.1	11,525,160	693,087,878	1.7
12	May 8-9	11,272,735	399,518	2821.6	83,646,958	2,755,872,982	3.0
13	May 16	2,498,215	77,856,242	3.2	1,004,460,954	3,771,417,812	26.6
14	May 22-23	10,578,294	26,373,527	40.1	408,621,694	10,631,747,686	3.8
15	May 28-30	43,648,763	1,098,096,397	4.0	1,061,170,355	2,919,475,481	36.3
16	Jun 6	0	100,370,738	0.0	79,549,897	405,294,499	19.6
17	Jun 13-14	88,674	2,539,316	3.5	41,765,419	272,976,441	15.3
18	Jun 20-21	0	90,155,978	0.0	45,909,234	62,088,551	73.9
19	Jun 26-28	0	1,633,428	0.0	21,351,288	230,313,405	9.3
20	Jul 2-4	1,168,834	3,287,493	35.6	70,032,625	68,215,473	102.7
21	Jul 11-12	0	223,060,545	0.0	6,821,118	41,905,699	16.3
22	Jul 18-19	0	0	0.0	13,728,325	25,327,663	54.2
23	Jul 25-26	0	8,445,853	0.0	8,493,326	70,382,109	12.1
24	Aug 1-2	184,943	1,847,809	10.0	29,868,299	57,282,073	52.1
25	Aug 8-9	0	591,197	0.0	2,544,486	20,100,683	12.7
26	Aug 15-16	95,814	0	*	12,455,848	12,075,852	103.1
27	Aug 23-24	1,974,033	0	*	5,563,184	17,533,966	31.7
28	Sep 26-27	0	0	0.0	804,910	0	*
29	Oct 23-24	0	0	0.0	0	0	0.0
30	Nov 20-21	0	0	0.0	0	0	0.0
31	Dec 27-28	0	0	0.0	0	0	0.0

ADEM Watermark

Table 8. (continued)

YEAR 2		Eggs			Larvae		
Sample Period	Sample Date	Numbers Entrained	Numbers Transported Past BFN	Percent Entrainment	Numbers Entrained	Numbers Transported Past BFN	Percent Entrainment
32	Jan 28-30, 2019	0	0	0.0	0	0	0.0
33	Feb 27	NS	33,140,095	*	NS	0	*
34	Mar 6-7	0	0	0.0	0	0	0.0
35	Mar 12-13	0	0	0.0	818,920	9,686,962	8.5
36	Mar 19-21	0	0	0.0	1,458,625	38,796,299	3.8
37	Mar 26-28	65,260	0	*	3,980,844	44,250,467	9.0
38	Apr 2-4	0	0	0.0	18,046,598	141,068,900	12.8
39	Apr 9-11	0	730,884	0.0	245,244,961	830,284,056	29.5
40	Apr 16-18	0	1,172,127	0.0	132,024,214	2,448,574,154	5.4
41	Apr 24-26	182,276	19,705,518	0.9	434,638,179	3,039,286,335	14.3
42	Apr 30-May 2	2,852,936	329,112,693	0.9	192,287,865	5,145,413,384	3.7
43	May 8-9	119,967,812	535,864,875	22.4	473,144,083	6,119,770,455	7.7
44	May 14-16	0	110,369,510	0.0	580,343,692	2,041,215,873	28.4
45	May 21-23	9,686,695	76,268,680	12.7	73,384,054	4,246,740,689	1.7
46	May 28-30	38,389,142	985,430,063	3.9	728,108,347	4,751,244,764	15.3
47	Jun 4-6	1,101,677	49,927,663	2.2	192,793,475	4,617,241,953	4.2
48	Jun 11-13	264,200	21,174,314	1.2	22,368,960	45,080,797	49.6
49	Jun 18-20	0	14,010,801	0.0	526,233	9,746,644	5.4
50	Jun 25-27	0	1,377,723	0.0	515,071	2,066,585	24.9
51	Jul 2-4	0	1,321,011	0.0	463,018	1,761,348	26.3
52	Jul 9-11	0	708,034	0.0	4,152,918	6,018,288	69.0
53	Jul 16-18	0	0	0.0	282,438	2,728,627	10.4
54	Jul 23-25	0	0	0.0	388,796	1,376,581	28.2
55	Jul 30-Aug 1	0	0	0.0	287,117	1,778,815	16.1
56	Aug 6-8	0	0	0.0	191,994	1,572,106	12.2
57	Aug 13-15	0	509,542	0.0	383,608	3,566,797	10.8
58	Aug 20-22	0	0	0.0	0	437,986	0.0
59	Aug 27-29	0	0	0.0	0	575,204	0.0
60	Sep 17-19	0	0	0.0	0	0	0.0
61	Oct 28-30	0	0	0.0	0	0	0.0
62	Nov 25-27	0	0	0.0	0	0	0.0
63	Dec 17-19	0	0	0.0	0	0	0.0
YR 1 Annual ENT		**72,889,307**	**1,658,387,510**	**4.4**	**2,977,785,786**	**23,584,565,080**	**12.6**
YR 2 Annual ENT		**172,509,999**	**2,180,823,532**	**7.9**	**3,105,834,009**	**33,550,284,068**	**9.3**
Annual ENT Both Years		**245,399,306**	**3,839,211,042**	**6.4**	**6,083,619,795**	**57,134,849,148**	**10.6**
Average Annual ENT		**3,958,053**	**60,939,858**		**98,122,900**	**906,902,367**	

***Collected in intake samples, but not in river samples; therefore, entrainment estimate not possible; NS-no sample collected due to dangerous weather conditions**

ADEM Watermark

Table 9. Estimated annual numbers (x 10^5) by sample period (S.P.) of all taxa entrained at the Browns Ferry Nuclear Plant's CCW intake from February 2018 to December 2018 (Year 1) and January 2019 to December 2019 (Year 2)

YEAR 1		Eggs						Larvae												
Sample Period	Sample Week/Month	Sciaenidae	Clupeidae	Moronidae	Unidentifiable	Atherinopsidae	Total	Clupeidae	Atherinopsidae	Moronidae	Centrarchidae	Sciaenidae	Cyprinidae	Catostomidae	Percidae	Unidentifiable	Ictaluridae	Fundulidae	Poeciliidae	Total	Total Eggs and Larvae
1	Feb 20-21, 2018																				
2	Feb 26-27									1					1					3	3
3	Mar 6-7													1	5					6	6
4	Mar 13-15										1				1					2	2
5	Mar 21-22													3	16					19	19
6	Mar 27-30													9	6					16	16
7	Apr 3-4									1				10	21					32	32
8	Apr 10-11			2		1	3			164	6			13	9					192	195
9	Apr 17-18		3	1			4	4		237	4			25	21					290	294
10	Apr 24-25							41	3	76	2			4	9					135	135
11	May 2-3		4		2	2	7	104	2	3				6	1					115	123
12	May 8-9	13	100				113	814	15	5	1	1		1						836	949
13	May 16	11	13		1		25	9,973	48	11	7	1			2	1		2		10,045	10,070
14	May 22-23	100	6				106	3,578	418	7	60	18	4			2				4,086	4,192
15	May 28-30	436			1		436	9,832	538	85	50	47	32		1	27	1			10,612	11,048
16	Jun 6							529	203	3	2	55	2			1				795	795
17	Jun 13-14	1					1	278	8		66	60	4			2				418	419
18	Jun 20-21							336	9		105		1			9				459	459
19	Jun 26-28							148	12		52					3				214	214
20	Jul 2-4	12					12	591	8	1	54		40			2	5			700	712
21	Jul 11-12							17	7		42					3				68	68
22	Jul 18-19							61	3		38		22			5	8			137	137
23	Jul 25-26							43			28					14				85	85
24	Aug 1-2	2					2	101	3		141		40			12	2		1	299	301
25	Aug 8-9							16	2		8									25	25
26	Aug 15-16	1					1	66	29		13		12			2	2			125	126
27	Aug 23-24	20					20	32			5		18							56	75
28	Sep 26-27							8												8	8
29	Oct 23-24																				
30	Nov 20-21																				
31	Dec 27-28																				

ADEM Watermark

Table 9. (continued)

Sample Period	YEAR 2 Sample Week/Month	Eggs						Larvae												Total Eggs and Larvae
		Sciaenidae	Clupeidae	Moronidae	Unidentifiable	Atherinopsidae	Total	Clupeidae	Atherinopsidae	Moronidae	Centrarchidae	Sciaenidae	Cyprinidae	Catostomidae	Percidae	Unidentifiable	Ictaluridae	Fundulidae	Poeciliidae	Total	
32	Jan 28-30, 2019																				
33	Feb 27	NS	NS	NS	NS	NS	NS														
34	Mar 6-7																				
35	Mar 12-13														8					8	8
36	Mar 19-21														15					15	15
37	Mar 26-28		1				1	5		9	3			3	18	1				40	40
38	Apr 2-4							5		152				12	8	3				180	180
39	Apr 9-11							155		2,206	3			40	41	8				2,452	2,452
40	Apr 16-18							933	1	326	4		1	42	12	3				1,320	1,320
41	Apr 24-26		2				2	2,782	1	1,496	1		2	23	31	10				4,346	4,348
42	Apr 30-May 2	29					29	1,152	3	742	2				25					1,923	1,951
43	May 8-9	1,199	1				1,200	3,937		744	1	32	2	1	12	3				4,731	5,931
44	May 14-16							5,644	11	88	5	45		1	8	1				5,803	5,803
45	May 21-23	97					97	679	6	6	3	34	3	1	2					734	831
46	May 28-30	384					384	7,033	98	7	72	66	5		1					7,281	7,665
47	Jun 4-6	11					11	1,549	84		274	21								1,928	1,939
48	Jun 11-13	3					3	210	5		7	2								224	226
49	Jun 18-20							2	1		2	1								5	5
50	Jun 25-27							2			3									5	5
51	Jul 2-4										5									5	5
52	Jul 9-11							2			9		29				1			42	42
53	Jul 16-18										3									3	3
54	Jul 23-25										4									4	4
55	Jul 30-Aug 1										3									3	3
56	Aug 6-8										2									2	2
57	Aug 13-15										4									4	4
58	Aug 20-22																				
59	Aug 27-29																				
60	Sep 17-19																				
61	Oct 28-30																				
62	Nov 25-27																				
63	Dec 17-19																				
Total	**Year 1**	**595**	**125**	**3**	**4**	**3**	**729**	**26,573**	**1,306**	**594**	**684**	**182**	**174**	**71**	**93**	**81**	**17**	**2**	**1**	**29,778**	**30,507**
Total	**Year 2**	**1,722**	**3**	**-**	**-**	**-**	**1,725**	**24,089**	**210**	**5,776**	**409**	**201**	**42**	**123**	**179**	**29**	**1**	**-**	**-**	**31,058**	**32,783**
Total	**Both Years**	**2,316**	**129**	**3**	**4**	**3**	**2,454**	**50,662**	**1,516**	**6,370**	**1,092**	**383**	**216**	**194**	**272**	**110**	**18**	**2**	**1**	**60,836**	**63,290**

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Table 10. Estimated percent of each family of fish eggs and larvae in the river that were entrained at Browns Ferry Nuclear Plant's CCW intake from February 2018 to January 2019 (Year 1) and February 2019 to December 2019 (Year 2) by diel period (day: 06:00–18:00; night: 19:00–05:00

	Year 1		Year 2		Years Combined	
Taxa	**Day**	**Night**	**Day**	**Night**	**Day**	**Night**
Fish Eggs						
Sciaenidae	1.7	2.0	1.6	5.2	1.7	4.1
Clupeidae	5.5	111.8	5.9	0.2	5.5	13.9
Unidentifiable	1.5	*	-	T	1.5	30.4
Moronidae	0.7	4.2	-	-	0.7	4.2
Atherinopsidae	22.7	-	-	-	22.7	-
Percidae	-	-	T	-	T	-
Cyprinidae	-	T	-	-	-	T
All Eggs	**2.0**	**2.4**	**1.5**	**5.2**	**1.8**	**4.2**
Fish Larvae						
Clupeidae	7.1	5.5	2.3	6.8	4.1	6.2
Moronidae	5.8	4.8	5.8	12.5	5.8	11.1
Atherinopsidae	35.5	48.4	1.3	7.7	19.7	23.1
Centrarchidae	13.8	11.4	2.0	23.1	6.6	15.2
Sciaenidae	1.0	0.9	1.6	3.5	1.1	1.7
Catostomidae	1.9	1.4	3.6	1.2	2.7	1.3
Percidae	12.5	15.1	8.9	4.6	9.8	6.2
Cyprinidae	12.3	14.1	8.2	7.9	11.5	11.9
Unidentifiable	88.5	169.6	2.1	*	12.2	7.9
Ictaluridae	6.9	29.2	*	T	7.9	25.0
Fundulidae	*	-	-	-	*	-
Poeciliidae	*	-	-	-	*	-
Total Larvae	**7.0**	**5.7**	**2.7**	**7.4**	**4.2**	**6.6**
Total Fish Eggs and Larvae	**6.7**	**5.5**	**2.6**	**7.1**	**4.1**	**6.4**

"--" denotes no fish collected in either intake or river sample; "0.0" denotes fish only collected in river samples; *denotes fish only collected in intake samples; therefore, no entrainment estimate can be made; "T" denotes percentage less than 0.05

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Table 11. Summary statistics (mean, maximum, minimum, and median dimensions) and standard deviations of head capsule measurements describing the sample composition of each taxon collected in ichthyoplankton samples near Sequoyah Nuclear Plant from March 2015 through September 2015

			Total Length (mm)					Head Depth (mm)					Head Width (mm)				
Taxon	N	SPC*	Mean	Max	Min	Median	St. Dev	Mean	Max	Min	Median	St. Dev	Mean	Max	Min	Median	St. Dev
Atherinopsids (Silverside)	54	8	7.6	13.7	4.0	7.3	2.4980	1.0	1.8	0.4	1.0	0.3218	1.0	1.6	0.5	7.3	0.2725
Blue catfish	1	1	19.0	19.0	19.0	19.0	--**	3.3	3.3	3.3	3.3	--	3.2	3.2	3.2	19.0	--
Channel catfish	5	4	17.4	19.3	16.4	17.0	1.1563	2.7	3.1	2.5	2.6	0.2490	3.1	3.6	2.8	17.0	0.3286
Clupeids	327	13	8.6	19.3	3.5	7.8	3.9706	0.7	6.0	0.3	0.6	0.5037	0.8	1.9	0.3	7.8	0.3807
Cyprinid (Pimephales group)	4	4	5.9	6.2	5.4	5.9	0.3697	0.6	0.7	0.4	0.7	0.1414	0.8	0.9	0.7	5.9	0.0816
Dorosoma spp.	6	2	20.7	21.7	20.0	20.6	0.6986	2.0	2.7	1.7	1.9	0.3882	1.9	2.1	1.7	20.6	0.1517
Freshwater drum	314	21	4.4	7.3	1.7	4.4	0.8023	0.7	5.0	0.3	0.7	0.3353	0.6	1.3	0.2	4.4	0.1868
Gizzard shad	75	6	24.7	39.0	19.5	23.3	4.8053	4.0	8.4	2.2	3.3	1.5383	2.5	4.7	1.6	23.3	0.7061
Grass carp	1	1	7.1	7.1	7.1	7.1	--	0.8	0.8	0.8	0.8	--	0.9	0.9	0.9	7.1	--
Ictiobinae (Buffalo or Carpsucker)	39	3	8.3	9.5	7.5	8.3	0.4334	1.0	1.0	0.8	1.0	0.0556	1.1	1.3	0.2	8.3	0.1715
Inland silverside	35	4	19.8	32.9	11.6	19.7	4.6864	2.3	3.5	1.4	2.3	0.5338	2.2	3.0	1.4	19.7	0.4025
Lepomis spp.	238	11	6.8	17.2	4.9	5.9	1.9526	0.9	3.2	0.5	0.8	0.4076	0.9	2.3	0.6	5.9	0.2737
Micropterus (not smallmouth bass) spp.	1	1	8.5	8.5	8.5	8.5	--	1.5	1.5	1.5	1.5	--	1.4	1.4	1.4	8.5	--
Morone spp.	135	9	7.8	15.3	5.2	7.4	2.0488	1.1	2.7	0.2	1.0	0.4066	1.0	2.0	0.2	7.4	0.2532
Morone (not *M. saxatilis*) spp.	204	9	4.4	5.5	3.4	4.2	0.4826	0.6	1.7	0.4	0.6	0.1236	0.6	6.0	0.4	4.2	0.3943
Pomoxis spp.	181	9	6.2	15.4	4.0	5.4	1.9349	0.9	2.8	0.6	0.8	0.3268	0.9	2.2	0.6	5.4	0.2223
Sauger	1	1	7.9	7.9	7.9	7.9	--	1.2	1.2	1.2	1.2	--	1.2	1.2	1.2	7.9	--
Skipjack	1	1	22.4	22.4	22.4	22.4	--	3.0	3.0	3.0	3.0	--	2.2	2.2	2.2	22.4	--
Threadfin shad	116	6	28.0	71.0	19.2	25.0	10.4658	5.1	13.0	2.4	4.5	2.5825	2.9	6.5	1.8	25.0	1.0959
Unidentifiable Darter (not *P. caprodes*)	2	2	9.4	9.8	8.9	9.4	0.6364	1.1	1.2	1.0	1.1	0.1414	1.1	1.1	1.0	9.4	0.0707
Unidentifiable Darter (*P. caprodes* type)	1	1	7.8	7.8	7.8	7.8	--	0.9	0.9	0.9	0.9	--	1.0	1.0	1.0	7.8	--
Walleye	1	1	17.9	17.9	17.9	17.9	--	2.9	2.9	2.9	2.9	--	3.4	3.4	3.4	17.9	--
White Bass	8	2	17.0	22.6	13.8	16.1	3.0563	3.0	3.9	2.3	2.9	0.5566	2.2	2.8	1.7	16.1	0.4086
White crappie	1	1	16.5	16.5	16.5	16.5	--	3.4	3.4	3.4	3.4	--	2.2	2.2	2.2	16.5	--
Yellow perch	11	4	8.3	11.3	6.7	7.8	1.4570	1.0	1.6	0.7	1.0	0.2505	0.9	1.4	0.3	7.8	0.2700

*** SPC denotes number of sample periods the taxa was collected (out of 27)**

****-- one individual measured; therefore, standard deviation could not be calculated**

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Table 12. Total CCW intake flow (m^3 x 10^5/day) by month at Browns Ferry Nuclear plant from 2014 through 2019

Month	2014	2015	2016	2017	2018	2019
January	2,949.8	3,402.5	3,578.0	3,265.6	3,320.7	3,495.8
February	2,160.0	3,073.2	3,347.2	2,915.9	2,501.7	2,928.5
March	2,559.8	2,853.7	3,578.0	2,590.4	2,254.4	2,344.6
April	2,854.6	2,984.9	3,214.5	3,186.9	3,232.9	3,261.8
May	3,241.8	3,285.6	3,348.3	3,403.4	3,403.4	3,476.9
June	3,292.7	3,292.7	3,462.6	3,297.2	3,186.9	3,186.9
July	3,402.5	3,402.5	3,578.0	3,293.2	3,578.7	3,569.5
August	3,373.3	3,402.5	3,293.2	3,293.2	3,578.7	3,578.7
September	3,234.3	3,292.7	3,196.1	3,463.3	3,463.3	3,124.9
October	2,546.7	3,366.0	2,554.4	3,578.7	2,739.1	3,578.7
November	3,292.7	3,400.3	3,278.8	3,325.4	2,628.9	3,380.1
December	3,402.5	3,578.0	3,504.5	3,376.1	3,532.1	3,422.2
Average	**3,025.9**	**3,277.9**	**3,327.8**	**3,249.1**	**3,118.4**	**3,279.0**

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Appendix A



Tennessee Valley Authority
River and Reservoir Compliance Monitoring

Quality Assurance/ Quality Control Program

Rev. 1

Title: ICHTHYOPLANKTON SAMPLE PROCESSING

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1.0 OBJECTIVE

To prescribe the standard method used by Environmental & Technology (E&T) for processing ichthyoplankton samples, including sorting (the removal and preliminary categorization of fish eggs and larvae), identification (classification of specimens to the lowest possible taxon), and length measurement of larvae. The sample processing procedures used in TVA laboratories are generally accepted by the profession.

2.0 SCOPE

Procedures are applicable to all ichthyoplankton samples. Ichthyoplankton data are typically collected as part of power plant site assessments and preoperational and operational monitoring studies. Considerations such as sensitivity, accuracy, precision, and interferences are discussed.

3.0 REFERENCES

3.1 Hogue, J.J. Jr., R. Wallus, and L. K. Kay. 1976. Preliminary guide to the identification of larva fishes in the Tennessee River. Tennessee Valley Authority Tech. Note B-19. 66 pages.

3.2 S&F OPS-FO-BR-22.1, “Receipt and Handling of Biological Samples.”

3.3 S&F OPS-FO-BR-23.5, “Ichthyoplankton Sampling.”

4.0 ABBREVIATIONS AND DEFINITIONS

4.1 E&T-- Environmental & Technology

4.2 ES&R-- Environmental Science & Resources

4.3 TL -- Total length

4.4 YOY -- Young-of-year

5.0 RESPONSIBILITIES

5.1 The Aquatic Management coordinator is responsible for coordinating with clients organizations and assigning specific projects to unit supervisors.

5.2 The Aquatic Management project manager, is responsible for scheduling the work; assigning qualified personnel to specific work; assuring that work is performed in a technically adequate, safe, and timely manner; providing adequate equipment and supplies; assuring that adequate records are kept; and coordinating with the E&T project leader.

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5.3 Aquatic Management Specialists processing fish samples are responsible for performing the work in accordance with this procedure and all other applicable procedures, keeping proper records, and reporting problems to the supervisor.

6.0 PROCEDURE

6.1 Equipment and Supplies

6.1.1 Sorting pans (black photo trays with approximate dimensions of 11 by 8-1/2 by 2-1/8 inches are preferred)

6.1.2 Flexible forceps

6.1.3 Bulb-type syringes

6.1.4 Washing sieve of 250-µm, mesh (Tyler equivalent 60 mesh)

6.1.5 Wide-mouth glass bottles, 1-oz capacity

6.1.6 Illuminated magnifiers, 5X

6.1.7 Digital counters

6.1.8 Squeeze bottles, 1-L capacity

6.1.9 Sample washdown sprayer (standard kitchen sing prayer)

6.1.10 Funnels

6.1.11 White adhesive tape

6.1.12 Waterproof paper

6.1.13 Wild M3 microscopes or equivalent (40X) equipped with polarizing filters

6.1.14 Petri dishes

6.1.15 Buffered formaldehyde solution, 5 percent, prepared as directed in attachment 1.

6.2 Sample Receipt and Storage

6.2.1 Samples shall have been collected, preserved, labeled, and transported or shipped to the laboratory.

6.2.2 Samples shall be received and handled as directed in reference 3.2, with the following specific forms used.

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6.2.2.1 Compare sample numbers on the transport invoices (attachment 2) with the sample numbers on the jar labels to ensure that all samples are accounted for. Place a check mark and enter the number of jars received. Report any defective samples to the supervisor.

6.2.2.2 Record all of the sample numbers in the larval fish laboratory log (attachment 4).

6.2.3 Record the sample number and collection date on an individual laboratory data form (Entrainment Laboratory Form, form TVA 20012B, attachment 5) for each sample entering the laboratory.

6.2.4. Temporarily store samples that cannot be immediately processed, as directed below.

6.2.4.1. Store all samples from an individual site together in chronological order.

6.2.4.2 Arrange samples collected on the same date in numerical order by sample number.

6.2.4.3 File laboratory data forms for stored samples in chronological sequence in the designated area of the laboratory.

6.3 Samples Preparation

6.3.1 Immediately prior to processing a set of samples, place the samples and corresponding laboratory data forms (arranged in the same sequence) in the designated area near the washing sink.

6.3.2 Process in order by date and sample number. When a sample is selected, record the samples number and date, sorting date, sorter's name or initials, and start time in the appropriate section of the time log (attachment 6).

6.3.3 Pour the sample into a 250-µm sieve and rinse with water to remove fixative and fumes. Thoroughly rinse and inspect the sample bottle and lid to ensure the removal of all sample contents. Save the internal label.

6.3.4 Remove the external label and store the jar and lid for reuse.

6.3.5 Thoroughly rinse the sample from the sieve into a sorting pan.

6.3.6 Take the sorting pan (with sample), internal label from the sample and the corresponding laboratory form to the sorting area. Record name and current date in the appropriate box on the laboratory data for (attachment 5).

6.4 Sorting

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6.4.1 Sorting consists of the removal, preliminary categorization, and enumeration of fish eggs and larvae from the sample. Larvae and eggs are preserved (in 1-oz bottles) with buffered formaldehyde as they are sorted and counted. Fish are categorized in various ways depending upon the individual contents of each sample and the expertise of the sorter. Perform the standard sorting procedures as directed below, measuring total lengths (TL) to the neatest mm.

6.4.1.1 Remove and bottle all eggs from the sample using forceps and/or bulb-type syringes, counting them with a digital counter as they removed.

6.4.1.2 Remove, count, and bottle all young-of-year (YOY) shad (clupeids) <20mm TL.

6.4.1.3 Remove, count, and bottle YOY shad ≥ 20 mm TL.

6.4.1.4 Remove and bottle all YOY nonshad.

6.4.1.5 Remove and bottle all non-YOY fish.

6.4.2 Label the sample bottles with sample number, date, contents (e.g., eggs, shad <20), and total number of specimens in the bottle (when applicable) using tape labels on the bottle lids and internal waterproof paper labels.

6.4.3 Record on the laboratory data form, the egg count in the blank space to the left of the words "length frequency," the shad 20 mm TL count in the first data row, and the total number of bottles used for the sample in the upper right hand corner.

6.4.4 Record total processing time for individual samples in the time log.

6.4.5 If immediate identification is not possible, store all bottles and laboratory data forms for each sample in designated areas in the laboratory.

6.5 Identification

6.5.1 Stereomicroscopes equipped with polarizing filters and stage-mounted millimeter rules are used for examination and measurement of specimens. Eggs and YOY fish are identified to the lowest possible taxon. Attachment 7 lists the current taxonomic standards used. These are reviewed annually and updated if necessary. Fish are individually measured to the nearest mm TL (a specimen that measures between 6.5 and 7.4 mm TL is recorded as 7mm). Reference 3.1, other pertinent literature and reference specimens of known identity are used as taxonomic aids. Process individual samples as directed below.

6.5.1.1 Identify all fish and eggs to the lowest possible taxon.

6.5.1.2. Count all eggs per taxon. Eggs are not measured.

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6.5.1.3 Measure up to 100 specimens of an individual fish taxon. If there are more than 100 specimens in a sample, select a subsample of 100 as directed in section 6.6.

6.5.1.4 Record taxonomic categories (names and numerical codes), total numbers, and numbers per length frequency of YOY fish on the laboratory data form. Each size class for a species shall be entered in only one black. If more than 12 size classes occur for a species, two or more consecutive lines may be used to record length frequencies, otherwise, data for each species will occupy only one line on the form. Record non-YOY data on the lower margin of the data form.

6.5.1.5 At the end of each day record the following in the Time Log (Measuring and Identification, attachment 8): sample date current date (date identified), identifier's name or initials, starting time, duration, and number of samples identifies.

6.6 Subsampling Methods for Length Frequency Estimates

6.6.1 Select a subsample for measurement by either the petri dish or bottle method. The bottle method is used when there are too many specimens to handle efficiently using the petri dish method.

6.6.2 Petri Dish Method

6.6.2.1 Place all specimens in the upper non-half of a petri dish and position the dish on the microscope such that no fish are visible when looking through the oculars.

6.6.2.2 "Rake" down and measure specimens while looking through the microscope oculars continuing until 100 specimens have been measured.

6.6.3 Bottle Method

6.6.3.1 Place all specimens in a bottle and agitate to mix the fish thoroughly.

6.6.3.2 Randomly extract a portion of the fish with forceps inserted through the mass of fish to the bottom of the bottle.

6.6.3.3 Measure 100 of the specimens removed using the petri dish method.

6.7 Disposition of Samples

6.7.1 Processed samples (identified by collection site, date, and sample number) shall be stored in buffered formaldehyde.

6.7.2 Removal of specimens from a sample for placement in a reference collection, donation to another agency, etc., shall be noted on the laboratory data form.

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6.8 Disposition of Data Forms

6.8.1 Upon completion of sample processing, the laboratory supervisor shall review laboratory data forms for errors and conformation to taxonomic guideline before submittal to Aquatic Management. Copies of laboratory data forms shall be retained in laboratory files until the forms are scanned as per section 7.2.

6.9 Quality Control

6.9.1 When an employee begins working in the laboratory or moves into a different phase of the processing (i.e., a sorter may become an identifier), the laboratory supervisor shall conduct checks on each samples processed to ensure that the person understands and is following laboratory procedures. These checks continue until the supervisor has confidence in the person's understanding and ability.

6.9.2 Record on laboratory forms any change in sample composition (spillage, breakage, ect.) after the sample reaches the laboratory.

6.9.3 Unannounced quality assurance checks shall be conducted periodically to maintain competence of sorters and identifiers. The checks shall be conducted by the laboratory supervisor or by appointed experienced laboratory personnel and may consist of repeat counts, measurements, and verification of taxonomy.

6.9.4 After all samples from a site are processed, data are entered into an electronic format and sent to River and Reservoir Compliance Monitoring staff and reviewed by the laboratory supervisor to detect errors and any errors not observed when the data forms were edited.

7.0 RECORDS

7.1 Laboratory logs and transport invoices are retained by the laboratory supervisor for the life of the monitoring program for tracking sample movement and disposition.

7.2 After data processing, River and Reservoir Compliance Monitoring staff scans the laboratory data forms and permanently stored by River and Reservoir Compliance Monitoring staff's server. The digital data will be permanently stored on a TVA server.

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ATTACHMENTS

1. Preparation and Maintenance of Buffered Formaldehyde Solution
2. Transport Invoice (Example)
3. Larval Fish Laboratory Log (Example)
4. Entrainment Laboratory Form (TVA form 20012B, Example)
5. Time Log (Picking and Sorting, Example)
6. Larval Fish Identification Standards
7. Time Log (Measuring and Identification, Example)

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ATTACHMENT 1

PREPARATION AND MAINTENACE OF BUFFERED FORMALDEHYDE SOLUTION

1. Prepare a five percent buffered formaldehyde solution by mixing 19 parts (gallons) distilled or spring water with 1 part (1 gallon) concentrated laboratory-grade formalin (37-40% aqucous solution of formaldehyde). Buffer to a pH of 7.2 to 7.5 by adding 175mL of ammonium hydroxide and mixing thoroughly.

2. Check the pH of the solution in samples annually with Fisher Universal pH indicator paper to ensure that the pH remains between 7.2 to 7.5. If the pH is not within the acceptable range, the old solution must be replaced with new.

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ATTACHMENT 2

TRANSPORT INVOICE (EXAMPLE)

Transport Invoice

Site: Bellefonte

Logged out Muscle Shoals: 5/26/81
Logged in Norris: 20 May 81
Received by: Star

		Sample Jars		Rack	Field Forms		Lab Forms	
Date	**Catalogue No.**	**Sent**	**Rec'd**	**Number**	**Sent**	**Rec'd**	**Sent**	**Rec'd**
05/11/1981	BL001-009	9	i9SR		i	i9SR		
05/11/1981	BL101-109	9	i9SR		i	i9SR		

Example

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Title: ICHTHYOPLANKTON SAMPLE PROCESSING NO._____ Rev. _____

ATTACHMENT 3

LARVAL FISH LABORATORY LOG (EXAMPLE)

LARVAL FISH LABORATORY LOG

Site: Browns Ferry
Month: March

Sample ID		Date Received		Sorting Complete (date)	Identification Complete (date)	Edit Complete		Data Out		Return from Keypunch	
Date	Cat. No's	Field Form	Lab Forms and/or samples			Field Form	Lab Form	Field	Lab	Field	Lab
03/10/1980	B7001-007 101-107 201-218	03/28/1980	03/28/1980	04/08/1980	04/23/1980	07/15/1980	05/15/1980	07/16/1980	07/16/1980	08/11/1980	08/11/1980
03/17/1980	B7001-007 201-209	03/28/1980	03/28/1980	04/08/1980	04/23/1980	07/15/1980	05/15/1980	07/16/1980	07/16/1980	08/11/1980	08/11/1980
03/19/1980	B7001-007 210-218	03/28/1980	03/28/1980	04/09/1980	04/323/80	07/15/1980	05/15/1980	07/16/1980	07/16/1980	08/11/1980	08/11/1980
03/25/1980	B7001-007 101-107 201-218	03/28/1980	03/28/1980	04/10/1980	04/23/1980	07/15/1980	05/15/1980	07/16/1980	07/16/2000	08/11/1980	08/11/1980
03/31/1980	B7001-007 101-106 201-218	04/17/1980	04/17/1980	04/21/1980	04/24/1980	07/16/1980	05/15/1980	07/16/1980	07/16/1980	08/11/1980	08/11/1980

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Title: ICHTHYOPLANKTON SAMPLE PROCESSING NO._____ Rev. _____

ATTACHMENT 5

TIME LOG (PICKING AND SORTING, EXAMPLE)

Site: Sequoyah 1981 Site:

Picking							Sorting						
Date	Sample #	Date Picked	Name	Time Start	Duration	Pay Period	Sample Date	Sample #	Date Sorted	Name	Time Start	Duration	Pay Period
5/26/81	SE264	7/14/81	BJ	7:00	310 min								
	265	7/14/81	Whit	11:20	160 min								
	271	7/14/81	BJ	3:15	350 min								
	272	7/15/81	Whit	1:25	165 min								
	273	7/15/81	Whit	10:30	140 min								
	274	7/15/81	Whit	2:00	315 min								
	275	7/15/81	L.R.H.	2:05	537 min								

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ATTACHMENT 6

LARVAL FISH IDENTIFICATION STANDARDS

Family	Qualifier	Genus/Species	Year Applicable	Taxa Code
Polyodontidae		Polydon spatula		10301001
Lepisosteidae		Lepisosteus spp. Lepisosteus spp. (not spatula)		10401000 10401801
Amiidae		Amia calva		10501001
Clupeidae	<20 mm TL			10600000
	≥20 mm TL	Alsoa chrysochloris[2]		10601003
		Dorosoma spp.[2]		10604000
	≥20 mm TL	Dorosoma cepedianum[2]		10604007
	≥20 mm TL	Dorosoma petenense[2]		10604008
Hiodontidae		Hiodon spp.		10801000
		Hiodon alosoides		10801001
		Hiodon tergisus		10801002
Esocidae		Esox spp.		11001000
Cyprinidae				11100000
		Pimephales type[3]	71-72, 77	11100804
		atherinoides type[3]	71-72, 77	11100805
		Volucellus-buchanani type[3]	71-72, 77	11100806
		Notemigonus crysoleucas	71-79	11124061
	≥15 mm TL[2]	Pimephales spp.		11129000
		Pimephales vigilax	80-81	11129169
	≥15 mm TL[2]	Notropis spp.	80-81	11125000
	≥15 mm TL[2]	Notropis atherinoides	80-81	11125073
		Cyprinus carpio		11105012
		Campostoma anomalum		11102003
Catostomidae				11200000
		Moxostoma type[4]	71-72, 77	11200801
		Ictiobus-Carpiodes type[5]	71-72, 77	11200802
		Catostominae (subfamily)	80-81	11200801
		Ictiobinae (subfamily)	80-81	11200802
	≥10 mm TL	Ictiobus spp.	80-81	11207000
	≥10 mm TL	Carpiodes spp.	80-81	11201000
		Minyrema melanops	71-81	11209034
Ictaluridae		Bullheads or Madtoms		11300801
		Ictalurus furcatus		11301002
		Ictalurus punctatus		11301009
		Pylodictus olivaris		11303032
Aphredoderidae		Aphredoderus sayanus		12101001
Cyprinodontidae		Fundulus spp.		11506000
Poeciliidae		Gambusia affinis		11602001

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ATTACHMENT 6 (CONTINUED)

Family	Qualifier	Genus/Species	Year Applicable	Taxa Code
Atherinidae		Labidesthes sicculus		12905002
Percichthyidae		Morone spp.		12201000
		Morone saxatilis		12201004
	≤6 mm TL	Morone spp. (not saxatilis)	71-72, 76-80	12201802
Centrarchidae				12300000
		Ambloplites rupestris		12303003
		Lepomis spp.		12307000
		Micropteris spp. (not smallmouth)	76-81	12308801
		Micropterus dolomieui		12308024
		Pomoxis spp.		12309000
		Lepomis or Pomoxis	76-81	12300802
Percidae		Darter (not logperch)	76-81	12400801
		Percid (not Stizostedion)	76-81	12400802
		Darter (unspecified)	79-81	12400803
		Perca flavescens		12403075
	≥18 mm TL[2]	Percina caprodes	80-81	12404077
		Etheostoma spp.		12402000
		Stizostedion spp.		12405000
		Stizostedion canadense		12405097
		Stizostedion vitreum		12405098
Sciaenidae		Aplodinotus grunniens		12501001
Cottidae		Cottus spp.		12709000
		Cottus carolinae[2], [6]		12709009
Unidentified Eggs[7]				00000000
Drum Eggs				02501001

1. Only listed if not applicable to all years.
2. Based on adult characters, i.e., finray counts, body morphology, pigmentation, etc.
3. This designation is for research purposes only. For reporting purposes these identifications would be grouped under family
4. Synonymous to Catostominae subfamily
5. Synonymous to Ictiobinae subfamily
6. Based on geographical range.
7. At times eggs containing late embryos may be identified using larval characters.

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Title: ICHTHYOPLANKTON SAMPLE PROCESSING NO._____ Rev. _____

ATTACHMENT 7

TIME LOG (MEASURING AND IDENTIFICATION, EXAMPLE)

Site: Bellefonte Year:

Measuring							Identification							
Sample Period	Date Measured	Name	Time Start	Duration	# of Samples	Pay Period	Sample Period	Date ID'ed	Name	Time Start	Duration	# of Samples	Pay Period	Comments Incl. total Number & Duration
							5/9/79	1/8/80	SL	11:00	4:20	5		
							5/9/79	1/9/80	SL	9:00	7:00	8		
							5/9/79	1/10/80	SL	2:00	2:30	2 1/2		
							5/9/79	1/11/80	SL	10:00	2:45	3		

EXAMPLE

Page 1 of 1

Date

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Appendix B

Tennessee Valley Authority
River and Reservoir Compliance Monitoring

Quality Assurance/ Quality Control Program

TITLE: ICHTHYOPLANKTON SAMPLE COLLECTION OER-ESP-RRES-AMM
Revision 1

1.0 OBJECTIVE

To prescribe the standard method for ichthyoplankton (fish eggs and larvae) sampling used by River and Reservoir Compliance Monitoring (RRCM). The purpose of sampling is to obtain accurate data on occurrence and densities of ichthyoplankton populations in the vicinity of TVA projects in order to assess potential impacts of these projects on the fish populations. The method involves oblique towing of a 0.75-m circular beam net through vertically integrated strata at approximately 1.0 m/s for approximately 7 minutes (or enough time to sample approximately 150 m^3 of water) to sample spatial distributions of ichthyoplankton. The procedure, developed by TVA personnel, is recognized by other biologists as a fully adequate sampling method for the types of reservoirs and habitats found in the Tennessee River Valley.

2.0 SCOPE

A 0.75-m circular beam net was towed and sampling procedure adopted so that habitats would be sampled consistently, yielding more comparable and readily interpretable data. This gear is used to sample all open water and near shoreline habitats. The accuracy and precision of this method are not known, as is true for other ichthyoplankton sampling methods. Disadvantages include the equipment- and manpower-intensive nature of the method; the method is efficient only for larvae which occur in the water column; the small net mouth size increases avoidance potential (reference 3.1), as does the moderate sampling speed [reference 3.2]; and newly-hatched larvae of some fish species may pass through the net mesh (reference 3.4). The most important advantage of the method is that it allows vertical integration of the entire water column (reference 3.5) which is lacking in most other commonly employed techniques. Other advantages are that this system has no net harness turbulence (reference 3.2), has a high filtration efficiency (reference 3.6), and allows control of sampling speed (using boat revolutions/min, cable angle, and flowmeters). Additionally, larger and more accurately measured volumes can be obtained than with other systems.

3.0 REFERENCES

3.1 Quirk, Lawler, and Matusky Engineers. 1974. Cornwall gear evaluation study. Q. L. and M. Laboratories Project No. 115-29. Tappan, New York. 96p.

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3.2 Graser, L. F. 1977. Selectivity of larval fish gear and some new techniques for entrainment and open water larval fish sampling. Pages 56-71.*in* L.L. Olmstead, ed., Proceedings of the First Symposium on Freshwater Larval Fish, 1977. 251 pp. Duke Power Company, Huntersville, North Carolina.

3.3 Graser, L. F. 1978. Flow through collection bucket for larval fish. Prog. Fish Cult. 40:78-79.

3.4 Tomljanovich, David A. TVA unpublished data.

3.5 Tuberville, J.D. 1979. Vertical distribution of ichthyoplankton in upper Nickajack Reservoir, Tennessee, with comparison of three sampling methodologies. Pages 185-203. *in* R.B. Hoyt, ed., Proceedings of the Third Symposium on Larval Fish. 1979, Western Kentucky University, Bowling Green, Kentucky. 236 pp.

3.6 TVA Engineering Laboratory, unpublished data.

3.7 S&F OPS-FO-BR-24.1, "Ichthyoplankton Sample Processing."

3.8 S&F OPS-FO-NRE-43.2, "Standardization of Hydrolab Equipment."

3.9 S&F OPS-FO-NRE-42.11, "Temperature."

4.0 RESPONSIBILITIES

4.1 The project leader is responsible for developing a workplan defining the sampling program, overall scheduling of the work, performing a pre-job safety discussion, and the technical adequacy of the work. The project leader selects the crew leader.

4.2 The crew leader is responsible for performing a pre-job safety discussion (when a new crew member participates in the sample), a post-job safety discussion, supervising fieldwork, assuring that all applicable procedures are followed, reviewing data for accuracy and completeness, and reporting problems to the project leader.

4.3 AM employees and/ or contractors involved in sampling operations are responsible for performing work in accordance with this procedure and all other applicable procedures, keeping proper records, and reporting problems to the crew leader.

5.0 PROCEDURES/REQUIREMENTS

5.1 **Personal Protective Equipment (PPE)**

5.1.1 Life jackets, float cushion, fire extinguisher, first aid kit, rain gear, insulated coveralls, sunscreen, whistle, and knife. Gloves – heavy-duty latex for sample processing and leather for equipment handling. Cell phones if possible.

5.1.2 No sandals or open-toed shoes.

5.2 **Equipment and Supplies**

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5.2.1 Work boat equipped with the following auxiliary equipment:

5.2.1.1 System for deployment/ retrieval of a 0.5-m beam net from the side or bow of the vessel

5.2.1.2 Sufficient lighting (stationary and hand held) for night navigation and work.

5.2.1.3 Cable metering device(s) to measure net deployment/retrieval to the nearest 0.1m.

5.2.1.4 Depth sounder capable of measurement of the maximum depth to be sampled.

5.2.1.5 Water supply system (electric or hydraulic) for washing nets.

5.2.1.6 Boat speed monitoring device or remote reading flowmeter (General Oceanics 2035-MKlll or equivalent). General Oceanics flowmeters are factory calibrated and are provided with calibration curves. Flume tests of flowmeters at the TVA Engineering Laboratory in Norris prior to use have shown them to be within close tolerances of company-provided data. Annual calibration checks at the Engineering Laboratory shall be made on all flowmeters. Acceptable flowmeter readings are between 10,500 and 12,500 counts per tow.

5.2.2 Beam net, 0.75-m circular equipped with the following:

5.2.2.1 363-µm (.363 mm) Nitex mesh

5.2.2.2 Spreader bar and harness

5.2.2.3 Digital flowmeter (General Oceanics Model 2030 or 2031, or equivalent) with large rotor vane

5.2.2.4 Catch cup

5.2.2.5 21-kg weight for net frame

5.2.2.6 Breakaway net frame assembly

5.2.3 Clock or wristwatch

5.2.4 Stopwatch or stopclock, capable of measuring to the nearest 0.1 second

5.2.5 Thermometer (Hydrolab T-4 or equivalent), range of -5 to 45°C, capable of measurement to 0.1°C at the maximum depth to be sampled, standardized for each excursion in accordance with reference 3.8.

5.2.6 Wide-neck funnel for transfer of sample from cod-end to sample jar (preferably one custom built to fit the mouth of l-pint jars)

5.2.7 Pencils, sharpener, special indelible ink pen for outside jar labels

5.2.8 Calculator (optional)

5.2.9 Leather work gloves

5.2.10 Formalin (8 L)

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5.3 **Preparation**

5.3.1 Before leaving for the field, check to see that all equipment is packed and operating properly.

5.3.2 Collect and prepare sample containers, labels, and field forms using information from the workplans.

5.3.2.1 Apply external label with catalog number to each jar.

5.3.2.2 Partially fill out an internal label for each jar with catalog number.

5.3.2.3 Enter preliminary information on Ichthyoplankton Field Forms (Attachment 1) as directed below:

5.3.2.3.1 Enter the site and transect name in the blank following the word "Transect" at the top of the sheet. Site is the name of the plant or project being monitored (Watts Bar Nuclear Plant, Murphy Hill, etc.). Transect is the area of the reservoir within the study reach (established in workplan) to be sampled (plant transect, TRM 461.7 or upstream transect TRM 464.5, etc.).

5.3.2.3.2 Enter names of crew members at top right of form.

5.3.2.3.3 Starting from the left bank (facing downstream), divide the river visually into fifths. Estimate the position of the sample area relative to the left bank and record it (e.g., left shoreline would be 1, midchannel would be 3)

5.3.2.3.4 Place a check mark in the appropriate box for time zone.

5.3.2.3.5 Enter the station identification codes for each sample in boxes labeled “Station ID.” Each sample has an alpha-numeric code. The first two digits are an abbreviation of the site name (WB = Watts Bar Nuclear; PA = Paradise Fossil). The last three digits constitute the sample number. Sample numbers are established by the crew leader prior to the first collection trip to the site and remain the same for individual samples throughout the study.

5.3.2.3.6 Enter sampling date for each respective sample in boxes labeled “Sampling Date.”

5.3.3 Check the rigging of the workboat to make sure it is properly and safely rigged before beginning fieldwork. Caution: All machinery and cables must be thoroughly checked for soundness and potential obstructions before any system is operated.

5.3.4 Before starting the motor, the engine compartment of boats equipped with inboard motors must be vented for the time prescribed by the manufacturer.

5.4 **Procedure**

5.4.1 Define the sampling site as directed below, recording data on the field forms. Some of the tasks listed may be executed simultaneously.

5.4.1.1 Using information in the workplan, locate the transect area to be sampled.

5.4.1.2 Determine and record the bottom depth (in m) using the depth sounder.

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5.4.1.3 Select the appropriate lift increment table from Attachment 2 for the strata to be sampled.

5.4.1.4 Record the minimum and maximum sampling depths, in meters, (e.g., surface to 5.0 m, would be recorded as: minimum 00.0, maximum 05.0).

5.4.1.5 Record water temperatures (to the nearest 0.l°C) for each sample. Temperatures should be measured at the middle of the stratum sampled (e.g., sampled stratum of 4 m to the surface should have a recorded temperature at 2 m) as directed in reference 3.9. Note: Water temperatures may be taken after each sample or enmasse at any time while sampling at a particular transect location.

5.4.2 Record the flowmeter start reading for each net on the field form. Note: Care must be taken to prevent wind from spinning the meter blade when the net is not in the water. If this occurs, a new reading must be recorded.

5.4.3 Lower the bottom edge of the net to the surface of the water.

5.4.4 "Zero" the cable meter while the boat driver stops the motion of the boat with respect to the water flow. Stopping the boat allows the net to be lowered through a "stationary" water mass and thus minimizes the filtration of water from undesired strata before the sample run begins.

5.4.5 When the boat stops, lower the net to the desired depth using the cable meter to monitor the cable deployed. Note: Because of boom geometry, the cable meters on twin- boom boats (with the booms lowered) read 1 m less than the actual depth of the net; this differential is compensated for on the lift increment tables. For single boom workboats only, use a gloved hand to align the cable on the boom pulley or bow roller before lowering the net.

5.4.6 Signal the boat driver to accelerate the boat to sampling speed (1 m/s), determining the proper power setting to attain the correct sampling speed as directed below.

5.4.6.1 Collect first sample as described in sections 5.4.7 through 5.4.15 with boat motor operating at 800-850 rpm (approximately 1 m/s under normal conditions).

5.4.6.2 If a 7-min tow at this power setting results in a flowmeter count within the acceptable range (section 5.4.15), continue sampling in this manner.

5.4.6.3 If flowmeter count is not within the acceptable range, wash the net and catch cup, discard the sample, and repeat, changing the motor power setting or duration of the sample accordingly. Continue to repeat until proper power setting is determined.

5.4.7 Start the stopwatch or clock as the boat begins to move forward. Record the start time (military) on the field sheet in box labeled “Sample Start Time (military).”

5.4.8 To keep the net at the desired stratum while compensating for increasing cable angle, deploy additional cable (40 percent) as the boat accelerates (refer to lift increment table). This additional cable should be fully deployed within 10 to 20 seconds as the boat accelerates to sampling speed.

5.4.9 Monitor the boat speed continually during the tow using tachometer.

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5.4.10 For tows covering strata greater than 0.5 m (e.g., from 5.0 m depth to surface), lift the net in increments (refer to lift increment table) at equal time intervals during the tow (e.g., nine 1-min lifts in a 10-min tow; or nine 30-s lifts in a 5-min tow).

5.4.11 If the net snags bottom or becomes fouled longer than momentarily, abort the tow and repeat the sampling from section 5.4.2 on.

5.4.12 At the completion of the tow, stop the motion of the boat with respect to water flow as directed in section 5.4.4, record the duration of the tow (in minutes and seconds), and retrieve the net quickly, taking care to prevent the flowmeter rotor from spinning in the wind. If spinning occurs, discard the sample, wash the net and catch cup, and repeat sampling from section 5.4.2 on.

5.4.13 Check for a tangled net (i.e., catch cup in net mouth). If the net fouls, discard the sample, wash net and catch cup, and repeat sampling from section 5.4.2 on.

5.4.14 Check the net and catch cup mesh for tears. If the net or catch cup tears, wash and repair or replace, discard the sample, and repeat sampling from section 5.4.2 on.

5.4.15 Record the flowmeter end reading and subtract the start reading (section 5.4.2) on the back or margin of the field form. The acceptable range is 10,500 to 12,500 counts. If the count is not acceptable, wash the net and catch cup, discard the sample, and repeat sampling from section 5.4.2 on. Note: On rare occasions, despite accurate tow speed (1 m/s) and proper sample duration (~7 min), flowmeter counts will be low due to net clogging from exceptionally high plankton or detritus loads in the water column. If this occurs, substitute two 5-min tows with 30-s lifts for the single 10-min tow with 1-min lifts. These two tows constitute one sample and are given the same sample number. Add the flowmeter counts for the two tows and record the total counts for the sample. Time limitations (typically a problem at night) may prohibit the taking of multiple pairs of tows. In this circumstance the crew leader may approve accepting tows with low flowmeter counts, documenting his/her approval, with appropriate notes, on the field form.

5.4.15.1 The recorder shall use strike marks to indicate errors. Erasures shall be minimized. Notes or calculations in the margins shall not be erased.

5.4.16 Place a U or D in boxes labeled “Direction” to indicate the direction (upstream U or downstream D) in which a sample was taken.

5.4.17 Wash the net thoroughly into the catch cup with the wash hose beginning at the canvas edge of the mouth and methodically covering all surface area to the bucket. Wash from the outside of the net through the mesh and toward the bucket. Wash each side of the net 3 times.

5.4.18 Remove the catch cup from net and screw a clean sample jar (1-pint) onto the catch cup.

5.4.19 Rinse the sample into the sample jar taking care to leave sufficient room for addition of formalin. If spillage occurs, discard sample and repeat sampling from section 5.4.2 on. Large fish and/or pieces of trash may have to be placed by hand into the sample jar; if so, thoroughly rinse the hand in to the sample jar also, to assure that no larvae or eggs adhere to the hand. High volumes of fish, plankton, or detritus may require multiple sample jars. All jars from a single tow must carry the same tag number on the external and internal labels, each jar numbered 1 of 3, 2 of 3, 3 of 3, etc. Record the number of jars on the margin of the field sheet for the appropriate sample number.

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5.4.20 Don safety glasses and heavy-duty Latex gloves. Using a funnel, add approximately 50 mL of 100 percent formalin. Use only jar lids with intact sealing gaskets.

5.4.21 Assure proper labeling (internal and external) of sample jar and formalin (10-15 percent).

5.4.22 Tighten the lid and invert the jar several times to assure thorough mixing of the formalin with the sample.

5.4.23 Store the sample jar in a secure rack or container. Spillage, breakage, or loss of a sample jar at any time while still at or near the site requires that the sample be retaken.

5.4.24 Repeat steps 5.4.2 through 5.4.23 for each subsequent sample.

5.4.25 Complete, sign, and date the field form and give to crew leader to review for completeness.

5.5 **Sample Shipment**

5.5.1 Pack the sample jars in shipping boxes or coolers provided by TVA Laboratories located in Norris, TN or Chattanooga, TN.

5.5.2 Prepare a Transport Invoice (Attachment 4) and ship the containers (and invoice) to the TVA Laboratory in Muscle Shoals, AL.

5.5.3 Time and place arrangements should be made by phone with TVA Laboratory personnel for receiving samples.

5.6 **Quality Control**

5.6.1 Quality control criteria in sections 5.4.2, 5.4.4, 5.4.6, 5.4.9, 5.4.11, 5.4.15, 5.4.19, and 5.4.22 must be met.

5.6.2 Any new stations or transects or other changes shall be reported to the project leader for use in editing data.

6.0 RECORDS

6.1 Data from the original field form is entered into electronic format (Excel spreadsheet) and sent to the project leader. The original field form is sent to the project leader. A copy of the field form is retained by the crew leader for the life of the project.

6.2 After processing of the samples, data from laboratory forms are entered into electronic format (Excel spreadsheet) and sent to the project leader. The laboratory forms are sent to the project leader.

6.3 Both field forms and laboratory forms are sent to project leader for scanning and verification

6.4 The scanned copies are permanently stored on the shared server and the field forms are retained by the project leader for one year and then destroyed

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ATTACHMENTS

1. Ichthyoplankton Field Form
2. Cable Deployment and Lift Intervals for Half-Meter Larval Fish Nets
3. Job Safety Analysis for Ichthyoplankton Sampling
4. Transport Invoice

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ATTACHMENT 1
Ichthyoplankton Field Form

WEATHER
SKY O O O O
WIND C L ST
PRECP F R- R+ T

TRANSECT ____

CREW MEMBERS: ____

ENTRAINMENT STUDIES – RESERVOIR SAMPLING

PROJECT 010

STATION ID | GRID CODE | BOTTOM DEPTH (meters) | SURFACE ELEVATION (meters) | TIME ZONE CST ☐ CDT ☐ EST ☐ EDT ☐

CATALOG NO.	SAMPLING DATE			GEAR CODE	SAMPLE TIME START (military)	DURATION		SAMPLING DEPTH		FLOW METER READINGS		Direction	SAMPLE TEMP C°	Ques data	PUMPING OR FLOW-RATE CU METERS/MIN	REP NO.
	month	day	year			minutes	sec	min	max	flow start	flow end					
				1 2 3 2 1 3 3												
				1 2 3 2 1 3 3												
				1 2 3 2 1 3 3												
				1 4 1 1 2 2 0												

STATION ID | GRID CODE | BOTTOM DEPTH (meters) | SURFACE ELEVATION (meters) | TIME ZONE CST ☐ CDT ☐ EST ☐ EDT ☐

CATALOG NO.	SAMPLING DATE			GEAR CODE	SAMPLE TIME START (military)	DURATION		SAMPLING DEPTH		FLOW METER READINGS		Direction	SAMPLE TEMP C°	Ques data	PUMPING OR FLOW-RATE CU METERS/MIN	REP NO.
	month	day	year			minutes	sec	min	max	flow start	flow end					
				1 2 3 2 1 3 3												
				1 2 3 2 1 3 3												
				1 2 3 2 1 3 3												
				1 4 1 1 2 2 0												

STATION ID | GRID CODE | BOTTOM DEPTH (meters) | SURFACE ELEVATION (meters) | TIME ZONE CST ☐ CDT ☐ EST ☐ EDT ☐

CATALOG NO.	SAMPLING DATE			GEAR CODE	SAMPLE TIME START (military)	DURATION		SAMPLING DEPTH		FLOW METER READINGS		Direction	SAMPLE TEMP C°	Ques data	PUMPING OR FLOW-RATE CU METERS/MIN	REP NO.
	month	day	year			minutes	sec	min	max	flow start	flow end					
				1 2 3 2 1 3 3												
				1 2 3 2 1 3 3												
				1 2 3 2 1 3 3												
				1 4 1 1 2 2 0												

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ATTACHMENT 2
CABLE DEPLOYMENT AND LIFT INTERVALS FOR ONE-METER LARVAL FISH NETS, MONARCH WORK BOAT

				Lift No.								
Stratum (m)	**Init.**	**+40%**	**Incr.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0-2	1	1.8	.2	1.6	1.4	1.2	1.0	0.8	0.6	0.4	0.2	Skim
0-2.2	1.2	2.1	.2 -.3	1.8	1.6	1.3	1.1	0.8	0.6	0.3	0.1	Skim
0-2.5	1.5	2.5	.3	2.2	1.9	1.6	1.3	1.0	0.7	0.4	0.1	Skim
0-2.7	1.7	2.8	.3 -.4	2.5	2.1	1.8	1.4	1.1	0.7	0.4	0	Skim
0-3	2	3.2	.4	2.8	2.4	2.0	1.6	1.2	0.8	0.4	0	Skim
0-3.2	2.2	3.5	.4	3.1	2.7	2.3	1.9	1.5	1.1	0.7	0.3	Skim
3.2-6.5	5.5	8.1	.4	7.7	7.3	6.9	6.5	6.1	5.7	5.3	4.9	Skim
0-3.5	2.5	3.9	.4 -.5	3.5	3.0	2.6	2.1	1.7	1.2	0.8	0.3	Skim
3-5-7.0	6	8.8	.4 -.5	8.4	7.9	7.5	7.0	6.6	6.1	5.7	5.2	4.8
0-3.7	2.7	4.2	.5	3.7	3.2	2.7	2.2	1.7	1.2	0.7	0.2	Skim
3.7-7.5	6.5	9.5	.5	9.0	8.5	8.0	7.5	7.0	6.5	6.0	5.5	5.0
0-4.0	3	4.6	.5 -.6	4.1	3.5	3	2.4	1.9	1.3	.8	.2	Skim
4.0-8.0	7	10.2	.5 -.6	9.7	9.1	8.6	8	7.5	6.9	6.4	5.8	5.3
0-4.2	3.2	4.9	.6 -.5	4.3	3.8	3.2	2.7	2.1	1.6	1	.5	Skim
4.2-8.5	7.5	10.9	.6 -.5	10.3	9.8	9.2	8.7	8.1	7.6	7	6.5	5.9
0-4.5	3.5	5.3	.6	4.7	4.1	3.5	2.9	2.3	1.7	1.1	.5	Skim
4.5-9.0	8	11.6	.6	11	10.4	9.8	9.2	8.6	8	7.4	6.8	6.2
0-4.7	3.7	5.6	.6 -.7	5	4.3	3.7	7	2.4	1.7	1.1	.4	Skim
4.7-9.5	8.5	12.3	.6 -.7	11.7	11	10.4	9.7	9.1	8.4	7.8	7.1	6.5
0-5	4	6	.7	5.3	4.6	3.9	3.2	2.5	1.8	1.1	.4	Skim
5-10	9	13	.7	12.3	11.6	10.9	10.2	9.5	8.8	8.1	7.4	6.7
0-5.2	4.2	6.3	.7	5.6	4.9	4.2	3.5	2.8	2.1	1.4	.7	Skim
5.2-10.5	9.5	13.7	.7	13.0	12.3	11.6	10.9	10.2	9.5	8.8	8.1	7.4
0-5.5	4.5	6.7	.8	5.9	5.1	4.3	3.5	2.7	1.9	1.1	.3	Skim
5.5-11	10	14.4	.8	13.6	12.8	12	11.2	10.4	9.6	8.8	8	7.2
0-5.7	4.7	7	.8	6.2	4.4	4.6	3.8	3	2.2	1.4	.6	Skim
5.7-11.5	10.5	15.1	.8	14.3	13.5	12..7	11.9	11.1	10.3	9.5	8.7	7.9
0-6	5	7.4	.8 -.9	6.6	5.7	4.9	4	3.2	2.3	1.5	.6	Skim
6-12	11	15.8	.8 -.9	15	14.1	13.3	12.4	11.6	10.7	9.9	9	8.2
0-6.2	5.2	7.7	.9	6.8	5.9	5	401	3.2	2.3	1.4	.5	Skim
6.2-12.5	11.5	16.5	.9	15.6	14.7	13.8	12.9	12	11.1	10.2	9.3	8.4

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ATTACHMENT 2 (continued)

				Lift No.								
Stratum (m)	**Init.**	**+40%**	**Incr.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0-6.5	5.5	8.1	.9	7.3	6.3	5.4	4.5	3.6	2.7	1.8	.9	Skim
6.5-13	12	17.2	.9	16.3	15.4	15.5	13.6	12.7	11.8	10.9	10	9.1
0-6.7	5.7	8.4	1	7.4	6.4	5.4	4.4	3.4	2.4	1.4	.4	Skim
6.7-13.5	12.5	17.9	1	16.9	15.9	14.9	13.9	12.9	11.9	10.9	9.9	8.9
0-7	6	8.8	1	7.8	6.8	5.8	4.8	3.8	2.8	1.8	.8	Skim
7-14	13	18.6	1	17.6	16.6	15.6	14.6	13.6	12.6	11.6	10.6	9.6
0-7.2	6.2	9.1	1 -1.1	8.1	7	6	4.9	3.9	2.8	1.8	.7	Skim
7.2-14.5	13.5	19.3	1 -1.1	18.3	17.2	16.2	15.1	14.1	13	12	10.9	9.9
0-7.5	6.5	9.5	1.1	8.4	7.3	6.2	5.1	4	2.9	1.8	.7	Skim
7.5-15	14	20	1.1	18.9	17.8	16.7	15.6	14.5	13.4	12.3	11.2	10.1
0-7.7	6.7	9.8	1.1	8.7	7.6	6.5	5.4	4.3	3.2	2.1	1	Skim
7.7-15.5	14	20.7	1.1	19.6	18.5	17.4	16.3	15.2	14.1	13	11.9	10.8
0-8	7	10.2	1.2	9	7.8	6.6	5.4	4.2	3	1.8	.6	Skim
8-16	15	21.4	1.2	20.2	19	17.8	16.6	15.4	14.2	13	11.8	10.5
0-8.2	7.2	10.5	1.2	9.3	8.1	6.9	5.7	4.5	3.3	2.1	.9	Skim
8.2-16.5	15.5	22.1	1.2	20.9	19.7	18.5	17.3	16.1	14.9	13.7	12.5	11.3
0-8.5	7.5	10.9	1.2 -1.3	9.7	8.4	7.2	5.9	4.7	3.4	2.2	.9	Skim
8.5-17	16	22.87	1.2 -1.3	21.6	20.3	19.1	17.8	16.6	15.3	14.1	12.8	11.6
0-8.7	7.7	11.2	1.3	9.9	8.6	7.3	6	4.7	3.4	2.1	.8	Skim
8.7-17.5	16.5	23.5	1.3	22.2	20.9	19.6	18.3	17	15.7	14.4	13.1	11.8
0-9	8	11.6	1.3	10.3	9	7.7	6.4	5.1	3.8	2.5	1.1	Skim
9-18	17	24.2	1.3	22.9	21.6	20.3	19	17.7	16.4	15.1	13.8	12.5
0-9.2	8.2	11.9	1.3-1.4	10.6	9.2	7.9	6.5	5.2	3.8	2.5	1.1	Skim
9.2-18.5	17.5	24.9	1.3-1.4	23.6	22.2	20.9	19.5	18.2	16.8	15.5	14.1	12.8
0-9.5	8.5	12.3	1.4	10.9	9.5	8.1	6.7	5.3	3.9	2.5	1.1	Skim
9.5-19	18	25.6	1.4	24.2	22.8	21.4	20	18.6	17.2	15.8	14.4	13
0-9.7	8.7	12.6	1.4	11.2	9.8	8.4	7	5.6	4.2	2.8	1.4	Skim
9.7-19.5	18.5	26.3	1.4	24.9	23.5	22.1	20.7	19.3	17.9	16.5	15.1	13.7
0-10	9	13	1.5	11.5	10	8.5	7	5.5	4	2.5	1	Skim
10-20	19	27	1.5	25.5	24	22.5	21	19.5	18	16.5	15	13.5
0-10.5	9.5	13.7	1.6	12.1	10.5	8.9	7.3	5.7	4.1	2.5	.9	Skim
10.5-21.0	20	28.4	1.6	26.8	25.2	23.6	22	20.4	18.85	17.2	15.6	14

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ATTACHMENT 2 (continued)

				Lift No.								
Stratum (m)	**Init.**	**+40%**	**Incr.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0-11	10	14.4	1.6	12.8	11.2	9.6	8	6.4	4.8	3.2	1.6	Skim
11-22	21	29.8	1.6	28.2	26.6	25	23.4	21.8	20.2	18.6	17	15.4
0-11.5	10.5	15.1	1.7	13.4	11.7	10	8.3	6.6	4.9	3.2	1.5	Skim
11.5-23	22	31.2	1.7	29.5	27.8	26.1	24.4	22.7	21	19.3	17.6	15.9
0-12	11	15.8	1.8	14	12.2	10.4	8.6	6.8	5	3.2	1.4	Skim
12-24	23	32.6	1.8	30.8	29	27.2	25.4	23.6	21.8	20	18.2	16.4
0-12.5	11.5	16.5	1.9	14.6	12.7	10.8	8.9	7	5.1	3.2	1.3	Skim
12.5-25	24	34	1.9	32.1	30.2	28.3	26.4	24.5	22.6	20.7	18.8	16.9
0-13	12	17.2	1.9	15.3	13.4	11.5	9.6	7.7	5.8	3.9	2	Skim
13-26	25	35.4	1.9	33.5	31.6	29.7	27.8	25.9	24	22.1	20.2	18.3
0-13.5	12.5	17.9	2	15.9	13.9	11.9	9.9	7.9	5.9	3.9	1.9	Skim
0-14	13	18.6	2.1	16.5	14.4	12.3	10.2	8.1	6	3.9	1.8	Skim
0-14.5	13.5	19.3	2.2	17.1	14.9	12.7	10.5	8.3	6.1	3.9	1.7	Skim
0-15	14	20	2.3	17.7	15.4	13.1	10.8	8.5	6.2	3.9	1.6	Skim
0-15.5	14.5	20.7	2.3	18.4	16.1	13.8	11.5	9.2	6.9	4.6	2.7	Skim
0-16	15	21.4	2.4	19	16.6	14.2	11.8	9.4	7	4.6	2.2	Skim
0-16.5	15.5	22	2.5	19.6	17.1	14.6	12.1	8.6	7.1	4.6	2.1	Skim
0-17	16	22.8	2.5	20.3	17.8	15.3	12.8	10.3	7.8	5.3	2.8	Skim
0-15.5	16.5	23.5	2.6	20.9	18.3	15.7	13.1	10.5	7.9	5.3	2.7	Skim
0-18	17	24.2	2.7	21.5	18.8	16.1	13.4	10.7	8	5.3	2.6	Skim
0-18.5	17.5	24.9	2.8	22.1	19.3	16.5	13.7	10.9	8.1	5.3	2.3	Skim
0-19	18	25.6	2.9	22.7	19.8	16.9	14	11.1	8.2	5.3	2.4	Skim
0-19.5	18.5	26.3	3	23.3	20.3	17.3	14.3	11.3	8.3	5.3	2.3	Skim
0-20	19	27	3.1	23.9	20.8	17.7	14.6	11.5	8.4	5.3	2.2	Skim

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ATTACHMENT 3

Job Safety Analysis for Ichthyoplankton Sampling

No.:	Job: Ichthyoplankton Sampling			Date: 10/14/1997
Section:	Skills Required: Operation of boat, winch	Analysis By: Johnny P. Buchanan	Reviewed By: Dennis S. Baxter	Approved By:
Required Personal Protective Equipment: Safety glasses, surgical gloves, leather gloves, rain gear				
Tools & Equipment Required: Tool box with cable cutters, and calculator.				
Job Preparation: Equipment Inspection Pre-job safety discussion and procedure planning				
Hazardous Materials: Formalin	Special Requirements:			

Sequence of Basic Job Steps	Potential Accidents or Hazards	Recommended Safe Job Procedures
I. Trip Planning A. Discussion.	I. Trip Planning. A. Discussion. 1. Uninformed crew members may create potential hazards.	I. Trip Planning A. Discussion. 1. The crew leader is responsible for all pre-job training and planning.
	2/3. Pre-planning can prevent potential hazards.	2. The workplan and standard procedures should be followed unless otherwise instructed. Being informed ensures that everyone understands the potential hazards that exist.
	a. A life jacket may save your life.	3. All safety procedures must be discussed. a. Always wear a personal flotation device (PFD).

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ATTACHMENT 3 (continued)

Sequence of Basic Job Steps	Potential Accidents or Hazards	Recommended Safe Job Procedures
	4. Dry box, gear storage. a. Unsecured gear may cause an accident.	4. Use a dry box to store gear (i.e., rain gear, secchi disk, conductivity meter, etc.)
	5. Without appropriate tools, work delays or cancellations may occur.	5. Load an appropriate tool kit. a. Stock tool kit with spark plugs, plug wrench, fuses, boat plug and cable cutter.
	6. Defective motor or winch may cause work delays and possible injury.	6. Check operating condition of motor and winches before leaving for the field.
	7. Without running lights and signaling device, collision with other vessels may occur.	7. Check horn and running lights.
	8. Work delays may occur if the boat runs out of gas.	8. Check external gasoline tank and oil levels
	9. A well lit work area will reduce potential accidents.	9. Use Q beam type spotlights and work lights if night work is necessary.
	10. Data may be lost if data are not recorded correctly. Work delays may result.	10. Use the proper data forms and formulas.
	11/12. Formalin is a known carcinogen. Do not expose chemical to skin or eyes.	11. Use protective equipment. 12. Read the Material Safety Data Sheets (MSDS).
	13. Without spare sampling equipment work delays and the loss of data may occur.	13. Spare net frame, net, cotter pins, clips, meter, catch cups, jars and funnels may be needed during sampling.
C. Truck and trailer attachment.	C. Attaching trailer to truck. 1. Damage may occur when backing towards a trailer tongue without directions.	C. Attaching trailer to truck. 1. Use two people to hook the trailer to the truck. A driver and someone to give directions should be used when backing towing vehicle to the trailer.
	2. If coupler isn't secured properly trailer may come off hitch during transport causing serious damage or bodily injury.	2. Attach coupler to the ball hitch and secure properly.
	3. If the coupler fails and the boat trailer comes off the hitch, the surge brake cable and safety chains are the only safety feature left to maintain	3. Securely attach chains and surge brake cable.

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ATTACHMENT 3 (continued)

Sequence of Basic Job Steps	Potential Accidents or Hazards	Recommended Safe Job Procedures
	control over a potentially dangerous situation.	
	4. Trailering boat without proper turn signals and running lights could cause an accident.	4. Plug in trailer lights.
	5. If trailer lights fail, do not tow until lights are repaired.	5. Check trailer lights to see they are functional. If not, repair before towing boat.
	6. Objects left in boat unsecured may blow out and cause an accident.	6. Make sure all equipment in the boat is secure and tied down if necessary.
III. Towing the Boat. A. Trailering.	III. Towing the Boat. A. Trailering. 1. Trailer inspections prior to towing may avoid serious problems that may arise in the field.	III. Towing the Boat. A. Trailering. 1. Pull boat and trailer out of the trailer stall slowly and check tire inflation, tire wear, bearing caps. Listen to insure bearings are not squeaking and test surge brakes to make sure they don't lock up.
	2. Serious bodily injury or property damage may occur when driving conditions are bad.	2. If trailering the boat in wet or freezing weather, drive slower according to road conditions. Always remember it takes at least twice as long to stop. a. Pump brakes on wet or frozen pavement to prevent hydroplaning unless the towing vehicle is equipped with Automatic Braking System (ABS) then apply constant pressure to brakes.
B. Launching the Boat	B. Launching the Boat. 1/2. Backing accidents may occur.	B. Launching the Boat. 1. Lock motor in upward position. 2. When backing always have an observer.
	3. Trailer light bulbs may blow.	3. Unhook tie down straps and trailer lights.
	4. This reduces excessive exposure of water in the bearing housing.	4. Let trailer bearings cool before launching the boat.
	5. Losing boat off trailer can be avoided if winch cable stays attached.	5. Keep trailer winch cable attached until launched.
	6. Excessive water may accumulate in the boat.	6. Check to see if boat plug is installed properly.

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ATTACHMENT 3 (continued)

Sequence of Basic Job Steps	Potential Accidents or Hazards	Recommended Safe Job Procedures
	7. Launching the boat without an observer may result in damage or loss of property.	7. Have observer guide driver when backing boat into the water.
	8. A cold motor may stall.	8. Start boat motor and warm it up.
	9. If motor is allowed to stay running without a driver, potential accidents may occur if motor "pops" into gear.	9. Turn motor off and unhook winch cable.
	10/11. The boat may drift off if left unattended.	10. Restart boat motor and push or motor boat off trailer, maneuver to the dock or bank and tie off. 11. Always tie off the boat or leave a driver in the boat.
IV. Collecting Larval Fish Samples (or Ichthyoplankton) A. Travel to Sampling Area	IV. Larval Fishing or Larval Sampling A. Travel to Sampling Area 1/2. Equipment damage or injury to personnel may occur from hidden obstacles in water.	A. Travel to Sampling Area 1. Beware of hidden obstacles, such as, underwater snags and rocks. 2. Night sampling requires running lights and spotlight.
	3. Objects left unsecured may blow into boat operators face causing an accident or serious injury.	3. Stow or tie down all gear.
	4. Equipment loss and damage may be avoided if the sample crew is familiar with bottom contours and obstructions.	4. Map out bottom of sampling area with a depth meter to avoid potential net snags.
V. Push Net Sampling. A. Raising Boom.	V. Push Net Sampling. A. Raising Boom. 1. Injury may occur if recommended procedures are not followed.	V. Push Net Sampling. A. Raising Boom. 1. Raise boom slowly, do not strain back, watch your head. Ask for help if boom is to heavy.

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ATTACHMENT 3 (continued)

Sequence of Basic Job Steps	Potential Accidents or Hazards	Recommended Safe Job Procedures
B. Attach Net and Flow Meter.	B. Attach Net and Flow Meter. 1. Equipment damage and work delays may arise.	B. Attach Net and Flow Meter. 1. Before lowering net into water, make sure cables are attached and on spools. Be sure winch is not on free spool.
C. Preparing to Sample.	C. Preparing to Sample. 1. Back strain or injury may occur.	C. Preparing to Sample. 1. Net frame is heavy, use the proper lifting techniques.
	2. Knowing where the net is at all times will reduce potential hazards.	2. Set cable counter at (00000) when net bottom is touching the surface of the water.
D. Lower Net.	D. Lower Net. 1. Cable may cause bodily injury.	D. Lower Net. 1. Wear leather gloves while handling cable.
	2. Damage to the winch may occur if recommended procedures are not followed.	2. Slow cable down before stopping at calculated depth.
E. Timed Run.	E. Timed Run. 1. Underwater hazard can cause equipment damage and accidents.	E. Timed Run. 1. Driver should monitor depth for underwater hazards.
	2. Winch and cable can cause injury.	2. Winch operator ensures cable stays on rollers and raises net at timed intervals.
	3. Damage to net, frame and cable may occur if net hangs up on the bottom.	3. If net drags bottom or snags, notify driver to stop boat and raise net.
F. Retrieve Net.	F. Retrieve Net. 1/2. Frayed cable may cause injury.	F. Retrieve Net. 1. Keep hands clear of cable while in operation. 2. Keep cable on rollers.
	3. Back strain may occur.	3. Pull net and frame into the boat using proper lifting techniques.
G. Net Wash Down.	G. Net Wash Down. 1/2. Net hangs over the water, be careful not to fall out of the boat.	G. Net Wash Down. 1. Remove net and attach rinsing boom. 2. Rinse net and remove catch cup assembly.

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ATTACHMENT 3 (continued)

Sequence of Basic Job Steps	Potential Accidents or Hazards	Recommended Safe Job Procedures
	3/4. Be aware of formalin in sample jar. Avoid contact with skin, eyes, and vapor. Read the MSDS. Irritation and/or injury to eyes or skin could occur.	3. Label jar with internal and external labels. 4. Pour contents of catch cup into sampling jar.
H. Lower Boom.	H. Lower Boom. 1. Objects left unsecured may blow out of boat and could cause potential injury or hazards.	H. Lower Boom. 1. After sampling, lower boom and tie down or stow gear for travel.
VI. End of Sampling..	VI. End of Sampling. A. To avoid possible hazards be very careful and drive intelligently.	VI. End of Sampling. A. Repeat, in reverse order, all steps prior to sampling.

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ATTACHMENT 4

Transport Invoice

TVA Aquatic Resource Transport Invoice					
Site:			**Sender of Samples:**		
Project:			**Date Sent:**		
Project Leader:			**Received by:**		
Date	**Sample Identification**	**Type of Sample**	**Number of Samples**	**Samples Received**	**Lab Forms Received**
Comments:					

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Tennessee Valley Authority

Browns Ferry Nuclear Power Plant

National Pollutant Discharge Elimination System (NPDES) Permit No. AL0022080

Updated Final §316(b) Rule Information

40 CFR 122.21(r)(10) Submittal



Prepared for:
Tennessee Valley Authority

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List of Acronyms and Abbreviations

Acronym/Abbreviation	Term/Phrase/Name
ºF	Degrees Fahrenheit
§	Section
AC	Alternating current
ACI	American Concrete Institute
ADEM	Alabama Department of Environmental Management
AEI	Adverse environmental impact
AIF	Actual intake flow
ANSI	American National Standard Institute
ANSI/HI	American National Standard Institute-Hydraulic Institute
ARCW	Auxiliary Raw Cooling Water
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	ASTM International
BFN	Browns Ferry Nuclear
BTA	Best technology available
btu	British Thermal Units
CCRS	Closed-cycle recirculating system
CCW	Condensing circulating water system
CFR	Code of Federal Regulations
cfs	cubic feet per second
CoC	cycles of concentration
CW	Circulating Water
CWC	Cold Water Channel
CWA	Clean Water Act
CWIS	Cooling Water Intake Structure
CWS	Circulating Water System
dB	Decibels
dBA	A-weighted decibels
DIF	Design intake flow
DO	Dissolved oxygen
ECCS	Emergency Core Cooling System
EECW	Emergency Equipment Cooling Water
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
EPU	Extended Power Uprate
FAA	Federal Aviation Agency
FAC	Flow accelerated corrosion
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FHRS	Fish handling and return systems
FMEA	Failure mode and effect analysis
FMS	Fine mesh screens
FRP	Fiberglass-reinforced polymer
ft	Feet
ft/sec	Feet per second

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Acronym/Abbreviation	Term/Phrase/Name
GDC	General Design Criteria
gpm	Gallons per minute
HDPE	High-density polyethylene
HMI	Human machine interface
hp	Horsepower
HPFP	High Pressure Fire Pump
hr	Hour
HVAC	Heating, ventilation, and air conditioning
HZOI	Hydraulic zone of influence
IBC	International Building Code
inHg	Inches mercury
I/O	Inputs and outputs
kWh	Kilowatt hour
kVA	Kilovolt-ampere
LED	Light-emitting diode
lb	Pounds
LOCA	Loss of coolant accident
LRA	License Renewal Application
MCR	Main Control Room
MDCT	mechanical draft cooling tower
MGD	Million gallons per day
mg/L	Milligrams per liter
MHHW	Mean higher-high water
min	Minutes
MLLW	Mean lower-low water
MOV	Motor operated valve
mm	Millimeters
MSL	Mean sea level
MWe	Megawatt electric
MWh	Megawatt hour
MWt	Megawatt thermal
NAS	Naval Air Station
NDBC	National Data Buoy Center
NEIL	Nuclear Energy Insurers Limited
NEPA	National Environmental Protection Act
NERC	North American Electric Reliability Corporation
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPV	Net present value
NRC	Nuclear Regulatory Commission
NWP	Nationwide Permit
O&M	Operation and maintenance
OCA	Owner Controlled Area
PEPSE	Performance evaluation of power system efficiencies
PLC	Programmable logic controller
POA	Percent open area

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Acronym/Abbreviation	Term/Phrase/Name
ppm	parts per million
PRA	Probabilistic risk analysis
psi	Pounds per square inch
psf	Pounds per square foot
PVC	Polyvinyl chloride
PWR	Pressurized Water Reactor
RCW	Raw Cooling Water
RHRSW	Residual heat removal service water
RTD	Resistance temperature detector
SBO	Station blackout
SDP	Standard Design Process
sec or s	Second
SSC	System, structure, or component
SWPPP	Stormwater pollution prevention plan
TDS	Total dissolved solids
TVA	Tennessee Valley Authority
UFSAR	Updated Final Safety Analysis Report
UHS	Ultimate Heat Sink
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VFD	Variable frequency drive
WWC	Warm Water Channel

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Executive Summary

Tennessee Valley Authority (TVA) owns and operates Browns Ferry Nuclear Plant (BFN), located on the Wheeler Reservoir in Limestone County, Alabama. BFN Units 1, 2, and 3 are designed to withdraw over 2,900 million gallons per day (MGD) for non-contact cooling purposes. As a result, BFN is subject to compliance with the U.S. Environmental Protection Agency (EPA) Clean Water Act Section 316(b) cooling water intake structures final rule at existing facilities (Final §316(b) Rule). Currently, BFN withdraws and discharges non-contact cooling water from Wheeler Reservoir in accordance with National Pollutant Discharge Elimination System (NPDES) Permit Number AL0022080. In accordance with the Final §316(b) Rule, TVA has prepared this document to address the Final §316(b) Rule information requirements specified in Title 40 of the Code of Federal Regulations (40 CFR) §122.21(r)(10).

The purpose of TVA's §122.21(r)(10) submittal, Comprehensive Technical Feasibility and Cost Evaluation Study, is to provide the engineering information necessary to make a best technology available (BTA) determination after considering all relevant factors under the Final §316(b) Rule for BFN. This report summarizes the evaluation of various technologies pursuant to §122.21(r)(10) of the Final §316(b) Rule.

While this report focuses exclusively on assessing cost and feasibility of the candidate technologies described below, an assessment of the entrainment benefits of these options is provided in the separate report under §122.21(r)(11).

Conversion to Closed Cycle Cooling

The total cost estimate for implementing closed-cycle cooling at BFN is approximately $334 million. In a closed-cycle cooling configuration, circulating water is routed to the cooling towers to reject the heat load picked up from the condensers. Cooled circulating water is discharged from the cooling towers back to the intake forebay, where the water is drawn back into the plant for reuse. The communication between the forebay and the Wheeler Reservoir would be maintained by an opening in Gate 3 for makeup and assurance of safety-related cooling water for the residual heat removal service water (RHRSW) system. Safety-related cooling water would be maintained in a once-through configuration. This is due to the high cost associated with conversion to closed-cycle cooling and limited benefit in reducing flow rate drawn from the Reservoir. The intake flow rate required to make up the condensing circulating water (CCW) inventory lost to blowdown, drift, and evaporation, would be approximately 160,000 gpm total, which represents a 92% reduction in intake flow from open mode. The primary driver of the makeup flow rate is the radwaste dilution requirement of 100,000 gpm.

The compliance option to retrofit BFN with a closed-cycle cooling system, while technically feasible, would pose significant engineering, construction, permitting, and operational challenges. Procurement, construction, and modification or refurbishment of mechanical draft cooling towers, water distribution piping, lift pumps, control gates, and electrical equipment would be required if a closed-cycle cooling system were implemented at BFN. Construction would require extensive clearing, grading, excavation, earthwork, piping placement, structure erection, equipment installation, and system tie-ins. The implementation of a closed-cycle cooling system at BFN would impose significant engineering fees, procurement costs, construction costs, power

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generation losses (estimated at 69 MWe), and recurrent operation and maintenance costs. Engineering, permitting, procurement, and construction would take approximately 8 years following the start of the project.

Fine Mesh Screens

The total cost estimate for retrofitting BFN with a new fine mesh screen (FMS) system is approximately $84 million. These costs include construction of a new screening structure, which is required to maintain acceptable through-screen flow velocity and pressure drop. The screening structure would be located approximately 270 ft in front of the existing cooling water intake structure (CWIS) and would house 22 new dual-flow fine-mesh screens with 0.5 mm openings and a fish handling and return system (FHRS). The overall project duration for the implementation is estimated to be six years. As explained in BFN's §122.21(r)(11) report, entrainment studies at BFN project that approximately 74% of the entrained organisms would be excluded by fine-mesh screens. However, entrainable species excluded because of the implementation of FMS, known as converts, would be subject to impingement. As shown in the §122.21(r)(11) report, the probability of converts surviving impingement, screen-wash systems, and fish return would be low.

Because the new screens would be installed between the safety related RHRSW pumps and the UHS, a safety related bypass would be required as part of the new FMS. An 8 ft diameter steel safety bypass pipe would be installed at either end of the structure, with each pipe capable of allowing at least the 80 ft^3/s required by the RHRSW pumps. The safety bypass pipes would have trash bars to protect the system from large debris, and the existing traveling water screens would be left in place to filter out small debris.

This report estimates a total loss of 802 kWe power generating capacity due to operation of additional FMS and FHRS equipment (e.g., screen drive motor and FHRS spray pumps). Operating and maintaining the new FMS system and FHRS would take approximately 3,725 man hours annually. Periodic maintenance dredging would be required in the vicinity of the safety related bypass piping. It is estimated that maintenance dredging would have an associated cost of $360,000 at a frequency of every ten years.

Adopting the new FMS system and FHRS would require a minimum 12-month study and field monitoring in order to assess this option's actual impacts on the impingement and mortality rate for the entrained organisms.

Water Reuse

The water reuse and alternate sources of cooling water option(s), which were evaluated during the initial screening processes, consistent with the requirements of §122.21(r)(10)(i), were ultimately not retained for the comprehensive evaluation due to limited amount of alternative water sources available near BFN.

Conclusions

The compliance options identified above, i.e. closed cycle cooling and fine mesh screen, while technically feasible would pose significant engineering, construction, permitting, and operational challenges. The implementation of either of the two technologies would impose significant

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engineering fees, procurement costs, construction costs, power generation losses, and recurrent operation and maintenance costs. For closed-cycle cooling construction would require extensive clearing, grading, excavation, earthwork, piping placement, structure erection, equipment installation, and system tie-ins. For fine mesh screens construction would require extensive dredging, concrete forming, metal work, piping placement, equipment installation, and system tie-ins. Both technologies would take over 5 years for full implementation following the start of the project – 8 years for closed-cycle cooling and 6 years for fine mesh screen. Because of this, implementation of either of the two technologies is not considered a prudent or practical measure for entrainment reduction.

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1 Introduction and Regulatory Framework

EPA's Final §316(b) Rule, which was codified in May 2014, establishes requirements under the Clean Water Act (CWA) for existing power generating facilities which withdraw more than two million gallons per day (MGD) of water from Waters of the United States and use at least 25% of that water exclusively for cooling purposes. Those requirements, implemented through NPDES permits, apply to the location, design, construction, and capacity of cooling water intake structures that reflect the BTA for minimizing adverse environmental impact (AEI).

There are two main components of the Final §316(b) Rule for existing facilities, such as BFN. The first requires the owner or operator of the facility to choose one of seven options for meeting BTA requirements for reducing impingement. The second component requires the facility to conduct studies to help the permitting authority determine whether and what site-specific controls, if any, would be required to reduce entrainment.

To address these two components, the Final §316(b) Rule establishes additional permit application requirements for existing power plants, which include 12 distinct submittals pursuant to 40 CFR 122.21(r)(2) through (13). This report fulfills the submittal requirements of the Comprehensive Technical Feasibility and Cost Evaluation Study of §122.21(r)(10).

1.1 Browns Ferry Nuclear Plant Background

BFN is a three-unit, boiling water reactor (BWR) nuclear power plant owned and operated by Tennessee Valley Authority (TVA). BFN is located on Wheeler Reservoir in Limestone County, Alabama. Each unit is a General Electric (GE) Mark I design. Units 1, 2, and 3 became operational in 1974, 1975, and 1977, respectively. The units were originally designed to operate at core power rating up to 3,293 MWt. In 2010 each unit was uprated to a core power output of 3,458 MWt, and additional uprates to 3,952 MWt were completed for all units by spring 2019. BFN draws water from Wheeler Reservoir for cooling purposes and discharges the water back to the reservoir under NPDES Permit No. AL0022080.

The condenser circulating water (CCW) system supplies screened water from the Wheeler Reservoir to the main condensers for all three units. Major components and structures within the CCW system include the intake channel, traveling water screens, the intake pumping station, the CCW pumps, the discharge conduit, vacuum priming/breaking systems and the "hump", the cold and warm water channels, cooling tower lift pumps, cooling towers, discharge diffusers, and a series of gates and weirs. A simplified diagram of the CCW system is shown in Figure 1 below. Figure 2 shows the CCW cooling modes and gate structures.

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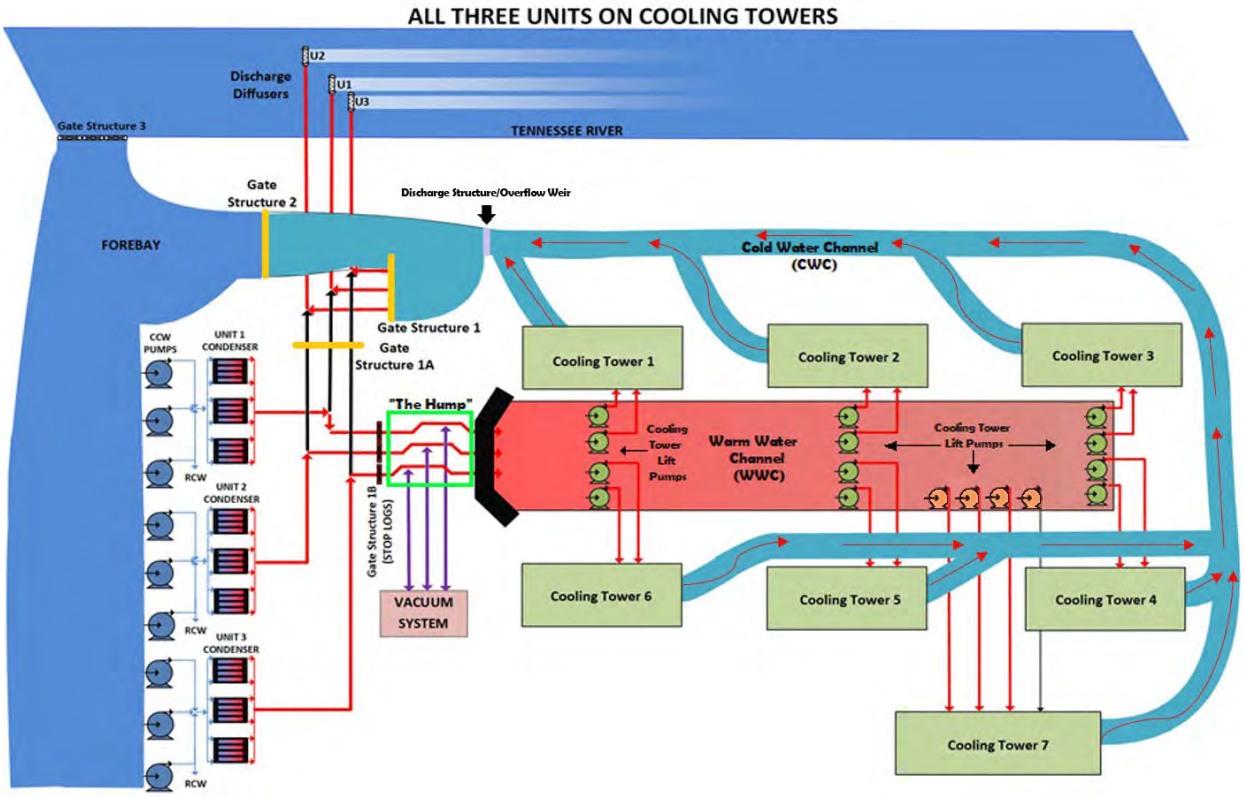


Figure 1: Condenser Circulating Water (CCW) System

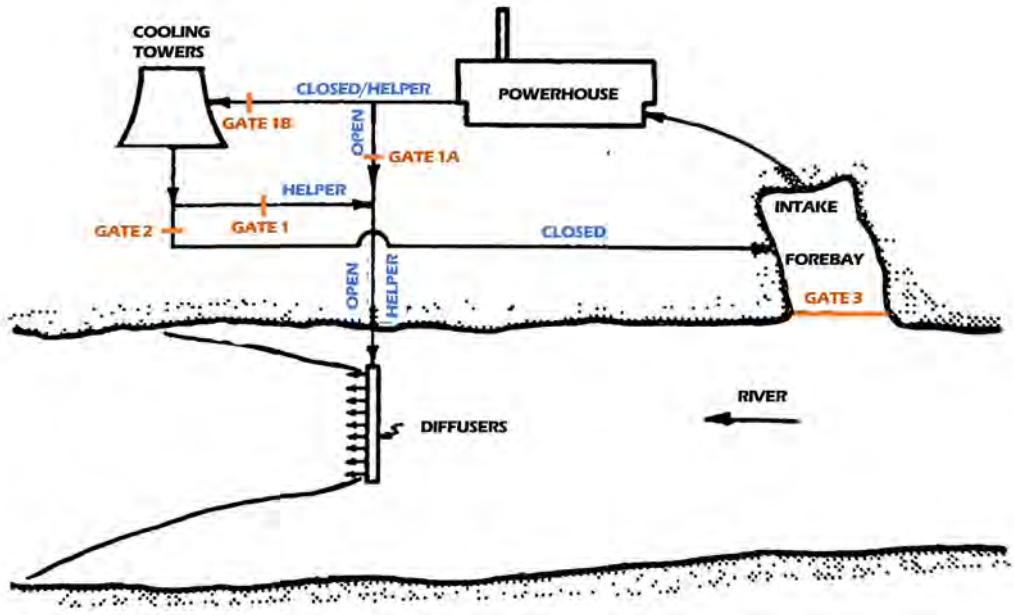


Figure 2: BFN condenser cooling modes and gate structures

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Screened water is drawn from the reservoir through Gate 3 into the forebay, from which the CCW, residual heat removal service water (RHRSW), and emergency equipment cooling water (EECW) systems draw water. The CCW system utilizes nine pumps (three per unit) that each have a design flow rate of 225,000 gpm (Ref. 10.1).

The discharge of the CCW pumps is brought together and enters a steel trifurcation, which distributes the flow among three tunnels (one per unit). The CCW then travels north in the tunnels towards the turbine building where it feeds into the main condensers for each of the units. The CCW exits the condensers into three discharge conduits (one per unit).

The CCW system is currently operated in a once-through configuration that can optionally use cooling towers to cool the effluent before it is discharged to the Wheeler Reservoir. Once-through configurations with and without the aid of the cooling towers are referred to as helper and open modes, respectively. In the open mode configuration, CCW passes from the condensers through Gate 1A into the discharge diffusers where it is expelled from the plant back into the Wheeler Reservoir. In the helper mode configuration, Gate 1A is closed or throttled, and CCW passing from the condensers is routed through Gate 1B (an open stoplog structure), over the “hump”, assisted by the vacuum primer, and into the warm water channel (WWC). As described in Section 3.6.1, the “hump” is a high point in the piping/conduit from the condensers to the WWC. Its purpose is to prevent backflow of “hot” water from the WWC into the forebay in the event of a breach in the Wheeler dam. This is accomplished in conjunction with the vacuum breaker system. Cooling tower lift pumps take suction from the WWC and pass water through the cooling towers and into the cold water channel (CWC) where it flows over the discharge control structure. Gate 2, which separates the CWC from the intake forebay, is closed, and Gate 1, which leads from the CWC to the discharge diffuser, is open. Therefore, the CCW flow passes from the CWC through Gate 1 into the discharge diffuser.

The closed-cycle cooling configuration, referred to as closed mode at BFN, is not currently utilized. In closed-cycle cooling, flow would be drawn from the intake forebay by the CCW pumps and travel through the condensers before being routed to the WWC. The lift pumps transfer the water to the cooling towers and the cooled flow discharges into the CWC. Finally, the flow travels over the discharge control structure and through Gate 2 back to the intake forebay, where it would be drawn back into the intake pumping station. Due to loss of CCW to evaporation and drift in the towers as well as blowdown, some flow would be drawn in from Wheeler Reservoir through the intake channel that passes underneath Gate 3, which separates the intake forebay from the Wheeler Reservoir.

The discharge control structure, located in the CWC, is an overflow weir that controls the water level in the portion of the CWC where the cooling tower discharge is accumulated. An overflow weir immediately upstream of the discharge control structure, which has the same top elevation as the discharge control structure, is used for blowdown to remove some of the CCW inventory as a means to control water quality.

The intake pumping station is safety-related and houses the safety-related RHRSW pumps, which provide the safety-related cooling water for both the RHRSW and emergency equipment cooling water (EECW) systems. The traveling water screens are non-safety-related and are installed on the front of the pumping station. Gate 3, which functions like a skimmer wall, is also safety-related

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and has dedicated openings beneath the gates large enough for the maximum safety-related flow required by all three units to be drawn from the reservoir at any time necessary for safe shutdown.

All gates except Gate 2 are capable of being aligned independently for each unit, such that one unit could be aligned to open mode and another to helper mode. The CCW conduit consists of three tunnels, each dedicated to one of the three units. The WWC, CWC, and blowdown structure are shared by all three units.

1.2 Comprehensive Technical Feasibility and Cost Evaluation Study Requirements

40 CFR §122.21(r)(10) of the Final §316(b) Rule requires submittal of a Comprehensive Technical Feasibility and Cost Evaluation Study consistent with the following requirements:

> *"For an existing facility that withdraws greater than 125 MGD actual intake flow (AIF), submit an engineering study of the technical feasibility and incremental costs of candidate entrainment control technologies. In addition, the study must include the following:*
>
> *(i) Technical feasibility. An evaluation of the technical feasibility of closed- cycle recirculating systems as defined at 40 CFR 125.92(c), fine-mesh screens with a mesh size of 2 millimeters or smaller, and water reuse or alternate sources of cooling water. In addition, this study must include:*
>
> *a. A description of all technologies and operational measures considered (including alternative designs of closed-cycle recirculating systems such as natural draft cooling towers, mechanical draft cooling towers, hybrid designs, and compact or multi-cell arrangements);*
>
> *b. A discussion of land availability, including an evaluation of adjacent land and acres potentially available due to generating unit retirements, production unit retirements, other buildings and equipment retirements, and potential for repurposing of areas devoted to ponds, coal piles, rail yards, transmission yards, and parking lots;*
>
> *c. A discussion of available sources of process water, grey water, waste water, reclaimed water, or other waters of appropriate quantity and quality for use as some or all the cooling water needs of the facility; and*
>
> *d. Documentation of factors other than cost that may make a candidate technology impractical or infeasible for further evaluation.*
>
> *(ii) Other entrainment control technologies. An evaluation of additional technologies for reducing entrainment may be required.*
>
> *(iii) Cost evaluations. The study must include engineering cost estimates of all technologies considered in paragraphs (i) and (ii) above. Facility costs must also be adjusted to estimate social costs. All costs must be presented as the net present value (NPV) and the corresponding annual value. Costs must be clearly labeled as compliance costs or social costs. The applicant must separately discuss facility level compliance costs and social costs, and provide documentation as follows:*
>
> *a. Compliance costs are calculated as after-tax, while social costs are calculated as pre-tax. Compliance costs include the facility's administrative costs, including costs of permit application, while the social cost adjustment includes the Director's administrative costs. Any outages, downtime, or other impacts to facility net revenue, are included*

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in compliance costs, while only that portion of lost net revenue that does not accrue to other producers can be included in social costs. Social costs must also be discounted using social discount rates of 3 percent and 7 percent. Assumptions regarding depreciation schedules, tax rates, interest rates, discount rates and related assumptions must be identified;

b. *Costs and explanation of any additional facility modifications necessary to support construction and operation of technologies considered in (i) and (ii) above, including but not limited to relocation of existing buildings or equipment, reinforcement or upgrading of existing equipment, and additional construction and operating permits. Assumptions regarding depreciation schedules, interest rates, discount rates, useful life of the technology considered, and any related assumptions must be identified; and*

c. *Costs and explanation for addressing any non-water quality environmental and other impacts identified in paragraph 122.21 (r)(12). The cost evaluation must include a discussion of all reasonable attempts to mitigate each of these impacts."*

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2 Technologies and/or Operational Measures Evaluated

In compliance with the permit application requirements codified in §122.21(r)(10)(i) of the Final §316(b) Rule, the enclosed Technical Feasibility and Cost Evaluation Study provides engineering and economic information related to the implementation of closed-cycle cooling, fine mesh traveling water screens, and water reuse/alternate water sources at BFN. Based on a preliminary review of the site-specific configuration and resources, no additional entrainment reduction technologies were identified as BTA candidates which warrant further evaluation.

Note that water reuse and alternate sources of cooling water were evaluated based upon the total flow potentially available from onsite and local offsite sources, consistent with the requirements of §122.21(r)(10)(i) but were ultimately not retained for the comprehensive evaluation due to the minimal amount of alternative water sources available at BFN.

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3 Closed-Cycle Cooling Using Mechanical Draft Cooling Towers

3.1 Conceptual Design

In a closed-cycle cooling system, waste heat is discharged to the atmosphere rather than a cooling water body. The CWA Final §316(b) Rule provides the following definition of a closed-cycle cooling system at §125.92(c)(1):

> *"Closed-cycle recirculating system includes a facility with wet, dry, or hybrid cooling towers, a system of impoundments that are not waters of the United States, or any combination thereof. A properly operated and maintained closed-cycle recirculating system withdraws new source water (make-up water) only to replenish losses that have occurred due to blowdown, drift, and evaporation. If waters of the United States are withdrawn for purposes of replenishing losses to a closed-cycle recirculating system other than those due to blowdown, drift, and evaporation from the cooling system, the Director may determine a cooling system is a closed-cycle recirculating system if the facility demonstrates to the satisfaction of the Director that make-up water withdrawals attributed specifically to the cooling portion of the cooling system have been minimized."*

Implementation of a closed-cycle cooling system would entail returning CCW from the cooling towers through Gate 2 back to the intake structure. Because the RHRSW and EECW systems draw water through the intake structure for safety-related functions, the CCRS design is required to ensure that the water returned to the intake will not exceed the UHS temperature limit.

The existing CCW flow infrastructure was evaluated for compatibility with closed-cycle cooling operation. The following sub-sections detail the technical challenges that BFN would face when converting the existing CCW systems to closed-cycle cooling. The potential solutions to the identified challenges are also discussed in each sub-section. Specifically, challenges related to cooling tower and lift pump upgrades (Section 3.2), new Gate 2 structure (Section 3.3), ultimate heat sink (UHS) protection (Section 3.4), radwaste discharge (Section 3.5), CCW system refurbishment (3.6), and operations and controls (Section 3.7) were evaluated.

The RHRSW system is recommended to continue operating in the once-through mode due to the high cost associated with adding safety-related cooling towers, power sources and significant updates to the control room (see Section 3.11). The RHRSW system would continue using the forebay and reservoir as the UHS. Under certain operating scenarios, which will be discussed later, Gate 2 would be closed to prevent warm water in the WWC from reaching the forebay and challenging the UHS temperature limit.

This section provides the preliminary design for a closed-cycle cooling system at BFN that would meet the definitions provided in the CWA Final §316(b) Rule.

3.2 Tower and Lift Pump Performance and Upgrades

BFN currently operates seven linear mechanical draft cooling towers with a total of 127 cells. Towers 1 and 2 are the original towers put into service in 1976. Towers 3, 4, 5 and 6 have been replaced with upgraded models. Tower 7 was added into service in 2012 to handle the additional heat load from the extended power uprates (EPU), which have been implemented for all three units. The towers have combined design flow capacities of 2,060,000 gpm (Ref. 10.2), which exceeds the combined CCW flow rate when aligned to towers: 635,000 gpm per unit, or 1,905,000

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gpm total (Ref. 10.3). Design data for the existing towers is summarized in Table 1 below. Towers 1 through 6 have two lift pumps each while Tower 7 has four.

Table 1: Existing Tower Design Data

			Design Data			
Tower	Startup	No. of Cells	Wet Bulb Temp, °F	Cold Water Temp, °F	Range, °F	Design Flow, gpm
1	1976	16	55	84	31.7	275,000
2	1976	16	55	84	31.7	275,000
3	2013	16	82	91.6	26.9	275,000
4	2007	16	80	91	28.2	275,000
5	2013	19	82	90	28.5	275,000
6	2014	16	82	91.6	26.9	275,000
7	2012	28	82	90	28.5	410,000

The towers are typically used in summer to cool site effluent for compliance with the NPDES permit. As discussed in Section 4, the evaluation of tower performance, including thermohydraulic analyses (e.g. PEPSE model outputs), concluded that the performance of towers at their design points, assuming upgraded replacement of Towers 1 and 2, would be sufficient to allow BFN to operate in closed-cycle cooling.

However, the cooling performance of the towers and lift pumps has been significantly below design in recent years due to degradation from aging, irregular use and lack of maintenance, and incompatible modification designs. One lift pump for Tower 7 has been taken out of service since 2016 to avoid overflowing the hot water basin on top of the tower. The overflowing event that occurred in 2016 caused a partial collapse of Tower 7 when all four lift pumps were in operation and delivered approximately 30,000 gpm more flow than the capacity of the tower nozzles (Ref. 10.4). The remaining original towers, Towers 1 and 2, reached the end of their useful life and are not performing to desired levels after over 40 years of service. Because of the way in which the towers are used, station resources are not prioritized for tower operations, and routine maintenance. Currently, the towers receive no regular chemical treatment, leading to problems with scaling and biological growth on the tower's fill and spray nozzles. In preparation for usage of the towers in the summer of 2019, it was found that none of the towers were available, and 26 fans were out of service.

Additionally, past modifications to select towers led to reduction of tower flow and efficiency. For example, replacement Towers 3, 5, and 6 are taller than the original towers, which increased the head requirement of the lift pumps. While they were designed for the same flow as the original towers, the increased head requirement prevents the lift pumps from delivering the design flow of the towers. The head requirement of the lift pumps depends on the difference in the water level of the warm water basin atop the towers and the WWC, so lift pump flows fall further below design when the WWC is at its low level (Refs. 10.24, 10.25, 10.26).

BFN has performed internal evaluation of the performance of the existing tower and has had a third-party vendor evaluate the necessary tower modifications to support continuous operation of

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all three units in closed-cycle cooling. The recommended changes are described in the sections below.

3.2.1 Existing Tower and Lift Pump Upgrades

To correct the degraded condition of the existing towers and lift pumps, the following modifications have been identified by BFN:

- Replacement of Towers 1 and 2
  - Current 16-cell towers designed for 275,000 gpm each
  - Specifications for the new towers require that they be 22-cell towers rated for 330,000 gpm with a cold water temperature of 90°F and range of 28.5°F at a wet bulb temperature of 82°F.
  - Replacement of Tower 1 is currently in process and replacement of Tower 2 is planned. These modifications are included in the implementation cost estimate for closed-cycle cooling.
- Upgrade of Towers 4 and 7
  - Tower 4 should be replaced or refurbished to correct performance degradation that has occurred since its start of service in 2007.
  - The flow distribution system of Tower 7 should be upgraded to allow the flow capacity of all four lift pumps (440,000 gpm).
- Replacement or upgrade of lift pumps and discharge valves for Towers 1 through 6.
  - Specifications for the new lift pumps for Towers 1 and 2 require that they be rated for 165,000 gpm with a head of 77 ft. Each tower would be served by two pumps, resulting in supply of 330,000 gpm per tower.
  - Lift pump and discharge valve upgrades should be implemented to increase flow capacity to meet the tower design flow rate at the full range of normal WWC water levels. This would include impeller replacements and/or discharge valve upgrades that incur lower head loss.

The design wet bulb temperature of 82°F is above the 0.4% exceedance value for the region (78.3°F, Ref. 10.27). The design cold water temperature is below the UHS temperature limit of 92.5°F. While the design range is slightly below the maximum CCW temperature increase across the condenser observed from the PEPSE model output (29.1°F[1]), the total design flow rate of the towers exceeds the CCW flow rate. The design point of Towers 1 and 2 brings the total design heat load capacity of the towers up to 30,500 MBtu/hr, which exceeds the maximum condenser heat load for all three units of approximately 27,800 MBtu/hr.

As described in Section 4, the thermal-hydraulic evaluation of closed-cycle cooling assumed that the performance of Towers 1 and 2 would be below what has since been specified for the new

[1] Observed with CCW flow rate of 317,800,000 lbm/hr (635,000 gpm), CCW condenser inlet temperature of 92.5°F, and 100% EPU power level.

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towers which would replace Towers 1 and 2. Therefore, the conclusion remains that closed-cycle cooling is viable with seven towers, as upgraded with planned replacements to Towers 1 and 2.

Upgrades to Tower 7 are expected to correct the flow balance issue that led to the partial collapse in 2016. Since the flow distribution system is not rated for the full flow rate of the lift pumps, it would need to be upgraded, including replacement of the existing spray nozzles with components allowing more flow. Upgrading the flow capacity of Tower 7 would increase the design heat load capacity of the towers to 31,000 MBtu/hr, which is approximately a 10% higher than the maximum condenser heat load. It should be noted that heat loads from the Raw Cooling Water (RCW) system are also handled by the towers. However, the RCW flow rate is less than 4% that of the CCW system flow rate in closed-cycle cooling and would not have a large impact on tower performance.

Upgrades to or replacement of Tower 4 would be required due to the intermittent usage and irregular maintenance, as described above, over its service life of more than 15 years. Further, the Tower 4 structure is wooden, which is susceptible to degradation from cycled wetting[2]. Upgrades to or replacement of Tower 4 would restore the tower to its design performance level. Improvements to achieve performance beyond original design are not necessary for the implementation of a closed-cycle cooling configuration.

Upgrades to or replacements of the lift pumps and discharge valves serving Towers 1 through 6 would be sufficient to supply design flow rates at all normal operating conditions, including at low WWC level conditions. Upgraded discharge valves would be capable of throttling lift pump flow as necessary to control the water level in the WWC by maintaining balance with the CCW flow rate.

3.2.2 Non-Safety Electrical Upgrades

The replacement of existing Towers 1 and 2 would require installation of new power distribution and control equipment for the cooling tower fans, lift pumps, and auxiliary electrical loads. The power distribution system would require the addition of four new unit substations per cooling tower. Each new substation would be required to include the following primary equipment:

1. One medium voltage, quick break, load interrupting, fused transformer primary disconnect switch. The switch would be required to conform to IEEE C37.20.3 and would be sized to supply unit substation transformers at maximum ratings. The medium voltage switch would be housed by a NEMA 3R enclosure.
2. One 4,160V to 480V delta-delta, oil filled transformer designed and constructed in accordance with ANSI/IEEE standards including C57.12.00.
3. One 480V Motor Control Center (MCC).

[2] Should BFN pursue and be awarded a subsequent renewal of its operating license, the last license among the three units would expire in 2056. Given the expected life of 30 years commonly attributed to mechanical draft cooling towers, it is expected that the existing Tower 4 would require replacement before the end of a potential subsequent period of extended operation. If Tower 4 were to be replaced now, it would likely serve through a potential subsequent period of extended operation.

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Two new NEMA 3R walk-in enclosures per cooling tower would be required to house the new 480V MCC equipment. Each walk-in enclosure would house two of the four 480V MCCs for each respective cooling tower. A 240/120VAC and 480VAC distribution system would be required in each distribution enclosure including transformers, breakers, and distribution panels.

The existing cooling tower transformers TCT1A, TCT1B, TCT2 have been recently upgraded. These modifications replaced the existing cooling tower 161/4.16 kV transformers and buses with new equipment with the capacity to allow for the future planned cooling tower replacements of Towers 1 and 2. These upgrades satisfy the required upgrades described above, and no further upgrades of cooling tower transformers or distribution buses are expected to be required.

3.3 New Gate 2 Structure

Gate 2 currently remains closed at all times, serving as a dam between the CWC and the forebay. The gate passively serves a safety function to prevent thermal mixing of potentially warm discharge from the cooling tower lift pumps with the forebay.

In closed-cycle cooling, Gate 2 must be opened to allow CCW to pass from the cooling towers back to the forebay. Openings in Gate 2 are currently sized to accommodate the CCW flow rate of two units. To support closed-cycle cooling operation of all three units, the openings in Gate 2 would be enlarged. Performing this modification while maintaining the safety function of the gate would require isolating the CWC and forebay from Gate 2, draining the water around Gate 2, and modifying/demolishing a portion of the existing Gate 2 structure.

Based on a review of site documents, modifying the existing Gate 2 and structure would be a high-risk activity that could potentially undermine the functionality and stability of Gate 2. Isolating a portion of the gate for modification would likely be completed using a cofferdam, with sheet piles driven into the channel bed immediately adjacent to the Gate structure. Gate 2 has existing aging concerns, including restoration activities to the cell walls and cofferdam cell wall deterioration due to corrosion. Additionally, draining water locally inside of a cofferdam to access Gate 2, likely for an extended period, could undermine the passive stability of the gate. Cutting, drilling, and removing portions of the existing structure would likely cause significant vibrations throughout the gate structure, which could introduce unforeseen challenges. Based on this, it is not recommended to modify the existing structure.

A proposed alternative would be to install a new gate structure downstream, in the approximate location indicated by the blue marker in Figure 3below. The proposed structure would consist of a dam extending into the channel, with a reinforced concrete center and a built-in gate. This reinforced concrete center structure would be similar in size and width to the existing Gate 2, but the size of the openings would be sufficient to accommodate the CCW flow of all three units.

Installation of this proposed structure would require a sheet pile cofferdam to install the reinforced concrete portion of the dam. The earthen portion of the dam would be supported with the use of sheet pile cofferdams backfilled internally with structural fill and externally protected by rip rap. Once installation is complete, modifications can be performed to remove portions of the existing Gate 2. Installation of the proposed new gate structure would allow modifications to be performed to the existing gate without the requirement of maintaining overall functionality of Gate 2.

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Figure 3: New Gate 2 Location (Map data courtesy of Google© 2021)

3.4 Ultimate Heat Sink Protection Mitigations

The UHS is the system of structures, components, and associated water source or atmospheric conditions credited for providing the ability to reliably reject reactor residual heat and essential station heat loads following a normal shutdown or a shutdown following a design basis event, including a loss-of-coolant accident. The UHS for BFN is the Wheeler Reservoir and the forebay. In open and helper modes, as described in Section 3.11, the intake pumping station draws water from the Wheeler Reservoir through the intake channel that runs underneath Gate 3. In addition to protecting the intake structure from floating debris and marine vessels, Gate 3 is designed to ensure that the maximum required RHRSW flow rate for all units is available from the reservoir at all times. Gate 2, on the other hand, is designed to separate the forebay from the CWC, which ensures intake water is drawn from the reservoir.

In closed-cycle cooling configuration, circulating water is returned to the forebay from the towers through Gate 2. The closed-cycle configuration biases flow into the forebay through Gate 2, and the flow rate through Gate 3 is the difference in the flow rates entering the forebay through Gate 2 and exiting the forebay through the intake pumping station. Since the makeup flow through Gate 3 is determined by the flow balance on the forebay without the need for throttling, Gate 3 would be maintained in the fully open position for closed-cycle cooling. In closed-cycle configuration Gate 3 must continue to provide access to the reservoir, but the flow through Gate 2 must be stopped to allow water to enter the forebay from the reservoir through Gate 3. Therefore, design features would be required to prevent water in the CWC from flowing into the

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intake pumping station forebay, which serves as part of the UHS for the safety-related RHRSW pumps, during design basis events. The UHS has an upper temperature limit[3] of 92.5°F.

In closed-cycle cooling, two unique scenarios exist in which flow from the CWC must be prevented from entering the forebay to ensure the forebay water temperature does not get unacceptably high and the RHRSW pumps have uninterrupted access to the reservoir.

1. A loss of towers with continued operation of the lift pumps would result in the contents of the WWC being pumped into the CWC and recirculated back to the forebay.
2. A loss of the lift pumps with continued operation of the CCW pumps could flood the WWC, causing the contents of the WWC to spill into the CWC and recirculate back to the forebay.

Modifications necessary to address these scenarios are discussed in the following sections.

3.4.1 New Lift Pump Trips

To address the first scenario above, a seismic Class I system would need to be designed and implemented to interrupt power to any of the individual lift pumps when the water temperature at the discharge of the cooling tower served by those lift pumps is too high. The discussion below identifies the necessary modifications.

A similar scheme was employed when closed-cycle cooling was included in the BFN licensing basis. Each of the cooling tower discharge channels had a safety-related temperature sensor that could generate a high-temperature signal to trip the associated lift pumps when the water temperature at the discharge of the tower served by those pumps exceeded 95°F (historical FSAR 11.6.4). The design was redundant and seismically quantified (Ref. 10.5). As stated in Reference 10.6, the high-temperature signal was sent to the 4K VAC distribution system, which provided 120-VAC tripping power for the cooling tower switchgear and lift pumps. The 4K VAC distribution system also powered the cooling water discharge temperature circuits. Upon receiving the high-temperature signal, the 4K VAC distribution system trips the cooling tower lift pump and switchgear feeder breakers. This was categorized as a protective safety function but was not part of direct accident mitigation. A review of a 1991 cooling tower study showed that the components for this tripping mechanism may not have been maintained (Ref. 10.7). All existing references to the electrical equipment configuration required for closed-cycle cooling operation were removed as part of a design modification.

For future closed-cycle cooling operation, it would be recommended that the tripping mechanism discussed above be restored with improvements such that each cooling tower switchgear, relays for the lift pump breakers, switchgear feeder breaker, and switchgear alternate feeder breaker would energize to trip the associated breaker in response to a high discharge temperature signal. Redundant control power consisting of a preferred power source and backup safety-related power would be supplied for the relays for the plant to operate in closed-cycle cooling operation.

[3] While the Technical Specification UHS temperature limit is 95°F, 100% reactor thermal power is not allowable with a UHS temperature beyond 92.5°F after EPU. For UHS temperatures beyond 92.5°F and up to 95°F, reactor thermal power is required to be reduced from 100% to 96.3%.

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New safety-related redundant seismic Class I temperature sensing trip circuits would be required to provide the intended trip functions. Each cooling tower discharge temperature would be measured by redundant sets of three resistance temperature detectors (RTDs), each tied to an independent temperature indicating switch. The redundant sets of temperature indicating switch output contacts using interposing relays would be configured in a two out of three logic configuration to minimize nuisance tripping of the respective cooling tower lift pumps. Redundant sets of interposing relays would be included to provide sufficient output contacts to trip the respective cooling tower lift pumps. The circuitry would be designed for fail safe operation such that it would trip the respective cooling tower lift pumps upon loss of power.

The temperature indicating switch units and other control equipment would be located in a NEMA 4 enclosure and provided with redundant air conditioners to maintain the internal panel temperature within the limits of the instruments and other components. The RTD sensors and control panel would be seismically mounted near each cooling tower discharge channel prior to the flow joining the common CWC. Sun shields would be installed over the RTDs and control panels to minimize heating from the sun.

Switchgears involved with the temperature control circuitry include:

- Switchgear A for Cooling Tower Lift Pumps 1A, 1B and 2A
- Switchgear B for Cooling Tower Lift Pumps 2B, 3A and 3B
- Switchgear C for Cooling Tower Lift Pumps 5A, 6A and 6B
- Switchgear D for Cooling Tower Lift Pumps 4A, 4B and 5B
- Switchgear E for Cooling Tower Lift Pumps 7A and 7B
- Switchgear F for Cooling Tower Lift Pumps 7C and 7D

Dual isolation would be required to provide an interface between the safety-related function and non-safety systems.

3.4.2 Gate 2 Replacement

To address the second scenario above, it would be recommended to credit Gate 2 for active separation of the forebay from the CWC. Currently, Gate 2 is credited for passive separation of the forebay from the CWC, but this would no longer be the case since Gate 2 would be open during normal operation of the CCW system in closed-cycle cooling.

As discussed in Section 3.3, the Gate 2 structure, which would be rebuilt as a seismic Class I structure, would feature safety-related fail-close gates capable of blocking the flow path from the CWC to the forebay. The gates would include a control scheme similar to that of the lift pumps, which would be a seismic Class I temperature sensing circuit to actuate gate closure in response to a high CWC temperature signal. This system would be installed in parallel to the cooling tower lift pump trip scheme to provide an alternate train of UHS protection that prevents the return of high temperature water to the pumping station forebay. The addition of this system would be provided on a separate control and power circuit to the cooling tower lift pump trip scheme to eliminate any single point of failure of the two systems.

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To limit the safety-related power required, the gate closure would be gravity-driven and actuated with a release mechanism. To ensure full closure and effective seal, the gate would have a hand crank and locking mechanism.

The new Gate 2 in combination with the lift pump trips would offer a redundant design capable of preventing recirculation of hot water discharged from the lift pumps through failed or inadequately performing towers or pumps back to the intake pumping station forebay.

3.4.3 New CWC and WWC Spillways

Should the lift pumps trip or be lost in an accident while the CCW pumps continue to run, the WWC level would rise and overflow its banks without operator actions. To prevent an uncontrolled flooding event, it would be recommended that a spillway be implemented from the WWC to the CWC.

Similarly, should Gate 2 be closed during this event, the CWC water level upstream of Gate 2 would also rise and possibly overflow its banks without operator actions. A similar spillway would be recommended to be installed from the CWC to the reservoir.

The WWC spillway would be implemented across the berm separating the WWC and CWC, spilling into the CWC as far upstream as practical (e.g., between Towers 4 and 5). Currently, an access road runs around the WWC, so vehicular access over the spillway would be required.

The CWC spillway would be implemented across the dike separating the CWC from the reservoir upstream of Gate 2. An access road also runs along the dike, so vehicular access over the spillway would be required.



Figure 4: Spillway Locations (Map data courtesy of Google©2021)

The approximate location of the spillways is indicated by the yellow markers in the figure above. The spillways would be constructed by excavation and backfill with crushed stone topped with riprap conforming to the sloping requirements for seismic qualification.

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Under normal operating conditions, the WWC level ranges from 550 feet to 561 feet. When all towers are being utilized, the CWC level is estimated to be up to 570 feet in the area of the spillway. Therefore, the spillway between the WWC and the CWC could have an elevation greater than 571 feet.

The top elevation of the dike between the CWC and the Wheeler Reservoir is 565 feet, the overflow elevation of Gate 2 is 563 feet, and the normal water level of the Wheeler Reservoir ranges from 550 feet to 556 feet. Therefore, the spillway between the CWC and the Wheeler Reservoir would have an elevation between 557 and 562 feet.

3.5 Radwaste Dilution Impacts

The closed-cycle cooling system blowdown flow rate would be driven by the minimum dilution required for discharge of liquid radwaste. The current licensed thermal power (CLTP) and EPU conditions use a minimum dilution flow rate of 100,000 gpm, which is less than the minimum expected blowdown rate of 115,960 gpm when all units are aligned to cooling towers. The normal operations liquid effluent for BFN Units 1, 2, and 3 meets the dose objectives of 10 CFR Part 50, Appendix I and 10 CFR Part 20 Appendix B, Table 2. Therefore, release of liquid radwaste through the cooling tower blowdown line with a dilution flow exceeding 100,000 gpm is recommended.

The cooling tower blowdown is achieved via an overflow weir in the CWC. The blowdown flow rate is dependent on the CWC water level which, in turn, depends on the lift pump flow rate. The CWC water level in closed-cycle cooling after the lift pump and tower improvements would be at least as high as current helper mode water levels, so the cooling tower blowdown line is a viable path for radwaste discharge in closed-cycle cooling. A radwaste release line to the cooling tower blowdown line is already in place, but, based on discussions with plant personnel, it has been used only once in at least 10 years.

3.6 CCW System Refurbishment

3.6.1 Vacuum Priming/Breaking System

The vacuum primer and breaker are interconnected systems located between the condenser and WWC and are used in conjunction with a high point in the CCW conduit, referred to as “the hump”, to control alignment of a unit’s CCW flow to the cooling towers. The primer is used to prime the hump when aligning a unit to the towers, and the breaker is used to break the water lock in the hump to disconnect the towers from the WWC and prevent siphoning of the WWC. Because siphoning of the WWC during a CCW backflow event (described below) could result in the discharge of hot water to the forebay where the RHRSW pumps take suction, the vacuum breaker is a safety-related component. Modifications necessary for the systems are described in the following sections.

<u>Vacuum Primer</u>

The vacuum priming system consists of two vacuum pumps (21.5 inHg, 115 CFM), two relief valves, one 600-gallon vacuum tank, and other piping components. These components collectively serve all three units for the purpose of priming the CCW conduits by pulling a vacuum to draw CCW over the hump. This process is used to route CCW from the condenser to the WWC.

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The system is operated continuously during cooling tower operation to remove entrained air and maintain alignment to the towers.

It would be recommended that the priming system be modified to serve each unit independently, which would require the addition of two new vacuum tanks, four new vacuum pumps, and associated piping and components. Such a modification would increase plant reliability to prime multiple units and would reduce risk of losing a unit due to priming failure.

Vacuum Breaker

Loss of CCW pumps in combination with a break of the downstream dam on Wheeler Reservoir could result in backflow through the CCW system as the forebay water level drops, pulling the WWC volume with it via a siphon over the hump.

The hump in the CCW conduits between the WWC and the condenser provides the operator with a means of preventing the water in the WWC from being siphoned in a CCW backflow event. A vacuum breaking system located over the hump is available to break the vacuum by utilizing two redundant 12-inch valves per unit to manually vent the CCW conduit to atmosphere. The vacuum breaking system is a redundant, seismic Class I engineered safeguard. The CCW system would be susceptible to backflow when all of the CCW pumps are stopped and the water level in the WWC is above that of the forebay, until the operator breaks the siphon at the vacuum loop.

In discussions with plant personnel, it was reported that breaking the siphon requires local manual operation of valves that are accessed through a confined space. Additionally, it was reported that unreliable performance and control of the vacuum breakers has made it hard to complete and maintain alignment of a unit to the towers with the vacuum primer system. Therefore, the vacuum breaker system would need to be upgraded by replacing the vent valves, their actuating components, and controls to improve reliability should the implementation a closed-cycle system configuration be required.

3.6.2 Blowdown Lines

Cooling tower blowdown is a method of controlling the total dissolved solids (TDS) within the CCW system water inventory, which concentrate via the evaporative process in the towers. Cycles of concentration (COC) is a measure of the level to which contaminants concentrate in the circulating water, where a lower number represents lower concentration. Lower concentration is achieved with higher blowdown flow, which reduces the percent reduction in flow over a once-through system. As noted in Attachment B, freshwater cooling towers typically operate with a COC of no less than 3.0. For reference, modern saltwater systems typically operate with a COC of at least 1.5.

Cooling towers at BFN have a common blowdown line, which is accessed via an overflow weir at the end of the CWC immediately upstream of the discharge control structure. The weir feeds into a 72-inch diameter underground conduit, which splits into three 42-inch diameter lines that run to the CCW discharge pipe. The 72-inch line has a flow element that has been abandoned in place, and each of the three 42-inch lines have a flow control valve. Liquid radwaste is connected to the 72-inch common blowdown line via a 3-inch underground discharge line upstream of the abandoned flow element.

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The blowdown lines would be used continuously in closed-cycle cooling to control concentration of impurities in the CWC water due to CCW water loss from evaporation and drift in the towers. Additionally, it would be recommended that the cooling tower blowdown flow path be used for dilution of liquid radwaste while in closed-cycle cooling. As discussed in Section 3.5, cooling tower blowdown flow with all three units aligned to the towers is at least 115,000 gpm, which exceeds the required dilution flow rate for liquid radwaste releases and results in a COC of 1.4.

It should be noted that the blowdown flow rate would be variable based on the water level in the CWC. Because the minimum blowdown flow is sufficient for radwaste dilution, and additional blowdown flow increases makeup, excess blowdown flow should be avoided. Existing flow control valves are installed on the blowdown lines and would be adjusted to limit blowdown flow to that required for radwaste dilution. The abandoned flow element would be replaced to allow monitoring of the blowdown flow during closed-cycle system operations.

3.6.3 Cooling Tower Bypass Lines

Operation of cooling towers when the outside dry bulb temperature is near or below freezing poses the risk of severe ice formation on the towers, which can cause significant tower damage. Towers should never be operated in freezing weather with a reduced heat load (e.g., during startup or shutdown or with reduced tower flow). When the design heat load is not available for a tower in freezing weather, the tower should be bypassed by directing the lift pump discharge directly into the CWC. Many other operational measures, including fan manipulation, may be taken to mitigate freezing of towers in winter at the design tower heat load. This discussion focuses only on bypass lines because of the need for modification to employ that mitigation strategy. Due to the abandoned condition of the existing bypass lines, new tower bypass lines would be required.

The bypass lines would run from the lift pump discharge header into and along the length of the respective cooling tower basin. The bypass pipe discharge within the basin would have evenly spaced openings, like a diffuser. The lines would be equipped with isolation valves so that they are used only when required. Use of the bypass lines would require isolation of the cooling towers, which would be achieved by installing new isolation valves to the tower supply lines downstream of the bypass lines.

Since cooling tower bypass is expected to be used in winter when the WWC temperature is much lower than the cooling tower lift pump trip temperature setpoint, it is not expected that tower bypass would lead to any accidental lift pump trips.

3.6.4 Dredging

The CCW, RHRSW, and EECW systems draw water into the forebay from the reservoir via the intake channel, which runs through Gate 3. The open communication between the forebay and the reservoir allows suspended river sediment to transport to and deposit in the forebay. Over time, the accumulation of river sediment in the forebay has led to raised bed levels in the forebay. In 2018, BFN dredged approximately 4,270 cubic yards over an area of approximately 130,000 ft^2 in the forebay area of the intake channel to restore the channel to its original contour (Ref. 10.8). Since the remainder of the forebay would be in the recirculation flow path for closed-cycle

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cooling, the bottom would be evaluated for excessive levels of sediment deposition, and it would need to be restored to its original depth as necessary via dredging.

3.7 Operations and Controls

Operation of the CCW system requires control of the following components for each unit:

- CCW pumps
- Gates 1A, 1, and 2
- Vacuum breakers/primers
- Lift pumps and towers

When the cooling towers were added to the plant, automatic controls designed by Swanson were used to allow operators to easily switch between the open, helper, and closed cooling modes from the control room. However, the original control equipment was largely inoperable by 1991 (Ref. 10.9). Currently, manipulation of these components is primarily a manual operation directed from the control room and performed by operators locally, in the cooling tower and gate areas.

Implementation of closed-cycle cooling would place additional burden on site operators. Per discussions with plant personnel, BFN currently staffs two operators on towers with overtime during tower operation in the summer months. If the towers were to be operated continuously year-round, staffing requirements would increase by at least 10 operators.

Implementing centralized performance monitors and controls for towers, lift pumps, and gates to ease operational burden is recommended. This could be achieved by installation of a distributed control system (DCS). All inputs from these components would be routed via fiber optic cables to a new control building for remote monitoring, and outputs would run from the control building back to existing MCCs. The new control building would be located in the cooling tower area and include monitoring and control of the following items:

- Tower Fans
    - On/off status
    - Fan speed
    - Fan direction
- Lift Pumps
    - On/Off status
    - Motor coil temperature
    - Bearing temperature
    - Suction pressure
    - Discharge pressure
    - Discharge valve position
    - Discharge flow rate
- Gates
    - Gate status (hand switch position)

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- Gate position

3.8 Fire Protection Modifications

The pump house for the diesel-driven high-pressure fire pump (HPFP) is a non-category I structure located on Gate 2 (Ref. 10.10) and is, therefore, susceptible to impact by the gate modifications required for closed-cycle cooling operation. Per the BFN fire protection requirements manual (FPRM), the HPFP is required to be functional, and backup supply must be provided when the HPFP is not functional for more than 7 days. After 90 days out of service, 24-hour fire watch is required until the HPFP is returned to service.

The partial demolition of the existing Gate 2 structure would temporarily impact suction of the HPFP, but the 90-day window would not be exceeded. Should backup supply be required, one of the two outside loop pumps could be used.

Modification to the Gate 2 structure would avoid permanently impacting the HPFP house, which would be retained on the existing Gate 2 structure. No modification to the fire protection program or associated components would be required to support the implementation of closed-cycle cooling at BFN.

3.9 Raw Cooling Water Modifications

The RCW system removes heat from turbine-associated equipment and accessories located in and adjacent to the turbine building, from the reactor closed cooling water heat exchangers, and from other reactor-associated equipment that utilize raw cooling water. The system is capable of supplying the flow requirements of the equipment it serves during the full range of operation. There are 12 main RCW system pumps which are supplied with water from the CCW conduits of each unit. The design intake temperature of the RCW system is 90°F, and the maximum expected temperature is 95°F (Ref. 10.11). The suction headers for Units 1 and 2 are interconnected. The Unit 3 suction header is served separately due to physical limitation.

During closed-cycle cooling operation in the past, the auxiliary raw cooling water (ARCW) system was used to provide river water to the RCW system to supplement the cooling capacity of the RCW system when the forebay temperatures were too high. Water from the ARCW pumps went through the RCW strainers, and plant personnel had concerns for the pumps flushing algae and clams into the strainers and jeopardizing the RCW system capability (Ref. 10.12). The closed-cycle cooling operation was removed from the BFN licensing basis in 1996 (Ref. 10.13), and the ARCW system went unused. Currently, two ARCW pumps, rated for 20,000 gpm each at 70 ft head, are retired in place, and the ARCW piping has been cut and capped.

In closed-cycle cooling, the RCW intake temperature would be approximately equivalent to that of the cooling tower discharge. If the tower discharge is much warmer than the river water during peak summer, performance of the RCW system could be challenged. There is currently little performance margin for summertime operation when river temperatures approach 90°F, and normally all 12 pumps are required during the warm months.

Based on discussions with plant personnel, it is expected that the RCW system could tolerate an intake temperature that is a few degrees over the river temperature during peak summer conditions. Since the cooling tower and lift pump modifications and upgrades are designed to

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handle the CCW heat load of all three units during peak summer conditions and with a design cold water temperature below the maximum inlet temperature of the RCW system, the capacity of the RCW system is not expected to be impacted.

To demonstrate that the additional heat load of the RCW system would not exceed the design margin of the towers over the condenser heat load, the potential heat load incurred by the RCW system on the towers is considered. According to Section 11.6.3 of the UFSAR (Ref. 10.1) the CCW system is designed to provide 675,000 gpm (in open mode) to the condenser and 25,000 gpm to the RCW system of each unit. The RCW system flow is only 3% of the CCW system design flow, and the heat load of the RCW system is expected to be well within the capacity margin of the cooling towers.

To better understand why the ARCW system was required during past closed mode operation but is not expected to be necessary now, the performance difference in the historical and proposed towers should be considered. From the available documentation of the ARCW system, it appears that the need for the system was based on the underperformance of the original cooling towers, which led to forebay temperatures that challenged the heat removal capability of the RCW system. Given the substantial upgrades that have been and would need to be performed to the cooling towers and lift pumps, the forebay temperature can be maintained within the RCW intake temperature limits while operating the CCW system in closed mode. Therefore, no need for RCW or ARCW system modifications is expected at this time. The only impact to the RCW system is that winter pump usage would increase, along with maintenance requirements, due to increased CCW temperatures in winter. The additional usage increase and maintenance requirements are negligible from a cost perspective.

3.10 Chemical Treatment Impacts

Currently, the CCW system is treated to maintain the condenser tubes, which are susceptible to biological growth when forebay temperatures exceed approximately 60°F. Sodium hypochlorite and bio-dispersant are injected into the CCW in the intake pumping station (Ref. 10.14). According to plant personnel, sodium bisulfate is injected near Gate 1A to neutralize the chemical residual prior to discharge of the CCW to the Wheeler Reservoir. The chemical injection system is unnecessary when temperatures are not high enough to sustain biofouling, which is approximately half of the year. Therefore, the chemical injection system is typically drained and flushed in the late fall.

It is estimated that closed-cycle operation would result in CCW system temperatures in excess of the threshold for biological growth year-round, and that year-round chemical treatment would be necessary. Per discussion with site personnel, no change in treatment chemicals would be expected as a result of closed-cycle cooling. Other sites operate their cooling towers without need for additional chemicals (e.g. Plant Hatch), but it should be noted that some sites have more extensive chemical treatment requirements (e.g. River Bend Station). It is recommended that the water treatment plan be re-evaluated for impact to tower performance in closed-cycle cooling, considering additional chemicals that may be necessary to maintain the appropriate water chemistry in the system (e.g. corrosion inhibitors, pH control, and anti-foam chemicals).

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Because of water loss due to evaporation and drift from the towers during closed-cycle cooling operation, concentration of chemicals within the system would occur naturally. The dosage requirements for chemical treatment currently in use may go down as a result. Therefore, although chemical treatment may be required year-round in closed-cycle cooling, the total annual volume of chemicals may not increase proportionally to the additional treatment time. A rule-of-thumb estimate provided by a water treatment vendor for another cooling tower retrofit study is that the chemical costs for circulating water treatment were expected to increase by a factor between 1.25 and 1.5. Circulation of chemically treated water through the towers year-round would reduce scaling and biofouling on the towers, and their performance should improve accordingly.

Since the chemical injection system would no longer be drained and flushed at the end of fall, it would be recommended that the chemical injection systems be heat-traced as a freeze-mitigation measure for winter operation.

In closed-cycle cooling, discharge of the CCW system would be through the blowdown line to the discharge piping downstream of Gate 1A. The chemical injection lines near Gate 1A would likely be used to neutralize the residuals in the blowdown flow.

3.11 RHRSW Modifications

The RHRSW system is a once-through system that provides safety-related cooling flow to the plant. Aside from sharing the intake structure, it is completely independent to the CCW system, and the closed-cycle cooling design for the CCW system would not reduce the intake of the RHRSW system. A separate closed-cycle design for the RHRSW system is considered for the sake of further reducing the plant intake flow rate from the Wheeler Reservoir.

System Description

At BFN the RHRSW System has the ultimate safety objective of removing heat from the primary water of the residual heat removal (RHR) system, using cooling water from the intake pumping station forebay delivered by service water pumps located within the safety-related intake pumping station. The forebay is in communication with Wheeler Reservoir through the intake channel, which runs underneath the fixed opening in Gate 3. The intake pumping station, intake channel, and Gate 3 are designed to ensure that the RHRSW pumps are supplied with the required flow rate (80 cfs or 36,000 gpm) so that the RHRSW system can always perform its nuclear safety functions (Ref. 10.15). The RHRSW system is a plant-shared system and is remote-manually operated from each of the three control rooms to pump screened raw river water from the intake station to the RHR heat exchangers and provide standby core cooling. The RHRSW system also supplies water to the EECW system.

There are twelve RHRSW pumps which provide flow to both the RHRSW and EECW systems. The entire systems are seismic Class I. The suction elevation of the RHRSW pumps is below the breach of Wheeler Dam and would, therefore, remain operable in the unlikely event of failure of the dam. Each pump has the capacity to supply 100 percent of the cooling water required by one RHR heat exchanger.

Although individual service water supply headers are provided to each RHR heat exchanger, the discharges from two adjacent heat exchangers are joined as a common discharge to Wheeler

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Reservoir. The RHRSW discharge to Wheeler Reservoir is completely separate from the CCW discharge.

Closed Loop Design Requirements

In order to replace the once-through RHRSW system with a closed loop system, a 200 percent seismically qualified safety-related cooling tower and a 100 percent capacity basin with a 30-day supply of water would be required, which is equivalent to the design used by River Bend Station.

Installation of a new safety-related cooling tower for RHRSW would require the addition of a new preferred power source and safety-related standby power. The new preferred power source would require an additional cooling tower transformer as the current transformers would be above capacity with the addition of the new non-safety cooling tower cells. Assuming the new 161-416KV transformer has a capacity of 21 MVA similar to the existing cooling tower transformers, both the non-safety and safety-related cooling tower additions could utilize the same preferred power source.

Safety-related standby power is required to be backed up by redundant diesel generator loading. It is anticipated that the existing diesel generator margin would not accommodate the load required for the new cooling tower (est. 3,600 KVA load total). Two safety-related diesel generators, each with the capacity to power the cooling tower independently, would be required to operate the tower in the event of loss of the preferred power source. A new diesel generator building would also be required to house the new generators.

Intake Flow Reduction

The normal combined flow rate for the RHRSW pumps is approximately 8,000 gpm, and the normal makeup flow rate for the closed-cycle CCW system is 160,000 gpm (Section 6). The additional flow reduction achieved by a closed loop RHRSW system under normal conditions with a closed-loop CCW system is negligible.

Design Recommendation

The cost of the RHRSW cooling tower (or towers) and basin using the EPRI methodology is estimated to be approximately $100M. this cost does not include the diesel generators, diesel generator building, safety-related boards and cables, and main control room (MCR) controls. Given the substantial cost and modifications involved with converting the RHRSW system to closed-cycle cooling combined with the small incremental increase in benefit beyond converting only the CCW system, it would not be practical to abandon the current RHRSW system and replace it with a closed loop system. For this reason, that option is not recommended for BFN.

3.12 Condenser Modifications

Evaluation of the condenser was performed as a part of the recent BFN EPU application. Prior to the EPU, BFN replaced the main condenser extraction steam bellows Nos. 2, 3, 4, and 5 to accommodate higher design temperatures and pressures for EPU. Evaluation of the CCW system concluded that sufficient system capacity was available to ensure that the plant maintains adequate condenser backpressure at EPU conditions. Additionally, evaluation of the main condenser showed that condenser backpressure remains below the high alarm setpoint (6 inHg) and the turbine trip setpoint (8 inHg) for normal operation. As a result, the main condenser was

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not modified prior to EPU issuance in 2017. The EPU evaluation assumed performance of the CCW system and towers at their original design capacity but did not assume closed-cycle cooling operation (Ref. 10.16).

Prior to EPU, modifications had been performed on the condenser to switch the condenser tubes from admiralty brass to stainless steel and increase the condenser tube diameter, which allows more CCW flow (Ref. 10.3).

The evaluation of closed-cycle cooling performance, described in Section 4, concluded that condenser backpressure limits (high alarm and turbine trip setpoints of 6 inHg and 8 inHg, Ref. 10.17) would not be exceeded in closed-cycle cooling. Therefore, no further condenser modifications are recommended at this time.

4 Power Generation Impacts of Continuous Closed-Cycle Cooling

Operation in closed-cycle cooling affects the net electrical power production of the plant in two ways. First, the power consumed by the closed-cycle cooling components (namely cooling tower lift pumps and fans) results in a direct reduction of net power production. Second, the thermal efficiency of the plant is reduced by the increased circulating water temperature.

The thermal performance of the CCW system was evaluated using outputs from the EPU PEPSE model, tower design curves and CCW system operating parameters. The PEPSE outputs were used to develop correlations for condenser backpressure, power generation, and circulating water outlet temperature as a function of circulating water inlet temperature. The tower design curves were used to develop correlations for tower outlet temperatures as functions of wet bulb temperature, tower flow rate, and inlet temperatures. The evaluation assumed that all towers performed according to their design curves and that Towers 1 and 2 were replaced with towers equivalent in performance to Tower 3. The CCW flow rate for helper mode (635,000 gpm per unit, Ref. 10.3) was used in the evaluation, and the tower flow rate was limited by using the design flow rates of Towers 1-6 and applying the balance of the CCW flow rate to Tower 7. A COC of 3.0 was used. The evaluation used a simplified arrangement of CCW system as shown in the figure below. Simplifying assumptions such as no heat loss from the canals to the environment and invariable lift pump flow rates were used.

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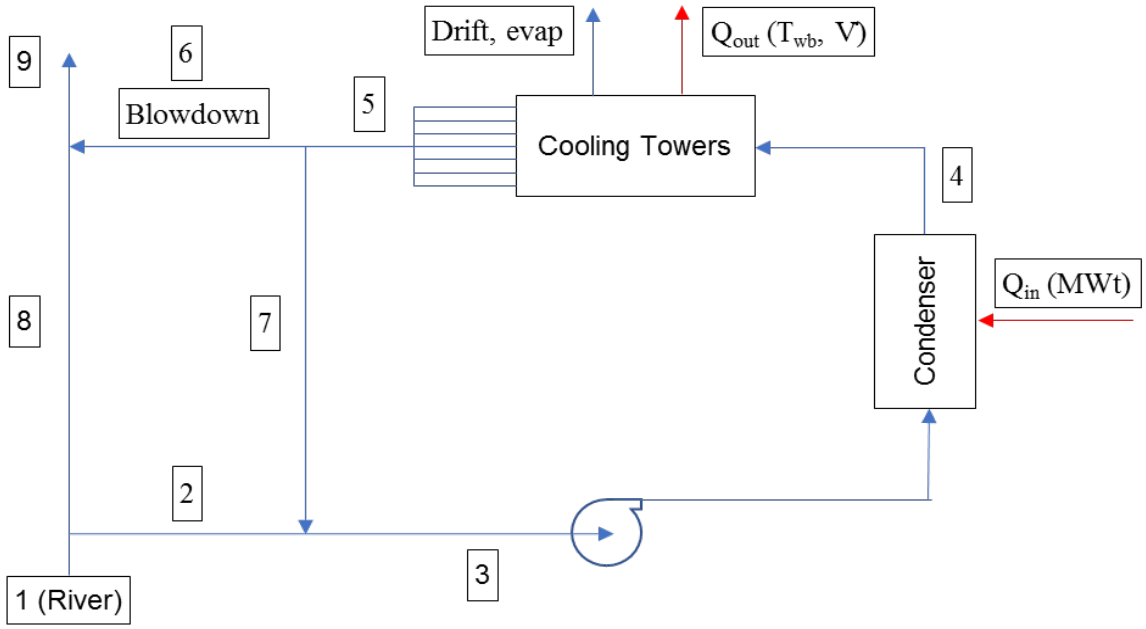


Figure 5: CCW Thermal Performance Evaluation Diagram

The evaluation showed that the condenser backpressure alarm level of 6.0 inHg was not reached, and no power derates would be required. Compared with operation in the open or helper mode (evaluated with a similar methodology), it is estimated that the decrease in thermal efficiency would result in the reductions to power generation shown in the table below, with an average impact of 17 MW annually for all three units combined.

Table 2: Monthly and Annual Reduction in Power Generation

Month	Average Power Loss with a CCRS (MWe)[1]
Jan	23
Feb	27
Mar	40
Apr	47
May	29
Jun	-11
Jul	-30
Aug	-28
Sep	0
Oct	38
Nov	37
Dec	34
Annual Average	**17**

[1]A negative number represents a gain in power production

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As noted in Section 3.9, closed-cycle cooling operation was removed from the BFN licensing basis in 1996, and therefore gains in power production during the summer months cannot currently be attained. It should also be noted that performing the evaluation with a COC of 1.4 would likely result in slightly lower power losses than those shown in the table. Further, the power losses may be over-estimated in the winter months by the assumption that the canals do not lose heat to the environment. In reality, the tower discharge would likely be maintained above 50°F, and heat loss from the canals would become more significant on cold days. The impact of this assumption on the results is mitigated by also neglecting fan manipulations or tower bypass in the model, which has a countering effect on CCW temperature. Stopping tower fans or selectively bypassing towers in the winter would be performed to control the tower discharge temperature as a freeze protection measure.

The power consumed by the closed-cycle cooling components is estimated by summing the rated power for the lift pump motors and fan motors. After the modifications to Towers 1 and 2, BFN will have a total of 139 tower cells, each cell having a fan powered by a 250 hp motor. This results in consumption of approximately 35,000 hp, or 26 MW, by tower fans. Towers 3, 4, 5, and 6 each have two lift pumps rated at 3,100 hp. Tower 7 has four lift pumps rated at 2,700 hp. After modification, Towers 1 and 2 will each have two lift pumps rated at approximately 3,750 hp. This results in consumption of approximately 51,000 hp or 38 MW. Therefore, the total power consumption of the closed-cycle cooling components for all three units is approximately 64 MW. Alternatively, the average annual power consumption of the towers and lift pumps in open/helper mode is estimated to be 12 MW. Therefore, operation in closed-cycle cooling results in an average increase in power consumption of 52 MW for all three units.

Combined with the reduction in power generation due to decreased thermal efficiency, the total power impact would be 69 MW. For a 90% utilization factor, this results in an annual energy penalty of approximately 544,000 MWh.

5 Other Impacts of Continuous Closed-Cycle Cooling

The operation of a closed-cycle cooling configuration would impact the site beyond power generation, including how the plant starts up and how it operates during freezing weather conditions. Since BFN already utilizes cooling towers, it may already deal with some of these impacts. However, implementation of continuous closed-cycle cooling would lead to the use of cooling towers during seasons in which they are not typically used in open/helper mode. Additionally, the continual use of the cooling towers may lead to an increased magnitude in the impacts over what BFN normally experiences with intermittent usage. Historical tower usage data from 2012 shows that towers were only used on 17 days of the year, with those days falling in the months of May through August. Therefore, implementation of continuous closed-cycle cooling would require a substantial increase in tower usage.

Impacts in other areas beyond operations are also considered in this section including environmental impacts, maintenance, outage, and licensing.

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5.1 Plume

During certain meteorological conditions, operation of evaporative cooling towers may result in the discharge of a large visible plume. Cooling tower plumes are the result of the much higher heat and moisture content of the exiting air relative to the ambient air around it. For this reason, plumes are most prominent in cold-weather conditions and in conditions of high relative humidity. Ambient air is shown at State 1 in Figure 6 below. When the saturated air leaves the top of a cooling tower (at State 2 or 4 in Figure 6 below), it is immediately cooled by the surrounding ambient air. If the ambient air is warm enough (State 3), the cooling tower discharge will not become super-saturated and a plume will not form. If the dry bulb temperature is low enough (State 1), the air exiting the tower (State 2) will become super-saturated for a brief time until diffusion allows the extra moisture to mix in with the surrounding ambient air. This results in plume formation at the top of the tower. Plumes can descend to ground level, causing fogging and moisture deposition. During freezing weather, plumes can result in deposition of small ice crystals. Therefore, forms of surface freeze protection may be required to mitigate hazards caused by plume-related formation of ice.

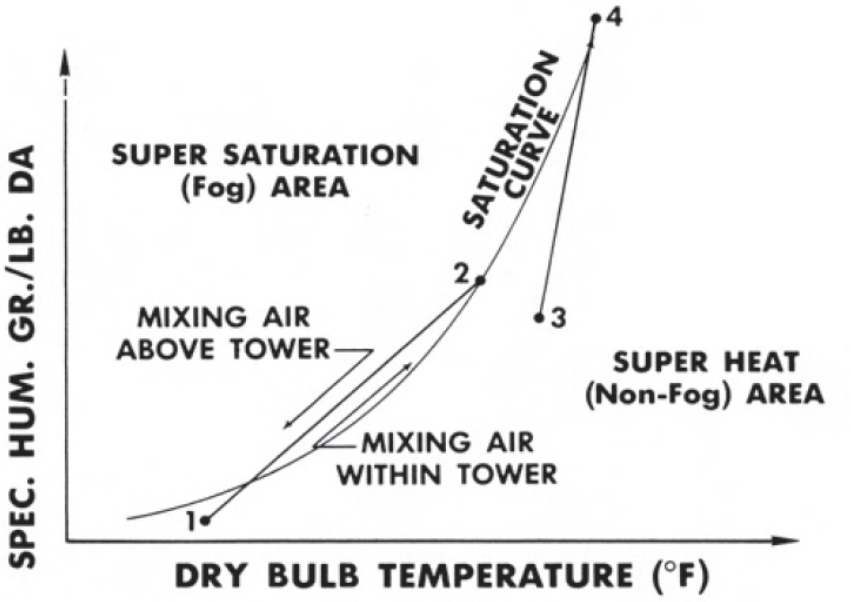


Figure 6: Plume formation in an evaporative cooling tower (Ref. 10.18)

Because the cooling tower are currently only needed during late July to early August, icing and fogging have not been concerns at BFN in recent history. During cooling tower operation, the plume is often visible in the early morning and evening, but it usually becomes invisible as the temperature rises during the day (Ref. 10.19).

Study of meteorological conditions indicates the potential for plume-induced icing in the area of BFN if winter tower operation is utilized. Data indicate that this could occur on 55 days per year from November to March, with the highest expected frequency in January and February. The period during which icing formation would be most likely to occur would be between midnight and 7 a.m. (Ref. 10.20).

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The directions with the maximum frequency of plume travel during icing conditions are south and southeast over the reservoir. These conditions would extend to more than 4 miles less than 2% of the time. On these occasions some light-to-moderate icing could be encountered by river traffic. A second direction of potential light-to-moderate icing is north-northeast of the plant out to approximately 3.5 miles. Such icing might occur up to five days per year with a possible hazard to road traffic on the Browns Ferry-Huntsville and Browns Ferry-Athens secondary roads and the plant access road. Some icing on structures in the immediate plant area and on adjacent transmission towers and lines might also be expected (Ref. 10.20).

5.2 Drift

Cooling towers are designed to promote close contact between air and water within the fill to improve heat transfer, and ultimately, the performance of the cooling tower. As a byproduct of this facet of their design, small water droplets become entrained in the air stream leaving the tower. Cooling tower drift is defined as the circulating water that is lost from a cooling tower as liquid droplets become entrained in the exhaust air stream (Ref. 10.18). Existing technology cannot eliminate drift, but it can be reduced to a very low percentage of the total tower flow rate.

Drift should not be confused with the very small water droplets that form when saturated water vapor leaves the top of the tower and condense out of the air due to a drop in temperature (i.e., the plume). The composition of the water that comprises drift is the same as that of the circulating water passing through the tower.

5.2.1 General Impacts of Drift

Impacts associated with cooling tower drift contacting nearby equipment and the environment are typically limited to the region immediately surrounding the cooling tower. Large drift droplets settle out of the tower exhaust air stream and deposit near the tower. This process can lead to wetting, icing, salt deposition, and other related problems such as damage to equipment or to vegetation (Ref. 10.21).

The vulnerability of existing facilities in the vicinity of the cooling tower to corrosion from drift is impacted by the drift amount, direction, and distance from the cooling system, as well as the salt concentration above the natural background level at the site. The environmental effects of drift are most severe where saline water or water with high mineral content is used for condenser cooling (Ref. 10.22). Since CCW at BFN does not have high salt content or mineral content, environmental effects from drift are not expected to be considerable.

5.2.2 Air Emissions

Another impact of drift on the local environment is air emissions. Drift rates are a function of the quality of the installation and the state of repair of the drift eliminators. Drift rates can be higher or lower depending upon installation-specific and site-specific circumstances. The drop size spectrum can change with different drift eliminator designs, as well as with the age and condition of the drift eliminators. Some fraction of the drift will fall to the nearby ground or surrounding structures, and the dissolved material in these drops will not be released into the atmosphere (Ref. 10.23). This would be expected to vary based on local geography, proximity of other structures, height of the tower, as well as typical wind velocities and directions.

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As noted above, drift that leaves the top of the tower will reflect the same water chemistry as that of the CCW system. Based on the salinity of the water used in the cooling tower, the drift may contain high levels of dissolved solids. When these small droplets are released into the air, evaporation occurs, leaving behind the solids that were once dissolved. This has the effect of introducing fine particulate matter into the atmosphere. Particles with a mean aerodynamic diameter of less than or equal to 10 microns or 2.5 microns are classified within the National Ambient Air Quality Standards (NAAQS) as PM10 or PM2.5, respectively (Ref. 10.23).

An evaluation of air emissions associated with the year-round operation of the cooling towers is provided in the §122.21(r)(12) report.

5.3 Water Consumption

The circulating water system at BFN draws water from Wheeler Reservoir into the CCW system and discharges heated water back to Wheeler Reservoir. Generally, the same amount of water is withdrawn from and discharged to the reservoir.

Operating the plant in closed-cycle cooling mode would increase water consumption due to evaporative losses and drift (i.e. water not returned to the reservoir). It is estimated that the rate of evaporation and drift for the cooling towers would be approximately 45,000 gpm.

5.4 Freezing Weather Operation

The winter climate at BFN is interchangeably continental and maritime (Ref. 10.1, Page 2.3-5). Although snowfall is not common during winter in this area of Alabama, it does occur occasionally, and freezing weather operation must be considered as part of the feasibility evaluation of continuous closed-cycle cooling. The very nature of cooling tower design promotes the maximum possible contact between air and water. While this provides high effectiveness in heat transfer, during freezing weather conditions it can create too much heat transfer, resulting in conditions that are conducive to ice formation within and outside the tower. Therefore, means for reducing the efficiency of the cooling tower during freezing conditions should be used by the operator when necessary (Ref. 10.18).

From Reference 10.18, there are acceptable and unacceptable degrees of ice formation on an operating cooling tower. Some ice formation is inevitable in very low temperatures. However, bulk ice formation that imposes upon and restricts air flow into the tower is deemed unacceptable. Additionally, large blocks of ice accumulating on a cooling tower can cause tower damage and present a safety hazard.

There are three primary effects that must be considered with regard to ice formation within and on a cooling tower during freezing weather conditions (Ref. 10.18).

- The potential for ice formation varies directly with the quantity of air flowing through the tower. Reducing air flow retards the formation of ice.
- The potential for ice varies inversely with the amount of water flowing over the fill. A reduced pumping rate increases the likelihood of unacceptable ice formation.

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- The potential for ice formation varies inversely with the heat load imposed on the tower. A reduced heat load decreases the incoming water temperature and increases the probability that unacceptable quantities of ice would form.

The three effects mentioned above can be used as guidance for freeze protection using air-side, water-side, and head load controls.

Since air flow rates are easily manipulated with mechanical draft cooling towers, air-side control measures should be taken to limit the impact of unacceptable ice formations during freezing conditions. Available air-side controls at BFN include reducing fan speed, shutting off fans, and operation of fans in reverse.

When air-side control measures are insufficient, water-side controls may be used in addition. Water-side controls include manipulating the water distribution system within a cell to distribute the water as close as possible to the area of the air inlet, thereby allowing the maximum amount of relatively warm water to flow in close proximity to the areas of greatest ice concern (Ref. 10.18). The only water distribution control capability of the BFN towers is to completely shut off flow to a cell. As shutting off flow on a cell-by-cell basis is not considered an effective means of freeze protection, BFN may not have any water-side control measures available for freeze protection.

As mentioned above, the heat load imposed on the tower corresponds to the incoming water temperature. The heat load is increased, and the potential for freezing on the fill is decreased, by increasing the incoming water temperature. Incoming water temperature can be increased by bypassing the cooling towers. Therefore, if unacceptable ice-formation were to develop despite air-side control measures, it may be necessary to use the tower bypass line to divert some or all of the CCW flow from the WWC directly to the CWC. This will increase the temperature of water at the condenser inlet, which will then increase the WWC temperature. It should be noted that bypassing flow should be incremented by the entire flow rate to a given tower. Partial bypass of a tower increases the likelihood of freezing in that tower, as noted in the second bullet above (Ref. 10.18).

As stated previously, the potential for ice formation varies inversely with the heat load imposed upon the tower. Therefore, during freezing conditions, the cooling tower should not be operated when no heat load is imposed on the CCW system. For example, during startup, or during periods in which the CCW system would be operated but the plant’s condensers would not heat the CCW, the cooling towers must be bypassed during freezing weather conditions.

5.5 Maintenance

If BFN were to implement closed-loop cooling, additional cooling tower maintenance by experienced personnel would be required. Additionally, relying on 100-plus cooling tower cells to operate continuously means that there is a significant amount of mechanical equipment that could fail. These potential failures could impact station reliability. Regular tower maintenance activities and their frequencies are demonstrated in Figure 7 below, reproduced from a tower vendor manual.

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	Fan	Motor	Drive Shaft and Guards	Gearreducer	Drift Eliminators	Fill	Cold Water Basin	Hot Water Basin	Float Valve	Suction Screen	Control Valves	Structural Members	Casing and Louvers	Fan Cylinder	Stairs, Ladders, Walkway, Doors, Handrail	Davits, Derricks, Hoists
1. Inspect for clogging					M	M		W		W						
2. Check for unusual noise or vibration	D	D	D	D												
3. Inspect keys, keyways and set screws	S	S	S	S												
4. Make sure vents are open				S												
5. Lubricate (grease)		R									S					
6. Check oil seals				M												
7. Check operating oil level				D												
8. Check static oil level				M												
9. Check oil for water and sludge				M												
10. Change oil				S												
11. Check fan blade tip clearance	S															
12. Check water level							D	D								
13. Check for leakage				W			S	S	S							
14. Inspect general condition	S	S	S	S	Y	S	Y	S	Y	S	S	S	Y	S	S	S
15. Tighten loose bolts	S	S	S	S								Y	R	S		
16. Clean	R	R	R	R	R	R	S	R	R	R	R					
17. Repaint	R	R	R	R												
18. Rebalance	R		R													
19. Completely open and close											S					
20. Inspect/repair for safe use	Y		Y												S	
21. Inspect and repair before each use																R

D – daily; W – weekly; M – monthly; Q – quarterly; S – semi-annually; Y – yearly; R – as required

Figure 7: Cooling Tower Routine Maintenance Schedule

Non-routine maintenance activities would also include fill replacement, valve repairs, drift eliminator replacement, structural repairs, gear box repairs, and rewinding fan motors. Routine maintenance schedules for the lift pumps would have to be implemented as well.

Operation of towers in the winter would introduce the possibility of settled plume and drift deposits on nearby equipment, which could have long-term reliability and maintenance impacts. While the BFN towers are not plume abated, the local climate would not be expected to result in frequent plume development, and no reliability impact on surrounding equipment is expected.

Maintenance on CCW condenser water box or CCW pumps is scheduled in winter when the intake water is the coldest to maximize thermal margin. As long as the forebay can be cooled to 60°F to 70°F in closed-cycle cooling, there would be sufficient thermal margin to perform winter

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time maintenance. However, the window in which adequate thermal margin is available would be reduced.

5.6 Extended Outage

As noted above, several significant modifications would be required for closed-cycle cooling implementation at BFN. While some of the electrical modifications may occur during planned refueling outage time, it is not expected that any additional outage impacts would be incurred by the modifications.

5.7 Regulatory, Licensing, Environmental, and Safety

5.7.1 Potential Applicable Federal Permits

United States Army Corps of Engineers (USACE) Permit

Implementing a CCRS at BFN would require construction of a spillway in the CWC spillway across the dike separating the CWC from Wheeler Reservoir. This dike work would require a CWA Section 404 permit issued by the USACE, either a Nationwide Permit (NWP) (e.g., NWP 3, Maintenance or NWP18, Minor Discharges) or an Individual Permit. Implementation of the CCRS would also require dredging in the forebay. The dredging could be covered under NWP 3 as the dredging within the forebay in 2018 was covered. However, because this project includes multiple components requiring separate USACE NWPs, the project could require an USACE Individual Permit. The USACE would decide whether an Individual Permit is appropriate. If the project does qualify for NWP authorization, TVA would submit a preconstruction notification for coverage under appropriate NWPs. If the project does not qualify for NWP authorization, a joint permit application to the USACE (Nashville District) and the Alabama Department of Environmental Management (ADEM) would be required.

Both the NWP and Individual Permit process addresses evaluation of the potential for impacts to threatened and endangered species and cultural resources. Projects with the potential for impact would require consultations with the USFWS and the Alabama Department of Conservation and Natural Resources regarding the potential for affects to protected species. The permitting process would also require consultation with the State Historic Preservation Officer regarding the potential for affects to cultural resources.

As part of the permit application process, a project description and project plans may be placed on public notice and open to public comment. While NWPs are generally not released to the public for comment, it is up to the discretion of the lead agency to determine if the proposed project has the potential to be controversial and, therefore, whether to open the project up to public comment.

U.S. NRC Review

All plant modifications require implementation of the BFN design change process, which includes assessments of all U.S. NRC licensing impacts. Plant modifications must follow the process established in 10 CFR 50.59. Because the new Gate 2 would serve a new, active safety function,

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the continuous operation of closed-cycle cooling utilizing mechanical draft cooling towers constitutes an unreviewed safety question in the Final Safety Analysis Report (FSAR) or Technical Specifications, then the NRC would determine that a License Amendment Request (LAR) and National Environmental Protection Act (NEPA) review are required.

National Environmental Protection Act (NEPA)

Because TVA is a Federal Agency, compliance with NEPA is required. TVA would decide the level of NEPA review required for the project. Because the project would require a permit or license issuance by federal agencies, the USACE and NRC, the NEPA obligation of the federal agencies could be undertaken jointly with one serving as the lead agency.

5.7.2 Potential Applicable State Permits

National Pollutant Discharge Elimination System Permit (NPDES)

It is anticipated that the proposed CCRS would be evaluated by ADEM as part of renewal process for NPDES Permit number AL0022080. If not evaluated as part of the renewal process, then a permit modification may be required.

Stormwater Permit

Construction activities resulting in land disturbance of one acre or greater must apply for a stormwater permit coverage under the Alabama Construction General Permit, ALR100000 2021 (ADEM 2021). The General Permit requires erosion and sediment controls and a best management practice (BMP) plan.

5.8 Plant Programs

5.8.1 Buried Components

Any new piping installed below standard ground elevation and in direct contact with the soil, will meet the definition for “buried piping” in NEI 09-14, and not “underground piping.” This piping would require addition to existing plant maintenance schedules for buried piping. Only limited portion of new piping would be buried, therefore the impact would be minor.

5.8.2 Fire Protection, Appendix R

BFN is committed to the 10 CFR Part 50 Appendix R Fire Protection Program requirements. The new components installed by the conversion to closed-cycle cooling would primarily be located outside of the power block. The new components would be integrated with the existing Appendix R program at BFN as necessary. This would include the addition of a new fire zone for the electrical substation building, including fire hazards evaluations. The fire hazards evaluations would evaluate ignition sources and combustible materials within the area to determine the appropriate suppression methods. Low-voltage control cables would be routed through the plant and into the control room, likely requiring multiple fire barrier penetrations along the run. The plant-specific fire barrier penetration specifications should be followed to ensure that the fire barriers remain intact following the breaches to these fire rated barriers. These items would need

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to be evaluated during detailed design to ensure compliance with plant licensing commitments. The modification of Gate 2 would be implemented without impacting the permanent operation of the HPFP house, as described in Section 3.8.

5.8.3 FLEX

The diverse and flexible mitigation capability (FLEX) strategy for safe shutdown following a beyond design basis events implemented at BFN encompasses procedural actions, dedicated equipment, utility connections, storage laydown space, and traffic corridors which satisfy the key functions necessary to ensure long-term core and spent fuel cooling and containment integrity. The modifications which would be required to implement closed-cycle cooling at BFN would not impact the ability to maintain the functional FLEX strategies. Temporary mitigating actions may be required due to impacts to roadways during construction activities.

5.8.4 Flow Accelerated Corrosion

Flow accelerated corrosion (FAC) is a form of material degradation that can affect metallic materials that are normally resistant to corrosion because they are protected by an oxide film that forms on the surface. Turbulent and fast-flowing water, or wet steam, can wear away the protective film and lead to continued dissolution of the underlying metal. FAC is not the same phenomenon as abrasion (caused by particles in the water), impingement (caused by water droplets in steam), or cavitation (caused by collapsing gas bubbles in a liquid flow). The phenomenon is limited to carbon steel. Stainless steel is practically immune to FAC.

FAC tends to occur at water temperatures from 175°F – 450°F in the liquid phase, which is far above the expected temperatures in the closed-cycle cooling system. Therefore, an impact to the FAC program at BFN is not anticipated.

5.9 Impact to Alabama's Electrical Grid Supply

The conversion of BFN to closed-cycle cooling would impact the Alabama electrical supply grid due to the operational losses associated with a closed-cycle cooling system.

The average annual loss in net power generation due to implementation of closed-cycle cooling is approximately 69 MWe. This results in an annual loss in electricity supplied to the grid of approximately 544,000 MWh, assuming a 90% utilization factor. Alternate sources of power would be required to replace this lost power on a continual basis.

6 Design Summary

The closed-cycle cooling system design presented in this report would support the CCW system for all three units. Cooling tower refurbishments, lift pump modifications, and Gate 2 replacement would be implemented to support the full CCW system flow rate for all three units. The cooling tower improvements would increase the heat rate capacity of the towers to a level 10% higher than the condenser heat rate. The blowdown flow rate would be maintained at approximately 115,000 gpm to provide sufficient dilution for release of liquid waste to the reservoir. The rate of evaporation and drift for the cooling towers would be approximately 45,000 gpm. The amount of makeup flow withdrawn from the river would be approximately 160,000 gpm to accommodate for blowdown and water loss due to evaporation and drift. This represents an intake flow reduction

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of 92% from the CCW pump flow rate of all three units in the once-through cooling mode (2,100,000 gpm). The dedicated opening in Gate 3 would be maintained for makeup and assurance of access to the reservoir for safety-related cooling by the RHRSW system, which would be maintained in a once-through configuration. Controls would be implemented on the cooling tower lift pumps and Gate 2 to protect the UHS by preventing recirculation of hot water to the forebay. CCW spillways would be implemented to prevent uncontrolled flooding in the event of emergency shutoff of lift pumps or closure of Gate 2. Refurbishments to the vacuum primers and breakers would be performed to achieve reliable performance and reduced risk during CCW alignment activities. Centralized controls for towers, lift pumps, and gates would be implemented to reduce the operational burden of continuous tower usage and CCW system alignment activity.

7 Construction Schedule for Closed-Cycle Cooling

A schedule for procurement and implementation of the closed-cycle cooling preliminary design is presented in Appendix B. The schedule assumes continuous implementation and does not consider project staging. The schedule includes permitting time, which can be highly variable. It should also be noted that uncontrollable factors such as severe weather conditions have not been considered. These factors could result in significant impacts to the overall project schedule.

The detailed engineering design and safety analysis is estimated to take approximately 30 months, and licensing and permitting is estimated to take approximately 12 months. Procurement is estimated at 30 months. Pre-construction activities (engineering/safety analysis, licensing/permitting, and procurement) can overlap; therefore, total pre-construction duration is approximately 42 months. Construction activities are estimated at 54 months for a total implementation schedule of 96 months.

The schedule includes the activities noted below. No outage time would be required for the activities required.

- Engineering
    - Hydraulic evaluation of modified gate structure
    - Structural design of modified gate structure
    - Electrical design for lift pump trips
    - Safety analysis
    - Engineering change package development
- Mobilization
    - Construction site set up, including delivery of onsite trailers, construction equipment, and labor
- General Site Modifications
    - Marking and protecting the construction area
    - Rerouting vehicle and pedestrian traffic around construction area
- Construction Activities

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  - Upgrades and refurbishment of towers 1, 2, 4, and 7
  - Installation of bypass lines
  - Refurbishment of blowdown line
  - Modifications to vacuum primer and breaker
  - Dredging
  - Modification of Gate 2
  - Installation of UHS protection controls
  - Testing and commissioning
- Demobilization and restoration of construction site

8 Cost Estimate of Closed-Cycle Cooling

In this section, an order-of-magnitude cost estimate is developed for the design presented in this report which complies with the standards of a Class 5 cost estimate per ASTM E2516-11. Costs that may be saved by the plant by implementation of closed-cycle cooling are discussed in the mitigated costs section. A description for each cost item included in the estimate is provided in the sections below. Cost estimates were completed using vendor quotes, prior project experience, and RSMeans estimation software. RSMeans is an industrial construction cost estimation tool by Gordian that combines local, quarterly updated cost data for material, labor, equipment, and overhead and profit into a total per-unit cost for numerous construction items and activities. The cost estimates are provided in Appendix A.

8.1 Capital Costs

One-time capital costs related to the implementation of closed-cycle cooling are summarized in the table below. The costs are in 2020 dollars without consideration of escalation. The estimates include material, labor, equipment, contractor overhead and profit, allowances, margin and fees, engineering, licensing, and permitting costs as described in the prior parts of this section.

Table 3: Summary of Capital Costs

Item	Estimated Cost
Cooling tower and lift pump upgrades	$239,000,000
Gate 2, spillways, and forebay dredging	$49,000,000
Vacuum primer/breaker system upgrades	$13,000,000
Blowdown and bypass	$9,000,000
UHS protection controls	$11,000,000

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Item	Estimated Cost
Performance monitoring and control centers for towers, lift pumps, and gates(1)	$13,000,000
Total Capital Cost	**$334,000,000**

Appendix A shows an itemized cost estimate that includes tabulated subtotals for construction, personnel, fees and allowances, and engineering costs. Sources for each cost estimate are also included within the table.

Given that this is a Class 5 estimate, some information associated with the cost of implementation of the closed-cycle cooling retrofit such as field conditions, structural design requirements, material selection, and construction schedule demands have only been preliminarily determined. Certain costs have been estimated with assumptions that are aimed to be accurate but remain uncertain, such as:

- drilling or blasting labor/equipment, which is dependent on location and depth of bedrock and subsurface conditions;
- mobilization and equipment transportation costs; and
- specialized equipment and materials required.

8.2 Recurring Costs

From an evaluation of CCW closed-cycle cooling performance using the PEPSE model, tower and lift pump design data, and site meteorological data, the annual average power penalty for continuous closed-cycle cooling operation is estimated to be approximately 69 MWe, which amounts to 544,000 MWh over the course of a year with a 90% utilization factor.

Staffing costs would be incurred for the 10 additional operators required to handle the operational burden of year-round cooling tower operation.

Average annual maintenance expenses, including labor and equipment, for cooling towers, lift pumps, discharge valves, vacuum primers, and other supporting components is estimated to be $1,300,000 per year. This estimate is based on recommended maintenance schedules provided by tower and pump vendors and expected cost for replacement parts. According to plant personnel, the annual budget for cooling tower maintenance is $800,000. Therefore, increases in maintenance costs are estimated to be $500,000 annually.

Using rule-of-thumb guidance, the annual chemical costs for treatment of CCW may increase by a factor of 1.5. According to plant personnel, the 2018 budget for CCW treatment chemicals was $1,000,000. Therefore, additional water treatment costs are estimated to be $500,000 annually.

8.3 Outage Cost

As noted in Section 5.6, the modifications necessary to implement closed-cycle cooling at BFN will not require extended outage time. Therefore, no outage cost is estimated.

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8.4 Mitigated Costs

By eliminating open/helper mode, it is anticipated that the implementation of fish-friendly screens may not be required by Alabama Department of Environmental Management (ADEM). The fish-friendly screens are estimated at $40,000,000, but approximately half of that is for upgrades necessary regardless of the new screens (e.g., electrical upgrades). Therefore, negating the need for the fish-friendly screens could save approximately $20,000,000.

9 Conclusions for Closed-Cycle Cooling

The compliance option to retrofit BFN with a closed-cycle cooling system, while technically feasible, would pose significant engineering, construction, permitting, and operational challenges. Procurement, construction, and modification or refurbishment of mechanical draft cooling towers, water distribution piping, lift pumps, control gates, and electrical equipment would be required if a closed-cycle cooling system were implemented at BFN. Construction would require extensive clearing, grading, excavation, earthwork, piping placement, structure erection, equipment installation, and system tie-ins. The implementation of a closed-cycle cooling system at BFN would impose significant engineering fees, procurement costs, construction costs, power generation losses, and recurrent operation and maintenance costs. Engineering, permitting, procurement, and construction would take approximately 8 years following the start of the project. The implementation of a closed-cycle cooling system at BFN is not considered a prudent or practical measure for entrainment reduction due to the challenges, impacts, costs, schedule, and risks identified in this Comprehensive Technical Feasibility and Cost Evaluation Study.

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10 References for Closed-Cycle Cooling

10.1 Browns Ferry Updated Final Safety Analysis Report, Revision 27

10.2 Browns Ferry Extended Power Uprate Application, Attachment 42, Supplemental Environmental Report

10.3 MDN0027900043 Rev. 6, Condenser Circulating Water Flows

10.4 Browns Ferry Nuclear Plant Thermal Performance Program Cooling Tower Capacity Improvements Environmental Assessment, June 2020

10.5 Memorandum, Browns Ferry Nuclear Plant – Safety-related Aspects of Cooling Tower Operation, July 23, 1980

10.6 920309F0023, Rev. 8 (historical), Safety Shutdown Analysis

10.7 911211T0170, Evaluation of Cooling Tower Alternatives Browns Ferry Nuclear Plant, November 27, 1991

10.8 Tennessee Valley Authority (TVA) – Browns Ferry Nuclear Plant (BFN) – Plant Intake Maintenance Dredging – Preconstruction Notification (PCN) For Coverage Under Nationwide Permit (NWP) Number 3. December 1, 2017

10.9 911211T0170, Evaluation of Cooling Tower Alternatives Browns Ferry Nuclear Plant, November 27, 1991

10.10 CDQ0303884871, Rev. 8, Cooling Tower System Gate Structure No. 2

10.11 BFN-50-7024, Rev. 21, Raw Cooling Water System

10.12 Memorandum, Browns Ferry Nuclear Plant Units 1-3 – Cooling Tower Acceptance Test and Closed Cycle Operation, April 17, 1979

10.13 DCN 39385, Eliminate Closed Mode

10.14 1-47E831-1, Rev. 40, Flow Diagram Condenser Circulating Water

10.15 BFN-50-7023, Rev. 28, Design Criteria Document, Residual Heat Removal Service Water System

10.16 Browns Ferry Nuclear Plant Units 1, 2, and 3 – Issuance of Amendments Regarding Extended Power Uprate. ADAMS Accession No. ML17032A120

10.17 3-OI-47, Rev. 116, Operating Instruction, Turbine Generator System

10.18 Cooling Tower Fundamentals, Second Edition, SPX Cooling Technologies, Inc

10.19 Browns Ferry Units 1, 2, and 3 License Renewal Application, Appendix E – Environmental Report

10.20 Tennessee Valley Authority Environmental Statement Supplements and Additions

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10.21 Wet Cooling Towers, https://www3.epa.gov/ttnchie1/ap42/ch13/final/c13s04.pdf, Accessed August 23, 2021

10.22 U.S. Nuclear Regulatory Commission Office of Nuclear Regulatory Research, Regulatory Guide 4.7, General Site Suitability Criteria for Nuclear Power Stations, Revision 3

10.23 CEC-500-2008-043, Performance, Cost, and Environmental Effects of Saltwater Cooling Towers, California Energy Commission, January 2010

10.24 MDN0000272013000155 Rev. 2, Calculation of Flow Rate to New Cooling Tower No. 3

10.25 MDN0000272013000162 Rev. 0, Calculation of Flow Rate to New Cooling Tower No. 5

10.26 MDN0000272013000197 Rev. 0, Calculation of Flow Rate to New Cooling Tower No. 6

10.27 2017 ASHRAE Handbook, Fundamentals

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11 Fine Mesh Traveling Water Screens

11.1 Conceptual Design

In compliance with the NPDES permit renewal application requirements codified in §122.21(r)(10)(i), the following information provides an evaluation of fine-mesh traveling water screens. Two traveling water screen configurations were evaluated for implementation at BFN: through-flow and dual-flow. Through-flow screens are oriented with the screening surface perpendicular to the approaching flow of water, where the water passing through the screen maintains the flow direction from its approach. This is the orientation of the existing traveling water screens. Dual-flow traveling water screens are mechanically like through-flow screens but are rotated ninety degrees, such that the screen face is parallel to the direction of approach flow. Dual-flow screens feature a nose cone that splits the approach flow and diverts the diverging streams to the sides. Flow diverters then direct the flow through the screen faces on each side. After passing through the screen, the streams converge in the center of the screen and exit through the back opening. Appendices E and F provide details of the FMS conceptual design. A simplified illustration of a dual-flow screen is shown in Figure 8.

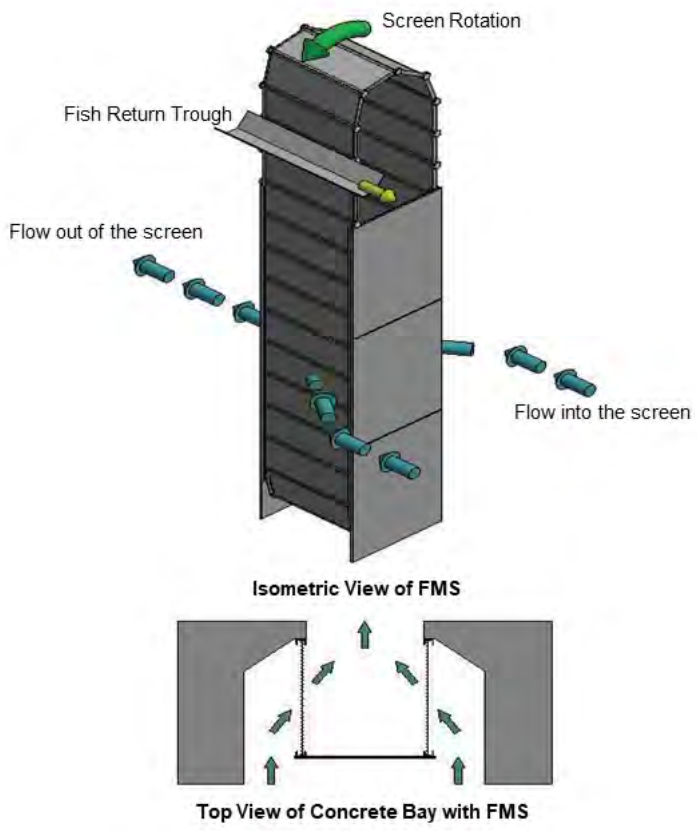


Figure 8: Dual-Flow Traveling Screen (Image Courtesy of WTR Engineering, Inc.[4])

[4] WTR Engineering is a leading designer and manufacturer of traveling water screens and was consulted on the project for the traveling water screen designs.

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Because dual-flow screens utilize both the ascending and descending sides of the screen for filtration, they provide the following benefits:

- Decrease of the velocity through the screens. The flow pattern of the dual-flow screen allows the entire submerged screen surface to be an active screen area. This means that a dual-flow screen may pass approximately twice as much water at the same velocity as a through-flow screen of the same width. Conversely, the same amount of flow can pass through a dual-flow screen at about half the velocity as a through-flow screen of the same width.
- Elimination of debris and organism carryover. The orientation of dual-flow screens makes it such that the path over the top of the screens does not lead to the backside of the screen. Rather, all flow going through a channel installed with a dual-flow screen must pass through the screen before entering the screen well. Therefore, the potential for debris carryover is eliminated.

Based on the operational benefits, an evaluation of dual-flow traveling water screens was selected for presentation in this NPDES permit renewal application compliance report.

Traveling water screens can utilize screen mesh of varying sizes. This report discusses mesh size with reference to two categories: coarse mesh and fine-mesh. Fine mesh screens are those utilizing opening sizes less than or equal to 2 mm, and coarse mesh screens are those utilizing larger openings. The small mesh size of fine-mesh traveling water screens is typically selected to increase filtration efficiency. Because the mesh opening size is smaller, a greater portion of the total area is covered by the screening material and not open for flow. The small opening size of fine-mesh screens improves their performance for entrainment reduction, but also increases the rate of impingement for small species and increases the through-screen velocity for a given screening area.

Additional screen modifications are available to improve survival of impinged fish and other organisms to reduce the impingement mortality rate. These modifications are meant to minimize fish mortality associated with screen impingement and screen-wash removal. The following features of traveling water screen systems improve the survivability of fish and other organisms:

- Continuous operation of traveling screens to minimize impingement time;
- Bucket configurations that include provisions to minimize damage to the fish upon entering the fish bucket, while they are in the bucket, and during transport to the fish handling and return system (FHRS); and
- Low pressure fish screen-wash systems to gently remove the impinged fish before the high-pressure debris spray is used to clean debris off the screens.

The following sections provide a summary of the preliminary design, hydraulic analysis, structural design, implementation cost estimate, conceptual construction sequencing, and other impacts associated with the implementation of fine-mesh traveling screens at BFN. The design presented in this report is considered a high level, preliminary design intended for feasibility determination.

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11.1.1 Overview of Design

If the implementation of fine-mesh screens were required at BFN, the existing through-flow traveling water screens would remain in place, and the existing intake pumping station would not be modified. Therefore, the existing CCW pumps and RHRSW pumps and the CCW, RHRSW, and EECW piping configurations would be unaffected. The existing intake structure is discussed further in Section 11.1.2.

A new screening structure featuring fine-mesh screens and an FHRS would be constructed between the existing intake structure and Gate 3. The FHRS would return collected organisms to Wheeler Reservoir using a gentle sluice designed for safe transportation of typical impinged organisms. Debris would be collected and handled separately from fish. It would then be transported from each screen via a trough to collection baskets at the end of the screening structure. Appendices E and F provide details of the FMS conceptual design.

The new screening structure would feature two sets of bypasses: a set of safety-related bypasses and a set of normal bypasses. There would be two safety bypasses, each large enough to pass the maximum shutdown cooling flow rate of 80 ft^3/s. The safety-related bypasses would be located below the minimum water level resulting from a downstream dam failure, 529 ft above mean sea level (MSL) and would be permanently open. There would be 22 normal bypasses (one per screen), with each normal bypass running through the “nose” of a screen to mitigate the potential impacts of high debris load events. The normal bypasses would each feature a normally closed manual gate valve.

The intake channel would be widened to allow utilization of the entire width of the screening structure. This configuration is illustrated in Figure 9.

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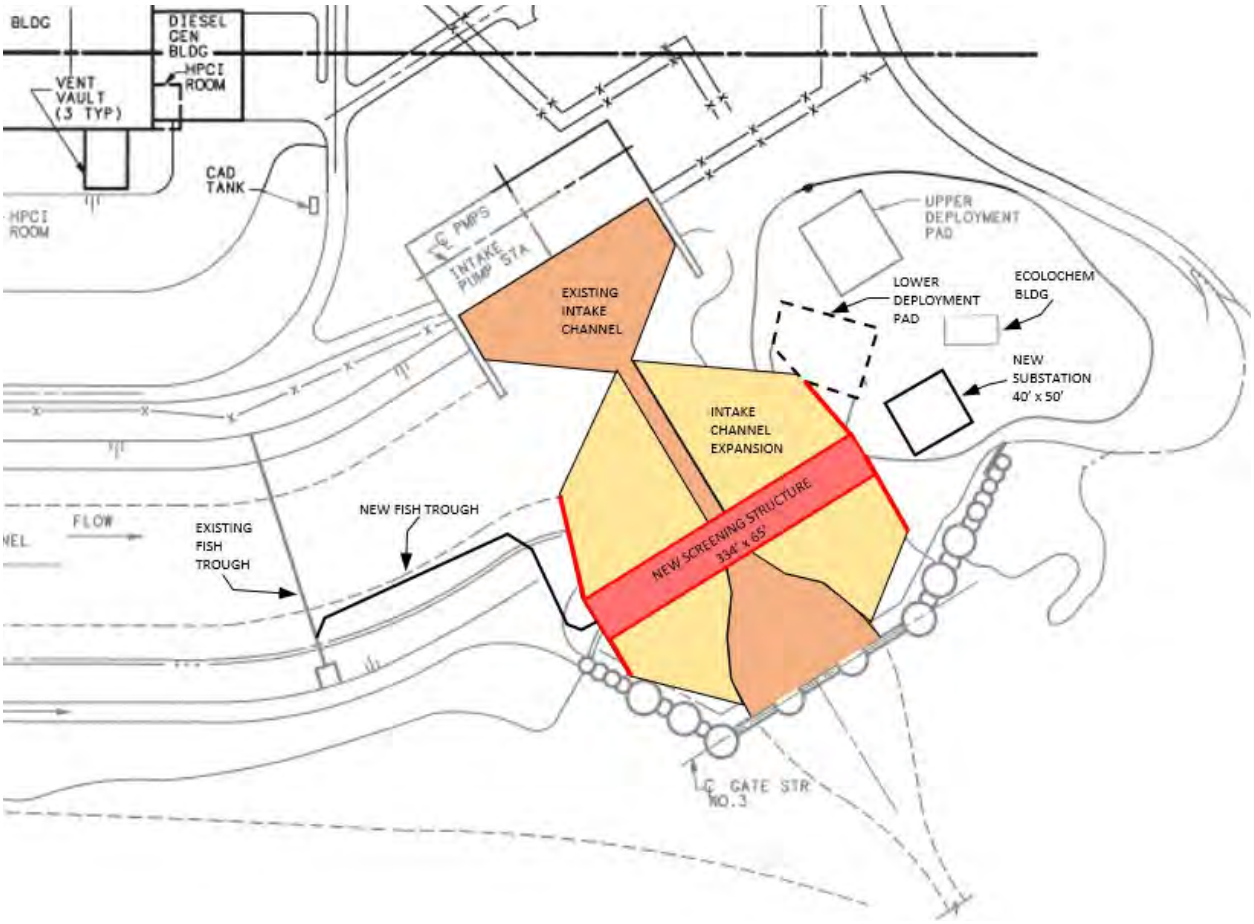


Figure 9 : BFN Site Plan View (Ref. 16.1)

11.1.2 Existing Intake Pumping Station

The existing intake pumping station is approximately 232 feet long and 77 feet wide (Ref. 16.2). It is split into nine bays, each served by two through-flow traveling water screens with 0.25 inch x 0.30 inch openings. The pumping station houses nine CCW pumps and twelve RHRSW pumps.

The CCW system utilizes nine pumps (three per unit) that each have a design flow rate of 225,000 gpm (Ref. 16.3). The RHRSW and EECW systems are served by twelve safety-related RHRSW pumps with design flow rates of 4,500 gpm each (Ref. 16.4).

At least two RHRSW pumps operate continually to keep the EECW headers flooded during normal operation. Additional RHRSW pumps may be necessary during normal operation to supply cooling water when insufficient flow is being supplied by the normal water source (Ref. 16.5).

The high-pressure screen-wash has a flow rate of 226.2 gpm per screen (1,357.2 gpm per unit) at 100 psi. The screen-wash flow is provided by three active and one spare screen-wash pumps, each rated for 1,360 gpm at 260 ft-H_2O (113 psi) (Ref. 16.6). The screen-wash pumps also provide backup cooling for the CCW pump bearings and motors (Ref. 16.7). The existing spray wash system and other equipment would be retained for use with the existing traveling water screens.

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There would be no modifications to the existing intake pumping station (as described herein), and it would remain in service to supplement the new screening structure in case the new screens require bypass.

11.1.3 New Screening Structure

The new screening structure would be approximately 334 feet in length and 65 feet in width. It would include 22 dual-flow traveling screens, trash bars, trash rakes, front and rear stop gates, screen-wash pumps, a FHRS, and supporting electrical equipment. The new screening structure would be constructed between the existing intake structure and Gate 3. The structure would feature dual-flow fine-mesh traveling water screens with 0.5 mm openings and a design through-screen velocity of no greater than 1.5 feet per second (fps) at the maximum intake flow rate and minimum normal water level.

The mesh size was selected based evaluation of entrainment sampling data that revealed measurably lower effectiveness for mesh sizes above 0.5 mm, as shown in Figure 10.

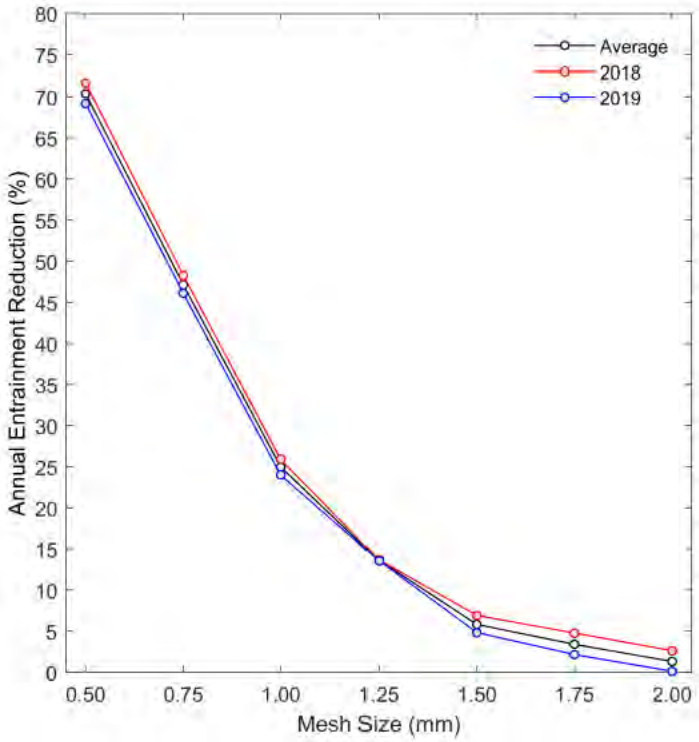


Figure 10: Entrainment reduction for various screen mesh sizes relative to the performance of existing intake structure traveling water screens

A maximum through-screen velocity of 1.5 fps was selected as a compromise between competing design factors of reduced impingement survivability caused by higher velocities and increased screening area required at lower velocities. Additionally, the selected velocity is lower than the current through-screen velocity (approximately 2.0 fps).

For a screen size of 0.5 mm, a primary design concern is that the rate of debris plugging of the screening mesh increases dramatically with increased pressure differential across the screen

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(Ref. 16.8). During periods of high suspended sediment load, rapid screen blockage, known as blinding, can occur. Therefore, the selected design velocity of 1.5 fps is also intended to limit the normal pressure differential across the screen and thereby mitigate the risk of blinding.

To achieve a through-screen velocity below the selected design point of 1.5 fps for the maximum intake flow rate resulting from operation of the CCW, RHRSW, and spray wash pumps, the new structure would include 22 dual-flow screens. Each new screen would be shared by all units, as the water passing through each screen would be collected in the intermediate body between the two structures, and that body of water would supply the entire intake pumping station.

The new structure would be placed approximately 270 ft in front of the existing intake structure, as illustrated in Figure 9, and the elevations of the bottom and top slabs would match those of the existing intake structure. The ends of the structure would border the land that runs around the forebay, which would allow for access to the deck of the structure from either end. On the back side (i.e., plant side) of the new screens, the structure would extend toward the plant for approximately 25 feet along the entire length of the structure. This would allow a crane to travel onto the structure as necessary for lifting during maintenance activities.

Between the trash rakes and screens, two troughs would run along the length of the intake structure for collection and transportation of debris and fish. The debris trough would empty into debris baskets at the end of the screening structure. The fish trough would empty into another trough which would be constructed to collect the FHRS output from the screening structure and return it to the Wheeler Reservoir at the existing FHRS discharge location. This location is outside the normal area of hydraulic influence (AHI) of the intake structure, as conservatively estimated in the§122.21(r)(2) report, which reduces the likelihood of immediate re-impingement of the fish and larvae at the traveling screens. The fish trough would be constructed of 30 inch fiber reinforced polymer (FRP) piping.

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Figure 11: Trash Rake System (Image Courtesy of WTR Engineering, Inc.)

Each new intake bay would consist of a single opening that would house a set of front stop gate guides, a set of trash bars, a concrete “nose” to support proper approach flow to the FMS, a dual-flow FMS, and a set of rear stop gate guides. All 22 dual-flow screen bays would empty into the forebay before being pulled into one of the nine bays of the existing intake pumping station.

The preliminary design and location of the new screening structure is intended to allow even distribution of approach flow among the new screens as well as the existing intake pumping station. However, a hydraulic model should be performed during detailed design to determine if vortexing or other irregular flow patterns resulting from the new screening structure would be a potential concern.

11.1.4 New Dual-Flow Traveling Water Screens

The new dual-flow traveling screens would be operated continuously. The through-screen velocity for each screen would be 1.47 fps, based on the same minimum immersion requirements applied to the existing screens (Appendix F). Even though the opening size is smaller, the reduction in velocity compared to the original is attributed to the increase in total screen surface area. This increase in screening width is the reason that a new structure must be constructed instead of retrofitting the existing structure with fine-mesh screens. As described in Section 11.1.3, the resulting reduction in through velocity is necessary to mitigate the risk of blinding of the 0.5 mm screens. Table 4 below captures the comparison of critical parameters between the existing through-flow and new dual-flow screens.

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Table 4 - Design Parameters for the Fine-mesh, Dual-flow Traveling Water Screens

Parameter	Existing Through-Flow Screens	New Dual-Flow Screens
Quantity	18	22
Mesh Opening Size	0.25 inch x 0.30 inch	0.5 mm square (0.02 inch)
Chamber Width	8’-8”	11’-0”
Effective Mesh Width	8’-2.4”	5’-0”
Minimum Immersion(1)	33’	33’
Flow per screen	117,566 gpm	96,821 gpm
Velocity through screens(2)	2.02 fps	1.47 fps
(1) Immersion height based on minimum normal water level (El. 550 ft MSL). (2) At minimum immersion and clean screen conditions		

Note that the head loss across the new dual-flow screens ranges from 2.5 inches of water when 100% clean to 5.0 inches of water when 50% clean. These head loss values are not expected to have a significant impact on the CCW system or challenge the NPSH margin of the CCW pumps. However, higher head losses may result, should more severe screen blockage events occur.

While the 0.5 mm mesh opening size improves the entrainment reduction effectiveness of the screens beyond larger fine-mesh opening sizes, it also increases the susceptibility of the screens to debris loading challenges. The potential for biofouling and the associated risk of partial or complete screen blockage is correlated with a decrease in mesh size due to the greater quantity of small-diameter debris susceptible to loading on the screens. Industry operating experience has demonstrated that implementation of FMS of mesh size smaller than 2 mm can be technically challenging, especially in productive, high debris environments. In certain cases, operation of FMS with mesh sizes smaller than 2 mm has led to temporary removal of the FMS, installation of larger mesh sizes, or, in extreme circumstances, catastrophic failure of the FMS.

The productive nature of the Wheeler Reservoir and debris loading challenges associated with traveling water screens is reflected in the operational experience at BFN. Annual high volume debris loading events typically occur during the late summer and fall seasons and result in the fouling of the existing traveling water screens. On several occasions since 2018, BFN has entered into unit derates or unplanned outages due to these debris loading events. Because smaller mesh sizes would increase the volume of debris susceptible to loading on the traveling water screens,

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there would be an inherent additional risk of screen overloading or failure associated with implementing FMS at BFN given the historical debris loading operating experience.

In an effort to mitigate this additional risk, a trash rake and an FMS bypass have been included with the design. As noted in Section 11.1.1, a safety-related bypass and a normal bypass are included in the design. The safety-related bypass would support the access to cooling water for the safety-related RHRSW pumps in the event of complete screen blockage. Therefore, the safety-related bypass would be designed to be fully redundant and feature two pipes that go around the end fine-mesh screens. The bypass pipes would each be sized to accommodate the maximum shutdown flow rate of 80 ft^3/s and would be located below the minimum water level corresponding to a failure of the downstream Wheeler Dam (529 ft MSL). A low velocity through the pipe would be desirable to reduce the likelihood of sucking excessive amounts of debris into the forebay. A 96-inch pipe would result in a maximum velocity below 2 fps. The pipes would be normally open. The normal bypass would include 22 pipes that run through the nose of each screen. They would be used to support access to cooling water for the CCW pumps to mitigate the operational risk of screen blockage events. Each normal bypass pipe would be 4 ft in diameter and would feature a normally closed manual gate valve. The pipes would be located below the 550 ft MSL elevation so that they would be submerged during normal minimum water level.

Given that the historical high-debris loading events have occurred concurrent with typical high entrainment periods, the use of the FMS bypass, and associated reduction of net screening effectiveness, may lead to decreased entrainment reduction benefits.

11.1.4.1 New Screen Wash and Fish Spray System

The dual-flow screens would require spray at both high and low pressures to operate the debris and fish screen-wash systems, respectively. The screens would use two sets of low-pressure fish spray nozzles – one on the inside of the screen and one on the outside (see Appendix F). The goal of the of the spray is to wash all the fish off the screen and into the fish trough. The fish sprays would operate at a nominal pressure of 7.5 psi and a maximum pressure of 10 psi.

The design of the screen is such that the fish would be gently removed from the screens by the low-pressure fish spray before the high-pressure debris spray is applied to remove debris. The debris sprays would operate at a nominal pressure of 35 psi and a maximum pressure of 40 psi.

The screening structure would use two separate troughs for transport of collected fish and debris. The fish return trough would be located above the debris trough. The fish trough would be used to transport fish back to Wheeler Reservoir (see Section 11.1.5), while the debris trough would carry debris to the end of the screening structure where it would be collected in trash baskets for removal.

Because the existing screen-wash pumps would be left in place for cleaning the existing screens and cooling for the CCW pump bearings and motors, new screen-wash pumps would be required for the new screening structure. The new screen-wash pumps would be located just behind the dual-flow screens. The nominal debris and fish screen-wash flow rates are 3,496 gpm and 10,392 gpm total, respectively. Suction piping would be large diameter and would draw water at El. 534. At the normal low water level, the suction bell would be located halfway between the water surface and the bottom slab. The distance of the suction bell to the water surface would be greater than

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the required pump submergence criterion. Additionally, the distance of the suction bell to the bottom slab would reduce the withdrawal of silt through the screen-wash pump. The location and design of the screen-wash pumps would promote reliable operation of the screen-wash system under all operating conditions. The screen-wash pumps would be required to overcome losses in the line and due to elevation change, which are estimated to be 75 ft combined.

Six debris screen-wash pumps would be used to provide spray to the 22 traveling screens. Four of the pumps would serve four screens each, and two of the pumps would serve three screens each. Each pump would discharge into a header pipe to distribute flow to each of the screens served by the pump. The header pipe would tee into each screen to supply the debris spray nozzles. Each pump would be designed to serve four screens. The flow rate and total developed head required for the debris screen-wash pumps is estimated to be 635 gpm at 167 ft. To provide operating margin that allows for pump degradation over its useful life, debris wash pumps that can supply 770 gpm at a design TDH of 170 feet are specified.

Six fish wash pumps would be split among the screens in the same way as the debris pumps and would also discharge to a header that distributes flow to the screens served by the fish wash pumps. The pumps would be designed to serve four screens. The flow rate and total developed head required for the fish wash pumps is estimated to be 1,890 gpm at 98 ft. To provide operating margin that allows for pump degradation over its useful life, fish wash pumps that can supply 2,270 gpm at a design TDH of 100 feet are specified.

Pressure-regulating valves would be used to maintain pressure within the design bands for the debris wash spray and the fish wash spray. Isolation valves would be installed on each spray header, so that screens could be individually isolated. The configuration and sizing of the spray wash piping would be finalized during the detailed design.

Figure 12 provides a profile view of the candidate FMS with the proposed fish and debris spray systems.

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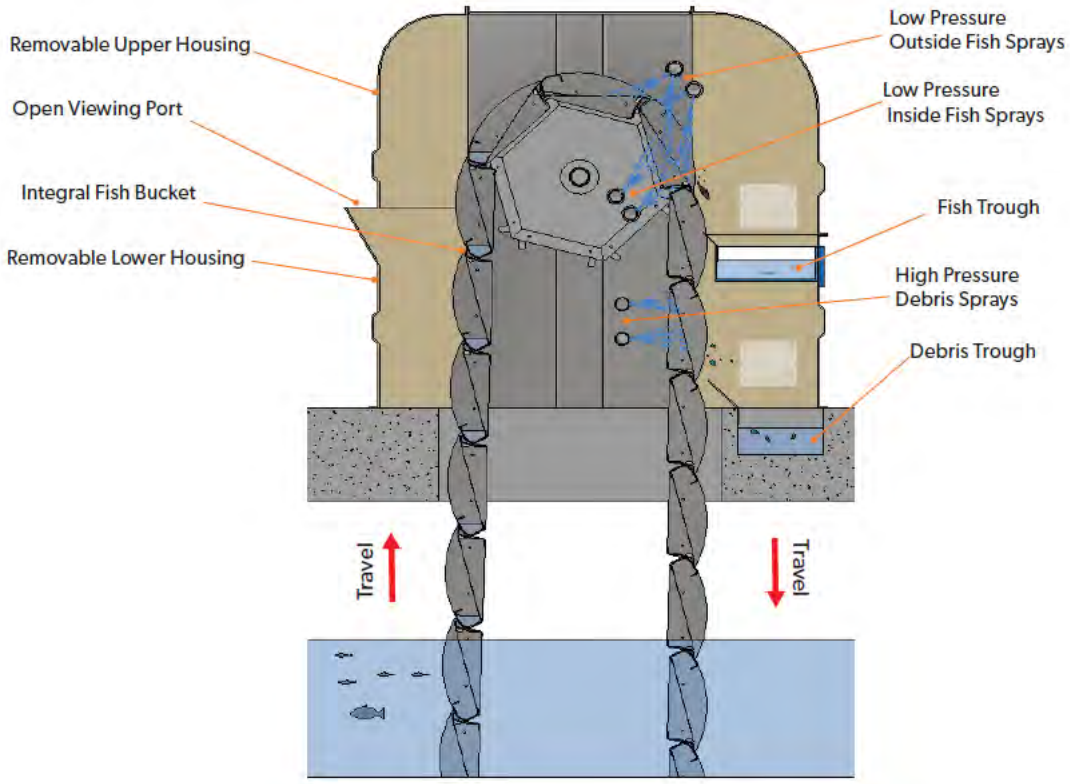


Figure 12: FHRS on Fish-Friendly Traveling Water Screens (Image Courtesy of WTR Engineering)

11.1.5 Fish Handling and Return System

A FHRS system would be constructed to receive fish from the fish trough at the end of the intake structure and transport them to Wheeler Reservoir.

The design of the FHRS is driven by the description of a fish handling system in the definition of a modified traveling screen at 40 CFR 125.92(s), which requires that a FHRS have sufficient water flow to return the fish directly to the source water in a manner that does not promote predation or re-impingement of the fish or require a large vertical drop. Additionally, this design considered the best practices and guidelines provided in References 16.9 and 16.10. The best practices are summarized in the numbered list below.

1. All conveyance structures shall be smooth to prevent abrasion to the fish.
2. Water depth shall be a minimum of 6 in. and shall have a minimum width of 18 in.
3. Transport velocities should be greater than the sustained cruising speed of fish. The cruising speed is often 2 – 4 fps.
4. Materials used should minimize bio-fouling.
5. Long radius (r/d > 2.5) bends shall be used to prevent abrasion at the bends.

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6. Pipe joints shall be constructed such that there is a smooth transition between pipe sections.
7. All transitions should be gradual and avoid flow separation.
8. Buried piping shall be below the frost depth.
9. The outlet shall be located well away from the intake to avoid re-impingement.

The design of the FHRS has been evaluated to meet each of the above criteria as follows:

To satisfy the first and fourth criteria, fiber-reinforced polymer (FRP) material would be used for the new fish trough. FRP would provide a smooth conveyance surface and is resistant to bio-fouling. To ensure that the second criterion is met, a 30 inch nominal diameter (24 inch inside diameter) trough would be used for the conveyance of fish, eggs, and larvae.

For the third criterion, the flow was evaluated assuming a continuous slope of 1 vertical ft per 100 horizontal ft in a 30 inch nominal diameter pipe. There are 22 FHRS sprays each providing 472.4 gpm of low-pressure spray which accumulates in the fish return trough. The flow was evaluated iteratively using Manning's equation for open channel flow:

$$Q = VA = \frac{1.49}{n}(R)^{2/3}S^{1/2}A$$

Where

Q – flow rate, ft^3/s

V – velocity, fps

n – Manning's roughness coefficient, dimensionless

A – cross-sectional flow area, ft^2

R – hydraulic radius, ft

S – channel slope, ft/ft

The flow was modeled with the parameters listed in Table 5. The flow velocity would satisfy the velocity recommendation of the third criterion.

Table 5: Fish Handling and Return System Parameters Modeled with Manning's Equation

Parameter	**Value**
Flow Rate	23.2 ft^3/s
Channel Slope	0.01 ft/ft
Manning's Roughness Coefficient	0.01
Cross-Sectional Flow Area	2.4 ft^2

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Parameter	Value
Hydraulic Radius	0.60 ft
Flow Depth	1.2 ft
Flow Width	2.0 ft
Velocity	10.6 fps

To meet the fifth and seventh criteria, sharp bends would be avoided in the design to reduce abrasion of fish around turns. All bends would have a turn radius ratio (r/d) greater than or equal to 2.5. FRP sections would be flange connected to provide a smooth conveyance surface, meeting the sixth criterion. The eighth criterion is not applicable as the FHRS troughs are above grade. In order to avoid re-impingement, the FHRS will discharge into Wheeler Reservoir at a location beyond the AHI of the intake structure, which is the area in which water is susceptible to be re-entrained in the intake flow.

The new FHRS would be merged with the existing FHRS trough on the plant side of the dike separating the forebay from Wheeler Reservoir. The existing discharge location would be maintained, which is approximately 530 ft from the intake, downstream of Gate 3. This location is outside of the AHI of the intake structure, as illustrated in the §122.21(r)(2) report. There, the sweeping velocity of the river would carry organisms away from the intake, meeting the requirement of the ninth criterion.

The fish trough required for the new FHRS would feature one run of approximately 330 ft (excluding the screening structure width), as depicted in Figure 13.



Figure 13: Layout of New FHRS (Map data courtesy of Google© 2021)

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11.1.6 Structural Design

The new screening structure would be designed to Seismic Category I requirements, and would be reinforced concrete primarily utilizing shear walls for lateral load resistance. The shear walls would be four-foot-thick reinforced concrete. The proposed design would be in accordance with International Building Code (IBC-2018, Ref. 16.11), American Society of Civil Engineers (ASCE 7-16, Ref. 16.12), American Concrete Institute (ACI 318-14, Ref. 16.13 & ACI 360-10, Ref. 16.14), and the American Institute of Steel Construction (AISC 14th Edition, Ref. 16.15). Furthermore, the applicable guidelines for environmental structures and seismic design of water retaining structures in ACI 350-06 (Ref. 16.16) and ACI 350.3-06 (Ref. 16.17), respectively, would be followed, as required. For purposes of this report, select bounding conditions from the codes of record were used to develop a preliminary design that supports a construction cost estimate and schedule for the new screening structure. The preliminary design has been included in Appendix E.

The top deck elevation would be the same as the existing intake pumping station and would include a railing around the perimeter of the top deck. The top deck would be made of three-foot-thick reinforced concrete. Major loads on the top deck include two new trash rakes (see Figure 11), dual-flow FMS housings, screen-wash pumps, FHRS equipment, and maintenance vehicles.

The bottom slab of the new screening structure would be reinforced concrete with a top of concrete elevation of El. 517 ft. The slab has a depth of three feet and would be cast on top of a concrete mud mat. The concrete mud mat consists of a loosely poured concrete slurry that will be used to help create a level and dry surface for construction. The bottom slab will support the equipment loads from the traveling screens, trash bars, trash rakes, and stop gates. The total area of required dredging is approximately 70,000 ft^2. It is expected that the dredged material would not be suitable for use as backfill in follow-on construction activities due to its composition. Dredging volumes were estimated using the intake expansion plan shown in Figure 14 and the 2018 bathymetry map shown in Figure 15, based on which an average elevation of 533 ft MSL was estimated over the dredging area.

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Figure 14: Intake Channel Expansion

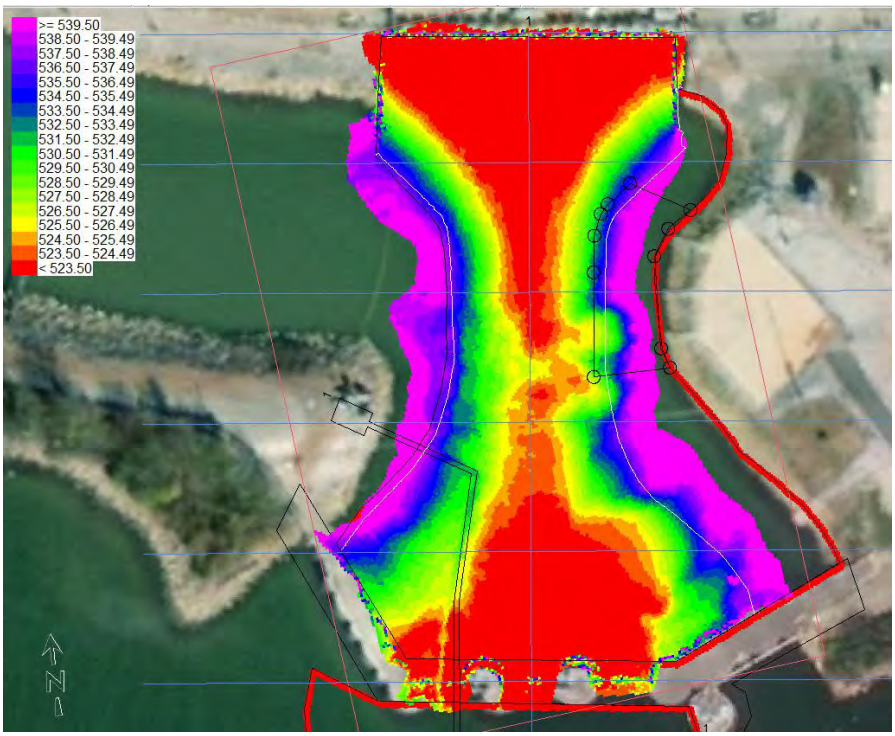


Figure 15: Intake Bathymetry

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Dredging of approximately 40,000 yd^3 of banked earth from the intake forebay would be required prior to construction of the mud mat and bottom slab of the new screening structure. The dredged earth could be added to the existing spoils pile on site, which features an area of approximately 50,000 square yards where the ground is below the peak elevation and slopes gently down toward the road with an average grade of approximately 1:5 (vertical to horizontal), as shown in Figure 16. The spoils would be spread so that the height would not exceed three feet above the natural ground surface and the spoil gradient would be no steeper than 1:3. The surface would be seeded daily throughout the spoils deposition process.

Cofferdams would be used in the construction of all parts of the structure submerged underwater in order to limit water ingress and allow dry space for concrete work.



Figure 16: Dredging Spoils Disposal (Map data courtesy of Google© 2021)

Extending out from the screening structure, along the embankment, reinforced concrete wing walls would also be provided to support the embankment and dredged areas. These wing walls would be similar in concept to the wing walls supporting the current pumping station on site (Ref. 16.18).

A preliminary review of the existing soil conditions indicates that there is sufficient capacity in the soil to support the screening structure as a slab on grade, cast on a concrete mud mat. A geotechnical study would be required during detailed design to determine if additional dredging, or if piles are required to support the structure, or address potential soil liquification concerns based on existing soil conditions.

11.1.7 Electrical Design

The incoming 4.16kV power source for the new MCC buildings are assumed to be provided by BFN. Costs for this new power source is not included in the electrical estimates. A new duct bank would be installed from the provided power source to the new screening structure for routing

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4.16kV power supply cables and any required control cables. A new overhead cable tray system would be installed in the new screen structure control house.

The new cable tray system for the screen structure control house would have separate cable trays for all voltage level designations, i.e., 480 VAC, 120 VAC, and medium-level signal. A minimum of four voltage level designations would be required for the new cable tray system: medium voltage power, low-voltage power, control, and medium-level signal.

The 480 VAC distribution equipment in the existing intake structure control building would be insufficient for future loads, and therefore, three new 480V electrical distribution systems would be required to serve the new and relocated equipment at the new intake structures. Each new 480 VAC electrical distribution system would include one new 500 KVA, 4.16kV/480 VAC three phase dry type transformer, one 480 VAC motor control center, one 480 VAC distribution panel, two 480V/208-120 VAC dry type transformers and two 208/120V distribution panels.

Each new 4.16kV/480 VAC transformer's secondary would be close coupled to the new 480 VAC motor control center. The new 480 VAC motor control center would have a main incoming breaker with circuit protection as well as the starters and breakers to support the new equipment.

Each new 480 VAC distribution system equipment would be installed in pre-fabricated buildings located at the new intake structures. The buildings would be climate controlled with air conditioning, heat, lighting, fire detection equipment, convenience outlets, etc. Each pre-fabricated power house would be purchased from a power house manufacturer that would install and prewire all distribution equipment; i.e., MCC, distribution panels, provide all HVAC, lighting and lightning protection needs as well as provide the necessary grounding connections for the building. Based on previous experience, the pre-fabricated electrical buildings are the most cost-effective approach.

The pre-fabricated electrical buildings would be installed on a slab on grade on the east side of the new screening structure, as illustrated in Figure 9. Cable trays would run from the power house building to the new loads and instrumentation and control systems.

A new cable tray system would be installed to service the new intake structure equipment from the new pre-fabricated elevated power house building. The cable tray system would have separate cable trays for all voltage levels; i.e. 480 VAC, 120 VAC, and instrumentation. A minimum of three voltage level designations would be required for the new cable tray system: low-voltage power, control, and medium-level signal.

The new cable tray system would contain the necessary cabling to support the powering of the new equipment.

New equipment to be powered from the new MCC includes:

- Twenty-two dual flow traveling water screens
- Six fish wash pumps
- Six debris wash pumps
- Two trash rakes

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Lighting systems would be designed and installed for the new intake structures. Waterproof LED lighting fixtures would be used. Lighting levels are estimated to be 15 foot-candles. Lighting would be attached to the bottom of the cable tray support structures. Maintenance lighting would also be supplied for the large pumps and general area lighting. Maintenance lighting would be located on poles.

A new lightning protection system for the new intakes would be installed. The lightning protection system would be tied into the plant's existing grounding grid.

A new electrical grounding system would be installed at the new intake structures and connected to the existing plant grounding system. All electrical equipment would be grounded.

Cable trays and conduits will be supported along the length of the intake structure with structural steel cantilever supports (consisting of tube steel and channel members) attaching directly to the concrete, with a maximum support spacing estimated at 10 feet. Exact sizing of structural members and overall supports would be determined during detailed design. These supports would be independent of the FHRS supports and any other mechanical equipment supports.

11.1.8 Major Components

Table 6 below is a list of major new equipment that would be required for retrofitting BFN with fine-mesh traveling screens.

Table 6 - Listing of Major Equipment Required for Installation

Component	Quantity	Notes
Dual-flow traveling screens	22	5'-0" effective screen width, includes spray (fish and debris) and 5 hp motor
Fish wash pump	6	Provides 2,270 gpm at 100 ft, includes 100 hp motor
Debris wash pump	6	Provides 770 gpm at 170 ft, includes 50 hp motor
Trash rake	2	Two 7.5 hp hoists, two 2 hp traveling motors, and two 2 hp rake closing motors
Screen-wash valves	22	Globe, debris spray nozzle isolation
	22	Globe, fish spray nozzle isolation
	22	Pressure reducing for fish spray
	22	Pressure reducing for debris spray
Safety bypass piping	2	8 ft diameter steel pipe, 30 ft each
Normal bypass piping	22	4 ft diameter steel pipe, 5 ft each

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Component	Quantity	Notes
Normal bypass valves	22	4 ft gate valves

Table 7 lists major new structures that would be required for retrofitting BFN with fine-mesh traveling screens.

Table 7 - Listing of Major Structures Required for Installation

Component	Approximate Size or Length	Notes
New screening structure	Length: 334’ Width: 65’ Height: 52’	22 screening bays and retaining wing walls
FHRS trough	330 ft	30” FRP pipe
Screen-wash piping for new screening structure	490 ft	12” carbon steel piping (suction)
	670 ft	10” carbon steel piping (headers)

12 Impacts of Fine Mesh Implementation

The purpose of this section is to discuss the various impacts associated with retrofitting BFN with 0.5 mm fine-mesh traveling water screens. Retrofitting BFN to fine-mesh traveling water screens would require construction of a new screening structure, resulting in various construction-related impacts. Additionally, the fine-mesh screens would also result in on-going operational impacts that are considered. Both the initial construction and on-going operation of the fine-mesh screens would have impacts to the power generating capacity of the plant. Impacts in other areas beyond operations are also considered, including licensing and environmental impacts. Construction-related impacts are discussed in the §122.21(r)(12) report.

12.1 Power Generation

Retrofitting BFN with fine-mesh screens would decrease net generating capacity of the plant due to parasitic losses resulting from the operation of the new dual-flow traveling water screens, screen-wash pumps, and trash rake system. Parasitic losses are defined as power consumption necessary to operate the plant, which therefore reduce the net generating capacity of the plant. This ultimately results in long-term recurring costs which must be considered along with the costs of the actual conversion to fine-mesh screens.

The motors for the new fish and debris screen-wash pumps would draw a maximum of 102 hp and 59 hp, respectively (note that the power discussed here is the motor input power as opposed to the motor output power displayed in Table 6). With six pumps each for both fish and debris screenwash, the power consumption for fish and debris screenwash would be 612 hp (456 kW) and 354 hp (264 kW), respectively. Since the dual-flow screens would operate continuously, the

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screen-wash pumps would also be required to operate continuously. Therefore, the net increase in power consumption from screenwash pumps would be 966 hp or 720 kW.

The motors for the new dual-flow traveling water screens would have nameplate power ratings of 5 hp. All 22 new dual-flow screens would operate continuously, resulting in a net increase in power consumption of 110 hp or 82 kW.

The motors associated with the new trash rake system would have a combined rated brake horsepower of 23 hp. The trash rake system would be expected to operate intermittently, on an “as-needed” basis. Therefore, the average power consumption is considered negligible and not included in the O&M costs.

As summarized in Table 8 below, an additional 802 kW of parasitic losses is estimated as a result of new equipment required to operate the new fine-mesh screens.

Table 8 - Estimate of Power Use by New Major Components

Component	Power Consumption (kW)
Debris Wash Pump (6 total)	264
Fish Wash Pumps (6 total)	456
Dual-Flow Traveling Water Screen Motors (22 total)	82
Trash Rake System	Intermittent
TOTAL	802

12.2 Noise

Sound is energy transmitted through the atmosphere in the form of pressure waves. The measurement of these sound pressure levels is expressed in terms of decibels (dB). Being that sound is a wave form, it also has frequency characteristics which are expressed in hertz (cycles per second). Knowing sound pressure levels and frequencies, the character of a given sound may be analyzed. Sound pressure levels can be A-weighted to adjust for the hearing range of the human ear. The sound loudness as perceived by the human ear is measured in A-weighted decibels (dBA).

Noise from an intake structure generally consists of sounds created by the motors, the speed reduction or power transmission units, and various pumps (circulating water, screen-wash, service water). The operation of the new dual-flow traveling water screen motors and screen-wash pumps would produce noise that would be incremental to existing level of noise produced by the intake structure. The fish wash pumps, debris wash pumps, and dual-flow screens are operated by 100 hp, 50 hp, and 5 hp motors, respectively. The noise levels of at a distance of three feet from 100 hp, 50 hp, and 5hp motors would be approximately 87 dBA, 84 dBA, and 74 dBA, respectively (Ref. 16.19). Noise would also be generated by the operation of the screen-

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wash nozzles, although this noise would occur within and be muffled by the screen motor housings.

12.3 Visual

The new screening structure required to retrofit BFN with fine-mesh screens would not create significant visual impacts for the surrounding areas. Although no significant visual impacts are anticipated, the full extent of the visual impacts and any possible permitting challenges would be analyzed fully in a detailed design phase.

The new screening structure would be 334 feet long and as tall as the existing intake structure. The new screening structure would be constructed between the existing intake structure and Gate 3 and would therefore have negligible impact on the view from across the reservoir.

As described in Section 11.1.5, a new FHRS would also be installed as part of retrofitting BFN with fine-mesh screens. The FHRS would include one run of trough from the screening structure to the location of merging with the existing trough. The FHRS would likely be visible from the surrounding areas as well as from boaters on Wheeler Reservoir, though its use of the existing FHRS discharge piping would cause little change to the current view.

This arrangement is illustrated in Figure 9, where the new screening structure is outlined in red, the new FHRS trough is shown in blue, and the existing intake, FHRS, and nearby gate structures are in green.

12.4 Water Consumption

The circulating water system at BFN draws water from Wheeler Reservoir into the CCW system and discharges heated water back to Wheeler Reservoir. Generally, the same amount of water is withdrawn from and discharged to the reservoir.

The addition of fine-mesh traveling water screens would not alter the existing configuration of how BFN draws water from and discharges to Wheeler Reservoir or increase the capacity of the plant to withdraw water from Wheeler Reservoir. The only new suction source added to the screening structure would be the new screen-wash and FHRS pumps. This results in a small increase in through-screen flow and an associated increase in entrainment impacts. However, the discharge flow from those pumps would fall either into the screenwell, upstream of the CCW pumps, or be returned to Wheeler Reservoir via the FHRS. Since the new screen-wash and FHRS pumps would discharge all of the water that is withdrawn, there would be no water consumption impacts associated with the implementation of fine-mesh screens.

12.5 Ultimate Heat Sink

Together, the intake forebay and Wheeler Reservoir form the water source for the plant's ultimate heat sink (UHS), which is defined by NRC Regulatory Guide 1.27 as the assured water credited for the heat removal of reactor residual heat and essential plant heat loads after normal reactor shutdown, accident, transient, or loss-of-coolant accident. The systems that use the UHS water for safe shutdown operations are the RHRSW and EECW systems, both of which are supplied water by the RHRSW pumps. The existing traveling water screens are required to supply screened water at the flow rate necessary for shutdown cooling to the RHRSW pumps. Because

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the existing screens are not safety-related, they are qualified to meet this requirement passively (i.e., without traveling) on the basis that the screens are sized for much higher flow rates than required for shutdown cooling and the screens are located in a seismic Category I structure.

The new fine-mesh traveling water screens would also be non-safety related and would assume the same requirement to supply the flow rate required for safe shutdown while stationary. This is acceptable, because the new fine-mesh screens have more open area (approximately 3,200 ft^2 at 550 ft MSL water level) than the existing screens (approximately 2,300 ft^2 at 550 ft MSL water level). Additionally, the new screening structure would be designed to Seismic Category I requirements. This would ensure that the structure would not crumble and fill the intake channel, which could obstruct the passage for water from the Wheeler Reservoir to the intake structure at the minimum water level resulting from a coincident downstream dam failure. Additionally, to ensure access of the RHRSW pumps to cooling water from Wheeler Reservoir in the event of a screen blockage event, a pair of safety bypass pipes would be installed around the screens.

No modifications to the existing intake structure or the RHRSW and EECW systems would be implemented with fine-mesh screens. Additionally, the implementation of fine-mesh screens would not impact the UHS water temperature, which would remain a function of the ambient water temperature of Wheeler Reservoir.

12.6 Regulatory, Licensing, Environmental, and Safety

12.6.1 Potentially Applicable Federal Permits

United States Army Corps of Engineers (USACE) Permit

Adding fine-mesh screens to BFN would require the construction of a new screening structure outfitted with fine-mesh traveling water screens and the construction of a new FHRS.

While alterations to the intake and fish collection system are usually authorized under NWP 7, which covers activities related to the construction or modification of outfall structures and associated intake structures, additional project components, including the construction of a FHRS would likely require that the entire project be permitted under a USACE Individual Permit. The USACE would decide whether an Individual Permit is appropriate. If the project does qualify for NWP authorization, TVA would submit a preconstruction notification for coverage under appropriate NWPs. If the project does not qualify for NWP authorization, a joint permit application to the USACE (Nashville District) and the ADEM would be required.

Both the NWP and Individual Permit process addresses evaluation of the potential for impacts to threatened and endangered species and cultural resources. Projects with the potential for impact would require consultations with the USFWS and the Alabama Department of Conservation and Natural Resources regarding the potential for affects to protected species and consultation with the State Historic Preservation Officer regarding the potential for affects to cultural resources. As part of the permit application process, a project description and project plans may be placed on public notice and open to public comment. While NWPs are generally not released to the public for comment, it is up to the discretion of the lead agency to determine if the proposed project has the potential to be controversial and, therefore, whether to open the project up to public comment.

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National Environmental Protection Act (NEPA)

Because TVA is a Federal Agency, compliance with NEPA is required and TVA would decide the level of NEPA review required for the project. Because the project would require a permit issuance by another federal agency, the USACE, the NEPA obligation of the two federal agencies could be undertaken jointly with TVA serving as the lead agency.

U.S. NRC Review

All plant modifications require implementation of the BFN design change process, which includes assessments of all U.S. NRC licensing impacts. The design change process requires consideration and review of the proposed modification using the criteria in 10 CFR 50.59. These criteria help BFN determine if prior NRC approval of some or all aspects of the proposed modification are required. If so, then prior NRC approval of those changes is needed. The new safety related bypass and seismic screening structure are the most likely issues to require NRC review. Evaluation under the design process would determine if prior NRC approval is required.

12.6.2 Potentially Applicable State Permits

National Pollutant Discharge Elimination System Permit (NPDES)

It is anticipated that the proposed screening structure modifications would be evaluated by ADEM as part of renewal process for NPDES Permit number AL0022080. If not evaluated as part of the renewal process, then a permit modification may be required.

Stormwater Permit

Construction activities resulting in land disturbance of one acre or greater must apply for a stormwater permit coverage under the Alabama Construction General Permit, ALR100000 2021 (ADEM 2021). The General Permit requires erosion and sediment controls and a BMP plan.

12.7 FMEA and PRA Reviews

The implementation of fine-mesh screens creates the potential for new failures within the CCW, RHRSW, and EECW systems and possible effects on the probability of failure for some existing plant equipment.

The greatest risk imposed from installing fine-mesh screens is the increased likelihood of screen blockage. Large-scale screen blockage would result in a partial loss of flow to the CCW, EECW, and RHRSW systems. Screen blockage may also affect the operation of the electric motor-driven fire pump, which is housed on the existing intake structure.

Potential causes of localized screen blockage include high debris loads and failure in the newly installed screen motors, screen-wash pumps, nozzles, valves, or piping. The risk of screen blockage is mitigated by redundancy and robustness in the fine-mesh screening structure design as well as the inclusion of safety and normal screen bypasses.

- Because water passing through each screen is collected in a common body from which the CCW and RHRSW pumps draw, each screen serves the entire intake structure. Therefore, failure of one screen is compensated by the remaining screens.

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- Filtration is accomplished by the new screening structure in two stages: bar screens first collect large debris, and then the traveling water screens collect fine debris entrained in the passing fluid.
- Screen controls monitor debris loading and increase the rate of cleaning when debris loads increase.
- The screen-wash system is designed such that failure of any given screen-wash component affects no more than four of the twenty-two screens.
- The trash rake system is designed with two rakes each serving half of the screens. Failure of one rake still allows clearance of large debris from the bar screens for half of the screening bays.
- Twenty-two normal bypass pipes (one per screen) run through the nose of each screen to mitigate the impact of screen blockage on the supply of CCW system flow.
- Two safety bypass pipes, each sized to pass the maximum safe shutdown flow rate of 80 ft^3/s, are designed to go around the screens to ensure access to cooling water for the RHRSW pumps despite screen blockage.
- The head loss across the screens when loaded with debris blockage up to 50% would not impact the operation of the fine-mesh traveling screens or downstream equipment.

An additional failure mode is structural failure caused by a seismic event. Coincident failure of the downstream Wheeler Dam would result in the water level of the Wheeler Reservoir being reduced to the minimum water level of 529 ft MSL. The intake channel would be designed with a ground elevation below the minimum water level to ensure that the RHRSW and EECW pumps have access to cooling water in such a scenario, but a structural failure of the new screening structure could result in pieces of debris and rubble filling the intake channel and obstructing the flow path of water from the Wheeler Reservoir to the intake structure. The new screening structure would be seismically qualified to mitigate this failure risk.

12.8 Plant Programs

Implementation of fine-mesh screens at BFN would require existing maintenance and aging management activities be applied to the new equipment. Fine-mesh screens would require new inspection and preventative maintenance schedules and may require new administrative programs for the operation and inspection of the screens. Additionally, if an impingement technology performance optimization study were required, new standard operating procedures would be required in support of the study. A preliminary consideration of plant program impacts is discussed in the following sections.

12.8.1 Fire Protection

One electric motor-driven fire pump is located on the existing intake structure and is therefore supplied screened water by the traveling screens. As discussed in the previous sections, the fine-mesh screens would be designed to ensure the supply of water to the intake structure is not interrupted. Therefore, no impact on the fire pump's operation would be expected.

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12.8.2 FLEX

Following the Fukushima disaster in 2011, the industry responded by implementing compensatory measures for beyond-design basis external events, including measures for core cooling, spent fuel pool cooling, containment cooling, and upgraded spent fuel pool instrumentation. The implementation of Diverse and Flexible Coping Strategies (FLEX), an NRC standard, required the addition of tie-ins to use portable equipment to maintain steam generator cooling, reactor coolant system inventory, and multiple ways to keep spent fuel covered and cool in the spent fuel pool. Infrastructure was also developed to allow for multiple methods of powering equipment from external generators, etc.

The implementation of fine-mesh screens would not result in any modifications to the existing intake structure. Therefore, the FLEX connections located in the RHRSW pump rooms of the existing intake structure would not be impacted.

The new screening structure and expansion of the intake channel would require excavation and dredging that would interfere with the lower FLEX deployment pad. The pad would be moved eastward by approximately 50 ft along with the forebay water line. Additionally, an area of approximately 40’ x 50’ would be dedicated to locating the electrical equipment to support the new screening structure. After relocation, the size of the pad and proximity to the water would be unchanged. The new screening and associated electrical structures would not prevent access to the staging pads or block access to the water from the staging pads. However, construction of the new screening structure may require construction equipment to temporarily occupy the FLEX staging area. Accommodations for these activities and related interferences from the presence of construction equipment may be required in the FLEX procedures.

12.8.3 Maintenance Rule

The scope of the Maintenance Rule (Regulatory Guide 1.160 and NUMARC 93-01) covers all safety-related structures, systems, and components (SSCs) as well as non-safety-related SSCs that are:

i) relied upon to mitigate accidents or transients or are used in plant emergency operating procedures,

ii) whose failure could prevent SSCs from fulfilling their safety-related function, or

iii) whose failure could cause a reactor scram or actuation of a safety-related system.

The new screens and bypass pipes could fall under the scope of the maintenance rule of 10 CFR Part 50.65 and would be considered for impact to the maintenance monitoring during detailed design.

12.9 Siting, Seismic, Geological, and Hydrological

12.9.1 Siting Impacts

As detailed in Section 11.1.3, the new screening structure would be constructed approximately 270 ft in front of the existing intake structure.

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A preliminary review of the site utilization indicates that the new screening structure and associated FHRS would not have any temporary or permanent interferences with existing site buildings or equipment. The new FHRS trough would be tied in with the existing trough upstream of the roadway that runs along the dike, as illustrated in Figure 9. This way, no disturbance to the roadway would be incurred.

12.9.2 Seismic Impacts

The new screening structure and safety bypass lines would be designed as Seismic Category I structures/components to preclude the possibility of blockage of the intake channel caused by a structural failure. All other supporting equipment would be seismically designed per the requirements for Site Class D, as presented in the International Building Code (Ref. 16.11), ASCE Standard 7-05 (Ref. 16.20), and other applicable building codes.

12.9.3 Geological Impacts

The new screening structure would be located approximately 270 ft in front of the existing intake structure. As such, the soil at this location is expected to share the same geologic characteristics of the soil supporting the intake structure. Because the new screening structure will be of similar size as the existing intake structure, but will not support as much load, the new screening structure is expected to be compatible with the supporting soil. As part of a detailed design phase, new soil borings would be taken in the proposed installation locations to validate this assumption and the structural designs of the supports and foundations of the screening structure.

12.9.4 Hydrological Impacts

The primary water source for the plant is Wheeler Reservoir, which is an impoundment of the Tennessee River formed by the Wheeler Dam, located approximately 18 miles downstream from the plant. Wheeler Reservoir extends approximately 74 river miles upstream from Wheeler Dam to Guntersville Dam. The site is built on massive formations of nearly horizontal bedrock. Due to the proximity of the bedrock formations and their shallow pitch, groundwater moves slowly from the plant area to the Tennessee River. Groundwater movement is further inhibited by thick eluvium deposited on the bedrock.

During normal operations, the surface water level of the Wheeler Reservoir typically varies between 552 ft MSL in winter and 556 ft MSL in summer. The new screening structure would be constructed at the same elevation as the existing intake structure and would feature a deck elevation of 565 ft MSL, matching the deck elevation of the existing structure. This elevation exceeds the maximum high water elevation of 562 ft MSL. All pumps, motors, and electrical controls would be mounted above the deck at an elevation of at least 572.5 ft, which is well above the maximum possible flood elevation. Therefore, flooding of the new or relocated pumps, motors, and electrical controls associated with retrofitting BFN with FMS and a new intake structure would not be of concern.

The Federal Emergency Management Agency (FEMA) flood zone map lists the BFN site as an “area of minimal flood hazard.” It was determined that no new structures or equipment required for the fine-mesh screen implementation would be located within a flood zone. As described

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above, the pumps, motors, and electrical control buildings would be installed at an elevation high enough that flooding would not be of concern.

Additionally, data from the United States Geological Survey (USGS) monitoring well number 342718087285601, which is located in Lawrence County, approximately 18 miles from the plant, shows that the depth to the water table has fluctuated, but has remained between approximately 6 and 15 feet from 1976 to 2020 (Ref. 16.21). Although not necessarily indicative of the ground-water level at the plant, these data show no significant upward or downward trends of the ground-water level that would need to be considered.

12.10 Impact to Alabama's Electrical Grid Supply

The conversion of BFN to fine-mesh traveling water screens would impact the Alabama electrical supply grid with a continual electrical power production loss due to the increased parasitic losses associated with the fine-mesh traveling water screens.

Retrofitting BFN with fine-mesh screens would result in increased parasitic losses that would have to be replaced in the electrical supply grid by alternative sources of power. As described in Section 12.1, the average increase in parasitic losses due to the additional equipment required to implement fine-mesh screens is approximately 802 kW, or 0.802 MWe. These increased parasitic losses result in an annual loss in electricity supplied to the grid of approximately 6,330 MWh, assuming a utilization factor of 90%, based on the average utilization of Unit 2 from 2014 to 2019 (as detailed in the §122.21(r)(8) report). Alternate sources of power would be required to replace this lost power on a yearly basis.

13 Construction Schedule for Fine Mesh Screen

A schedule for the detailed permitting, design, procurement and implementation of the new fine-mesh traveling water screen retrofit is presented in Appendix D. The schedule includes a high-level estimate for permitting time, but this can be highly variable. Completion of the modification to the new screening structure should not require a plant outage. Testing and tie-ins should be completed without need of an outage, or in conjunction with a scheduled outage. The construction would be planned such that these items are completed in a manner that should not require outage time.

The new screening structure would be constructed in two phases, such that approximately one-half the width of the screening structure would be obstructed by cofferdams at any time during construction. During the first phase, the remaining portion of the intake channel width would be open to provide flow for the intake structure. During the second phase, the intake flow would pass through the first half of the screening structure. To reduce the through velocity for the traveling water screens during the second construction phase, installation of the screening equipment for the phase I screening bays would be postponed until after removal of the phase II cofferdams.

Pre-construction activities include detailed engineering design, safety analysis, permitting, and procurement, which are each expected to take 12 to 18 months. By running the pre-construction activities partially in parallel, the overall timeframe for pre-construction activities is estimated to take 30 months total. Additionally, for several tasks it is assumed that multiple crews would work simultaneously to expedite completion. Construction activities are estimated at 42 months for a

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total implementation schedule of 72 months. Note that severe weather conditions have not been considered and could result in schedule delays. The schedule includes the following construction activities:

- Mobilization
  - Construction site set up to include delivery of onsite trailers, construction equipment, and labor
  - Delivery and inspection of pumps and traveling water screens
- General Site Modifications
  - Marking and protecting construction area
  - Rerouting vehicle and pedestrian traffic around construction area
- Construction activities
  - Mechanical dredging and site excavation
  - Clearing and management of spoils pile
  - Placement of phase I cofferdams (sheet piled area for new screening structure)
  - Dewatering and excavating inside of phase I cofferdams (as required)
  - Soil preparation and casting of the phase I concrete mud mat
  - Placement of phase I concrete slab, walls, columns, and safety bypass
  - Installation of phase I normal bypasses
  - Removal of phase I cofferdams
  - Placement of phase II cofferdams
  - Dewatering and excavating inside of phase II cofferdams (as required)
  - Soil preparation and casting of the phase II concrete mud mat
  - Placement of phase II concrete slab, walls, and columns, and safety bypass
  - Installation of phase II dual-flow FMS, trash bars, and stop gate rails
  - Installation of phase II normal bypasses
  - Removal of phase II cofferdams
  - Installation of phase I dual-flow FMS, trash bars, and stop gate rails
  - Installation of electrical building
  - Installation of screen wash piping
  - Metalwork and miscellaneous
  - Installation of FHRS
- Demobilization

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- Clean-up of construction site
- Restoration of construction site

14 Cost Estimate of Fine Mesh Screen

14.1.1 Capital Costs

The capital costs estimated for retrofitting BFN with fine-mesh traveling water screens include costs related to design, procurement, implementation, and startup activities. Estimates for significant and unique components or construction activities included in the design were derived from vendor quotations or past project experience. Estimates for construction labor, materials, and basic equipment for construction were derived from RSMeans for Decatur, Alabama. The cost estimates are located in Appendix C.

The total cost to construct the new screening structure, install the fine-mesh traveling water screens, and construct the FHRS is estimated as $84,300,000 based upon 2018 dollars. Construction estimation tools, vendor quotations, and previous project experience are utilized for this estimate. In several instances multiple crews were assumed in order to complete the project within a reasonable timeframe. Any overtime costs that may be incurred by these additional crews were not considered in this cost estimate.

Table 9 lists the major cost categories for retrofitting BFN with fine-mesh screens along with the respective costs for each category. The budget does not include engineering field support during construction or BFN's staff support of the project. This is a Class 5 estimate per ASTM E2516-11 (Ref. 16.22), which is a high-level estimate intended for use in screening and feasibility determinations.

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Table 9 - Breakdown of Cost by Major Category (Values are Rounded)

Category	Cost (2018 $)[5]
New Screening Structure	18,600,000
Screening and Screen-wash Components	14,300,000
Electrical	1,500,000
Earthwork	3,500,000
Personnel	1,900,000
Adjustments	4,600,000
Contingencies	34,400,000
Construction Total	**78,900,000**
Engineering and Permitting	5,400,000
Grand Total[6]	**84,300,000**

Appendix C shows an itemized cost estimate which includes tabulated subtotals. Sources for each cost estimate are also included within the table. The items that affect the total cost the most for this option are:

- Screening and screen-wash components
- Concrete and Substructure

Given that this is a Class 5 estimate, some information associated with the cost of implementation of a new screening structure for fine-mesh traveling water screens such as field conditions, structural design requirements, material selection, and construction schedule demands have only been preliminarily determined. Certain costs have been estimated with assumptions that are aimed to be accurate but remain uncertain, such as:

[5] All values are rounded to the nearest $100,000

[6] The total cost presented here is the sum of all the unrounded project costs (as presented in Appendix C) rounded to the nearest $100,000. This total may differ from the sum of the category costs presented above due to intermediate rounding difference.

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- Mobilization and equipment transportation costs
- Specialized equipment and materials required
- Labor required for screen installation

Finally, given the preliminary nature of this assessment, there are several items remaining to be investigated during detailed design that may affect the cost. These considerations include the following:

- An assessment of required spares would need to be evaluated during detailed design. Critical spares are not included in the cost estimate but in certain cases may be essential to maintaining reliable plant operation.
- A detailed routing plan for the screen-wash piping and FHRS would be required.
- A hydraulic model study of the new screening structure and existing intake would be required to determine if vortexing would be a potential concern. Based on the results of the hydraulic model study, vortex suppression devices such as flow straighteners may be required.
- Site-specific dredging factors, including methods employable within the forebay.
- Geotechnical considerations related to temporary sheet pile installation and screening structure foundation design.
- The 4.16 kV power source for the three new 500 kVA transformers will be required. The unit boards feeding the water boards do not have sufficient available capacity, so an alternate power source will be determined during detailed design.

14.1.2 O&M Costs

Retrofitting BFN with fine-mesh screens would result in new operation and maintenance costs. These costs would result from the new equipment that would be installed as part of the retrofit.

The estimated number of hours to operate and maintain each piece of equipment is based on previous experience and inspection schedules provided by equipment vendors. The screen-wash pumps maintenance activities include verification that the pump is operating within design conditions, checks for leaks, as well as weekly inspections of the pump lubricant and semi-annual inspections of the pump foundations and coupling alignment. The dual-flow traveling screens maintenance activities would include inspections of the chain mechanisms and removal and repair of various sub-components. The maintenance activities of the existing through-flow traveling screens is assumed to not increase. The maintenance activities associated with the trash rake system and the associated screen-wash system’s valves and pipes are assumed negligible since operation of the trash rake system and changes to the screen-wash system’s valve lineup are expected to occur relatively infrequently.

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Table 10 - Estimated Additional Operation and Maintenance Costs per Year

Component	Man-Hours
Dual-Flow Traveling Water Screens + Pumps	3,600
Trash Rake System	125
TOTAL	3,725

Additionally, periodic dredging of the intake forebay in the vicinity of the safety bypass pipes would be required to assure availability of the UHS under all design basis events. Dredging precautions, such as the use of specialized siltation curtains or reductions in dredging rate, would be used during maintenance dredging to mitigate potential impacts to plant operation. The estimated maintenance dredging cost would be $360,000 based upon 2018 dollars, comprised of $320,000 of implementation costs and $40,000 of engineering and permitting costs. These costs are assumed to occur at a frequency of ten years. The frequency of maintenance dredging may differ based on the findings of a detailed design or operational experience.

The lifespan of the screens is expected to fall between 25 and 40 years, according to the screen vendor. Therefore, a life of 30 years is assumed for this evaluation. Assuming the screens become operational in 2027 (allowing time for the Director's determination of BTA and the implementation schedule), the screens could be expected to last until 2057. The current operating licenses for Units 1, 2, and 3 expire in 2033, 2034, and 2036, respectively. Therefore, the screens would be expected to remain operational for beyond the current licensed period for all three units.

14.1.3 Lost Revenue Due to Reduction in Net Generating Capacity

As described in Section 12.1, the total reduction in net generating capacity would be due to the operation of additional equipment required to support the intake structure. The parasitic losses associated with retrofitting BFN to traveling screens with fine-mesh would result in approximately 6,330 MWh of losses annually.

15 Conclusions for Fine Mesh Screen

The compliance option to retrofit BFN with FMS, while technically feasible, would pose new engineering, construction, permitting, and operational challenges. Procurement and construction of large dual-flow FMS, bypass pipes, new intake structure, screen-wash pumps, screen-wash piping, trash rake system, FHRS, and electrical equipment would be required if FMS were implemented at BFN. Construction would require extensive dredging, concrete forming, metal work, piping placement, equipment installation, and system tie-ins. The implementation of FMS at BFN would impose significant engineering fees, procurement costs, construction costs, power generation losses, and recurrent operation and maintenance costs. Engineering, permitting, procurement, and construction would take over 5 years following the start of the project. Poor viability of impinged eggs and larvae is also a key liability of FMS as discussed in the (r)(11) report. The implementation of FMS at BFN is not considered a prudent or practical measure for

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entrainment reduction due to the challenges, impacts, costs, schedule, and risks identified in this Comprehensive Technical Feasibility and Cost Evaluation Study

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16 References for Fine Mesh Screen

16.1 0-10E201-7, Rev. 5, Location of Principal Plant Structures

16.2 0-31E201, Rev. 2, Concrete General Outline Features

16.3 Browns Ferry Updated Final Safety Analysis Report, Revision 27

16.4 BFN-50-7023, Rev. 28, Design Criteria Document, Residual Heat Removal Service Water System

16.5 BFN-50-7067, Rev. 25, Design Criteria Document, Emergency Equipment Cooling Water System

16.6 BFN DCN 70515, Replace Traveling Water Screens for Units 1, 2, and 3

16.7 1-OI-27, Rev. 54, Operating Instruction, Condenser Circulating Water System

16.8 Envirex, Inc., Fine Screen Evaluation, January 19, 1993

16.9 ASCE, “Design of Water Intake Structure for Fish Protection,” ASCE Task Committee of Fish-Handling Capability of Intake Structures, 1982

16.10 EPRI Document: 1021372, “Evaluation of Factors Affecting Larval Fish Survival in Fish Return Systems at Cooling Water Intakes,” 2010

16.11 2018 International Building Code

16.12 ASCE Standard 7-16, Minimum Design Loads and Associated Criteria for Buildings and Other Structures

16.13 ACI Standard 318-14, Building Code Requirements for Structural Concrete (ACI 318-14)

16.14 ACI 360R-10, Guide to Designs of Slabs-on-Ground

16.15 AISC, Steel Construction Manual, 14th Edition

16.16 ACI Standard 350-06, Code Requirements for Environmental Engineering Concrete Structures and Commentary (ACI 350-06)

16.17 ACI Standard 350.3-06, Seismic Design of Liquid-Containing Concrete Structures and Commentary (ACI 350.3-06)

16.18 Drawing 31N208, Rev. 1 “Concrete Retaining Walls at Pumping Station Outline & Reinforcement

16.19 CED Engineering, “An Introduction to Sound Level Data for Mechanical and Electrical Equipment”, Table 10 and Fig 4, 2013

16.20 ASCE Standard 7-05, Minimum Design Loads for Buildings and Other Structures, 2006

16.21 USGS, Groundwater Wells in Lawrence County, AL: Site# 342718087285601

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16.22 ASTM E2516-11, “Standard Classification for Cost Estimate Classification System, ASTM International, 2011

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17 Compliance and Social Cost Estimates

This section summarizes the social costs and compliance costs associated with the implementation of the candidate technologies at BFN, which were the subject of technical feasibility and cost evaluation studies pursuant to 40 CFR 122.21(r)(10). A detailed description of the inputs, methodology and results of the compliance and social cost estimation is provided in Appendix G.

The social costs evaluated include the capital costs required to procure, construct and install the candidate technologies, the recurring operation and maintenance labor costs involved in operating the new systems, structures and components, and the cost of periodic replacement of new equipment. The development of total social costs is detailed in Sections II through VII of Appendix G.

The compliance costs evaluated include costs which are defined as costs borne by the facility owners. Compliance costs differ from social costs for several reasons: they take into account federal and state income taxes, timing of costs, and a “private” discount rate rather than the social discount rate to discount social costs. The development of compliance costs is detailed in Section VIII of Appendix G.

Table 11 and Table 12 summarize the social and compliance cost estimates for each candidate technology based on information provided in Appendix G, Table 19. All dollar values are in millions of 2018 dollars.

Table 11: Social Costs Discounted by 3% and 7% Discount Rates (Reproduced from Appendix G, Table 19)

Discount Rate	Technology	Social Costs (2018$)
3%	Closed-Cycle Cooling	$398.73M
	Fine-Mesh Screens	$79.00M
7%	Closed-Cycle Cooling	$316.90M
	Fine-Mesh Screens	$68.78M

Table 12: Compliance Costs Discounted by 2.3% Discount Rates (Reproduced from Appendix G, Table 19)

Discount Rate	Technology	Compliance Costs (2018$)
2.3%	Closed-Cycle Cooling	$444.07M
	Fine-Mesh Screens	$87.48M

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Appendix A. Closed-Cycle Cooling Cost Estimate

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	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1	**Category**	**Quantity**	**Reference**	**Line Source**	**SubContracted Ind.**	**Item Description**	**Crew**	**Daily Output**	**Labor Hours**	**Unit**	**Material**	**Labor**	**Equipment**	**Total**	**Ext. Mat.**	**Ext. Labor**	**Ext. Equip.**	**Ext. Total**	**Mat. O&P**	**Labor O&P**	**Equip. O&P**	**Total O&P**	**Ext. Mat. O&P**	**Ext. Labor O&P**	**Ext. Equip. O&P**	**Ext. Total O&P**
2	**Demo Existing Towers**																									
3		5,400,000	RSMeans 024116130700			Demolition of Towers 1, 2, and 4 wood and concrete building, including 20 mi. haul.				CF												0.5				$ 2,700,000
4	**New Cooling Towers**																									
5		2	Project Experience			New towers 1 and 2, 22 cell mechanical draft towers																$ 20,000,000				$ 40,000,000
6		1	Project Experience			New tower 4, 16 cell mechanical draft tower																$ 15,000,000				$ 15,000,000
7		1	Project Experience			Tower 7 refurbishment. Replacing flow distribution system																$ 1,000,000				$ 1,000,000
8	**Tower Basins**																									
9		25000	RSMeans 033053400500			Tower basin concrete, 5000 psi includes forms (4 uses), concrete (Portland cement Type I), placing and finishing	C14C	32.22	3.48	C.Y.	$ 242.97	$ 132.26	$ 0.84	$ 376.07	$ 6,074,250.00	$ 3,306,500.00	$ 21,000.00	$ 9,401,750.00	$ 267.54	$ 199.95	$ 0.92	$ 468	$ 6,688,500	$ 4,998,750	$ 23,000	$ 11,710,250
10		185	RSMeans 032111600250			Tower basin #4 column rebar, in place, columns, A615, grade 60, incl labor for accessories, excl material for accessories	4 Rodm	2.3	13.91	Ton	$ 1,028.08	$ 738.23	$ -	$ 1,766.31	$ 190,194.80	$ 136,572.55	$ -	$ 326,767.35	$ 1,128.38	$ 1,109.75	$ -	$ 2,238	$ 208,750	$ 205,304	$ -	$ 414,054
11		375	RSMeans 032111600600			Tower basin #8 slab rebar, in place, slab on grade, A615, grade 60, incl labor for accessories, excl material for accessories	4 Rodm	2.3	13.91	Ton	$ 1,028.08	$ 738.23	$ -	$ 1,766.31	$ 385,530.00	$ 276,836.25	$ -	$ 662,366.25	$ 1,128.38	$ 1,109.75	$ -	$ 2,238	$ 423,143	$ 416,156	$ -	$ 839,299
12		106	RSMeans 032111600600			Tower basin #8 wall rebar, in place, wall, A615, grade 60, incl labor for accessories, excl material for accessories	4 Rodm	2.3	13.91	Ton	$ 1,028.08	$ 738.23	$ -	$ 1,766.31	$ 108,976.48	$ 78,252.38	$ -	$ 187,228.86	$ 1,128.38	$ 1,109.75	$ -	$ 2,238	$ 119,608	$ 117,634	$ -	$ 237,242
13		3675	RSMeans 032111600250			Tower basin #11 column rebar, in place, columns, A615, grade 60, incl labor for accessories, excl material for accessories	4 Rodm	2.3	13.91	Ton	$ 1,028.08	$ 738.23	$ -	$ 1,766.31	$ 3,778,194.00	$ 2,712,995.25	$ -	$ 6,491,189.25	$ 1,128.38	$ 1,109.75	$ -	$ 2,238	$ 4,146,797	$ 4,078,331	$ -	$ 8,225,128
14	**Lift Pumps**																									
15		4	Project Experience			New lift pumps, 165,000 gpm, 80ft																$ 4,000,000				$ 16,000,000
16		8	Project Experience			New pumps, 137,500 gpm, 80 ft																$ 3,000,000				$ 24,000,000
17		12	RSMeans Extrap 2			Lift pump discharge valve replacements, 72" flow control valves																$ 100,000				$ 1,200,000
18	*Subtotal Direct Construction*										**$ 4,355**	**$ 3,085**	**$ 1**	**$ 7,441**	**$ 10,537,145**	**$ 6,511,156**	**$ 21,000**	**$ 17,069,302**	**$ 4,781**	**$ 4,639**	**$ 1**	**$ 43,109,421**	**$ 11,586,798**	**$ 9,816,175**	**$ 23,000**	**$ 121,325,972**
19																										
20	**Field Personnel**																									
21		156	RSMeans 013113200140			Field personnel, field engineer, engineer, senior		0	0	Week	$ -	$ 1,250.00	$ -	$ 1,250.00	$ -	$ 195,000.00	$ -	$ 195,000.00	$ -	$ 1,850.00	$ -	$ 1,850.00	$ -	$ 288,600.00	$ -	$ 288,600
22		156	RSMeans 013113200160			Field personnel, general purpose laborer, average		0	0	Week	$ -	$ 1,175.00	$ -	$ 1,175.00	$ -	$ 183,300.00	$ -	$ 183,300.00	$ -	$ 1,950.00	$ -	$ 1,950.00	$ -	$ 304,200.00	$ -	$ 304,200
23		156	RSMeans 014523500080			Testing and inspecting, supervision of earthwork	1 Skwk	1	8	Day	$ -	$ 221.03	$ -	$ 221.03	$ -	$ 34,480.68	$ -	$ 34,480.68	$ -	$ 367.20	$ -	$ 367.20	$ -	$ 57,283.20	$ -	$ 57,283
24		156	RSMeans 014523505570			Concrete inspection technician, per day		0	0	Ea.	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 264.12	$ -	$ -	$ -	$ 41,203
25		156	RSMeans 013113200220			Field personnel, project manager, average		0	0	Week	$ -	$ 2,075.00	$ -	$ 2,075.00	$ -	$ 323,700.00	$ -	$ 323,700.00	$ -	$ 3,025.00	$ -	$ 3,025.00	$ -	$ 471,900.00	$ -	$ 471,900
26		156	RSMeans 013113200280			Field personnel, superintendent, average		0	0	Week	$ -	$ 1,925.00	$ -	$ 1,925.00	$ -	$ 300,300.00	$ -	$ 300,300.00	$ -	$ 2,800.00	$ -	$ 2,800.00	$ -	$ 436,800.00	$ -	$ 436,800
27		156	RSMeans 013113200020			Field personnel, clerk, average		0	0	Week	$ -	$ 355.00	$ -	$ 355.00	$ -	$ 55,380.00	$ -	$ 55,380.00	$ -	$ 595.00	$ -	$ 595.00	$ -	$ 92,820.00	$ -	$ 92,820
28		156	RSMeans 013113200290			Field personnel, timekeeper, average		0	0	Week	$ -	$ 980.00	$ -	$ 980.00	$ -	$ 152,880.00	$ -	$ 152,880.00	$ -	$ 1,625.00	$ -	$ 1,625.00	$ -	$ 253,500.00	$ -	$ 253,500
29		520	RSMeans			Crew B-34T (2 pipe fitters, heavy truck and driver, 40 ton trailer, 80 ton crane and operator), truck tractor				Day												$ 5,246.40				$ 2,728,128
30		520	RSMeans			Crew L-1 (1 plumber, 1 electrician)				Day												$ 1,502.40				$ 781,248
31	*Subtotal Field Personnel*										**$ -**	**$ 7,981**	**$ -**	**$ 7,981**	**$ -**	**$ 1,245,041**	**$ -**	**$ 1,245,041**	**$ -**	**$ 12,212**	**$ -**	**$ 12,476**	**$ -**	**$ 1,905,103**	**$ -**	**$ 5,455,682**
32																										
33	**Margin and Fees**																									
34		4%	RSMeans 011131200110			Construction Management																				$ 4,853,039
35		2.5%	RSMeans 013113900100			Performance Bond																				$ 3,033,149
36		1.30%	RSMeans 013113302000			Worker's Comp										$ 16,186										$ 16,186
37		0.62%	RSMeans 013113300250			Insurance																				$ 786,046
38		3.90%	RSMeans 013113400300			Main Office Expense												$ 48,557								$ 48,557
39		0.08%	RSMeans 013213500700			Scheduling and Coordination																				$ 101,425
40		5.08%	RSMeans 012163100020			Sales Tax																				$ 6,440,508
41	*Subtotal Margin and Fees*																									**$ 15,278,910**
42																										
43	**Allowances**																									
44		10%	RSMeans 12155500600			Contractor Inexperience																				$ 12,678,165
45		1%	RSMeans 019113000000			Commissioning, verification, training, turnover																				$ 1,213,260
46		15%	RSMeans 012157500020			Overtime										$ 186,756										$ 186,756
47		20%	RSMeans 012116500020			Conceptual design contingency																				$ 25,356,331
48		30%	Project Experience			Owner-Controlled Area (OCA) adjustment																				$ 38,034,496
49																										
50	*Subtotal Allowances*																									**$ 77,469,008**
51																										
52	**Engineering**																									
53		10.1%	RSMeans 011131301100			Engineering design.																				$ 12,804,947
54		5%	RSMeans 014126000000			Licensing and Permitting. Includes allocation for NRC review.																				$ 6,339,083
55	*Subtotal Engineering*																									**$ 19,144,030**
56																										
57	*Total Capital Cost*																									**$ 239,000,000**

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	B	C	D	G	I	K	P	Q	R	S	T	U	V	W	AA
1	**Category**	**Quantity**	**Reference**	**Item Description**	**Daily Output**	**Unit**	**Ext. Mat.**	**Ext. Labor**	**Ext. Equip.**	**Ext. Total**	**Mat. O&P**	**Labor O&P**	**Equip. O&P**	**Total O&P**	**Ext. Total O&P**
2	**Earthwork**														
3		8889	RSMeans 312316131335	Excavating, trench or continuous footing, common earth, 3-1/2 C.Y. excavator, 14' to 20' deep, excludes sheeting or dewatering	1150	B.C.Y.	$ -	$ 5,422.22	$ 17,066.67	$ 22,488.89	$ -	$ 0.93	$ 2.10	$ 3	$ 26,933
4		4444	RSMeans 312323131400	Backfill, bulk, air tamped compaction, add	80	E.C.Y.	$ -	$ 37,022.22	$ 22,488.89	$ 59,511.11	$ -	$ 12.50	$ 5.55	$ 18	$ 80,222
5															
6	**Tower Blowdown**														
7		1	Instrumart Extrap 6	Blowdown 72" vortex flowmeter										$ 600,000	$ 600,000
8		3	RSMeans Extrap 1	Blowdown 42" flow control valves										$ 100,000	$ 300,000
9		3	RSMeans Extrap 1	Blowdown 42" flow control valve actuators										$ 100,000	$ 300,000
10		1	ENERCON Estimate	Blowdown line refurbishment allotment. Assuming line inspection finds issues										$ 500,000	$ 500,000
11	**Tower Bypass**														
12		16	RSMeans Extrap 2	Bypass tower isolation valves. 72" butterfly valves.										$ 100,000	$ 1,600,000
13		2000	RSMeans 331413253200	Bypass line. Water supply distribution piping, piping polyvinyl chloride, 48" diameter, AWWA C905, PR 100, DR 25, excludes excavation or backfill, unless specified	60	L.F.	$ 379,200.00	$ 35,260.00	$ -	$ 414,460.00	$ 208.56	$ 26.45	$ -	$ 235	$ 470,020
14	**Chemical Injection Heat Treatment**	1	ENERCON Estimate											$ 100,000	$ 100,000
15	**Lift Pump Bearing Cooler Upgrades**	1	ENERCON Estimate											$ 50,000	$ 50,000
16	***Subtotal Direct Construction***						**$ 379,200**	**$ 77,704**	**$ 39,556**	**$ 496,460**	**$ 209**	**$ 40**	**$ 8**	**$ 1,550,256**	**$ 4,027,176**
17															
18	**Field Personnel**														
19		26	RSMeans 013113200140	Field personnel, field engineer, engineer, senior	0	Week	$ -	$ 32,500.00	$ -	$ 32,500.00	$ -	$ 1,850.00	$ -	$ 1,850.00	$ 48,100
20		26	RSMeans 013113200160	Field personnel, general purpose laborer, average	0	Week	$ -	$ 30,550.00	$ -	$ 30,550.00	$ -	$ 1,950.00	$ -	$ 1,950.00	$ 50,700
21		26	RSMeans 014523500080	Testing and inspecting, supervision of earthwork	1	Day	$ -	$ 5,746.78	$ -	$ 5,746.78	$ -	$ 367.20	$ -	$ 367.20	$ 9,547
22		26	RSMeans 014523505570	Concrete inspection technician, per day	0	Ea.	$ -	$ -	$ -	$ 6,202.56	$ -	$ -	$ -	$ 264.12	$ 6,867
23		26	RSMeans 013113200220	Field personnel, project manager, average	0	Week	$ -	$ 53,950.00	$ -	$ 53,950.00	$ -	$ 3,025.00	$ -	$ 3,025.00	$ 78,650
24		26	RSMeans 013113200280	Field personnel, superintendent, average	0	Week	$ -	$ 50,050.00	$ -	$ 50,050.00	$ -	$ 2,800.00	$ -	$ 2,800.00	$ 72,800
25		26	RSMeans 013113200020	Field personnel, clerk, average	0	Week	$ -	$ 9,230.00	$ -	$ 9,230.00	$ -	$ 595.00	$ -	$ 595.00	$ 15,470
26		26	RSMeans 013113200290	Field personnel, timekeeper, average	0	Week	$ -	$ 25,480.00	$ -	$ 25,480.00	$ -	$ 1,625.00	$ -	$ 1,625.00	$ 42,250
27		52	RSMeans	Crew B-34Q (pipefitter, 25 ton crane and operator, truck and driver, 25 ton trailer, and dump truck)		Day								$ 3,318.09	$ 172,541
28	***Subtotal Field Personnel***						**$ -**	**$ 207,507**	**$ -**	**$ 213,709**	**$ -**	**$ 12,212**	**$ -**	**$ 15,794**	**$ 496,925**
29															
30	**Margin and Fees**														
31		4%	RSMeans 011131200110	Construction Management											$ 161,087
32		2.5%	RSMeans 013113900100	Performance Bond											$ 100,679
33		1.30%	RSMeans 013113302000	Worker's Comp				$ 3,708							$ 3,708
34		0.62%	RSMeans 013113300250	Insurance											$ 28,049
35		3.90%	RSMeans 013113400300	Main Office Expense						$ 27,697					$ 27,697
36		0.08%	RSMeans 013213500700	Scheduling and Coordination											$ 3,619
37		5.08%	RSMeans 012163100020	Sales Tax											$ 229,824
38	***Subtotal Margin and Fees***														**$ 554,664**
39															
40	**Allowances**														
41		10%	RSMeans 12155500600	Contractor Inexperience											$ 452,410
42		1%	RSMeans 019113000000	Commissioning, verification, training, turnover											$ 40,272
43		15%	RSMeans 012157500020	Overtime				$ 11,656							$ 11,656
44		20%	RSMeans 012116500020	Conceptual design contingency											$ 904,820
45		30%	Project Experience	Owner-Controlled Area (OCA) adjustment											$ 1,357,230
46	***Subtotal Allowances***														**$ 2,766,388**
47															
48	**Engineering**														
49		10.1%	RSMeans 011131301100	Engineering design.											$ 456,934
50		5%	RSMeans 014126000000	Licensing and Permitting. Includes allocation for NRC review.											$ 226,205
51	***Subtotal Engineering***														**$ 683,139**
52															
53	***Total Capital Cost***														**$ 9,000,000**

ADEM Watermark

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	AA
1	**Category**	**Quantity**	**Reference**	**Line Source**	**SubContracted Ind.**	**Item Description**	**Crew**	**Daily Output**	**Labor Hours**	**Unit**	**Material**	**Labor**	**Equipment**	**Total**	**Ext. Mat.**	**Ext. Labor**	**Ext. Equip.**	**Ext. Total**	**Mat. O&P**	**Labor O&P**	**Equip. O&P**	**Total O&P**	**Ext. Total O&P**
2																							
3	**New Gate 2 Structure**																						
4	*Construction*																						
5		1	RSMeans			Mobilization and de-mobilization costs				Ea.												$ 50,000	$ 50,000
6		5200	RSMeans			Mechanical clamshell dredging, clamshell excavation into scows, dumped on shore, maximum				BCY												$ 19	$ 97,084
7		6435	RSMeans 312323154080			Borrow pile, common earth, 5 C.Y. bucket, loading and/or spreading, front end loader, wheel-mounted	B10U	2600	0.01	B.C.Y.	$ 13.29	$ 0.20	$ 0.39	$ 13.88	$ 85,521.15	$ 1,287.00	$ 2,509.65	$ 89,317.80	$ 14.62	$ 0.31	$ 0.42	$ 15	$ 98,777
8		579	RSMeans 312323209014			Cycle hauling (wait, load, travel, unload or dump & return, excavated or borrow, 15 min load/wait/unload, 18 C.Y. 8 wheel truck, cycle 0.5 mile, 15 MPH, excludes loading equipment	B34I	504	0.02	L.C.Y.	$ -	$ 0.67	$ 1.43	$ 2.10	$ -	$ 388.03	$ 828.18	$ 1,216.22	$ -	$ 1.00	$ 1.57	$ 3	$ 1,488
9	*Cofferdam Sheet Piling*																						
10		30000	RSMeans 314116101900			Temporary sheet piling. Sheet piling, 50,000 psi steel, not incl. wales, extract & salvage				SF												$ 29	$ 856,800
11		100	RSMeans 314116102500			Wales, connections & struts, 2/3 salvage				Ton												$ 494	$ 49,433
12		10	RSMeans 312319201100			Dewatering system, attended 2 hrs./day, two 6" centrifugal pumps, incl. 20 LF suction hose & 100 LF discharge hose each				Day												$ 1,147	$ 11,468
13	*Concrete Dam Structure*																						
14		1742	RSMeans			Aggregate, sand & stone, loaded at pit, crushed bank gravel, 67% of concrete volume, incl. trucking 30-mile round trip				CY												$ 37	$ 63,635
15		2600	RSMeans			Concrete, volumetric site-mixed, includes Type I Portland cement and water, 4500 min psi, 5 CY volumetric truck				CY												$ 150	$ 390,000
16		1400	RSMeans			Placing concrete, includes labor and equipment to place, level (strike off) and consolidate, foundation mats, pumped				CY												$ 8	$ 11,690
17		1200	RSMeans			Placing concrete, includes labor and equipment to place, level (strike off) and consolidate, walls, pumped				CY												$ 28	$ 33,396
18		108	RSMeans			Epoxy-coated reinforcing in place, slab on grade, #8 to #18				Ton												$ 2,741	$ 295,133
19		92	RSMeans			Epoxy-coated reinforcing in place, slab on grade, #8 to #18				Ton												$ 2,724	$ 251,424
20		4100	RSMeans			Concrete forms in place, mat foundation, 4 use, includes erecting, bracing, stripping, and cleaning				SFCA												$ 7	$ 29,971
21		4300	RSMeans			Concrete forms in place, walls, 4 use, includes erecting, bracing, stripping, and cleaning				SFCA												$ 8	$ 34,099
22		500	RSMeans			2 line pipe rail with pickets and attached handrail, aluminum, 1-1/2" pipe, 1/2" pickets @ 4-1/2" OC, 42" high				LF												$ 408	$ 204,010
23	*Earthen Dam Walls*																						$ -
24		3700	RSMeans 353116196000			Earthen dam fill material				CY												$ 42	$ 153,550
25		500	RSMeans 353116190260			Permanent sheet piling. Steel sheeting 12' high, with 4' x 4' x 8" concrete deadmen, at 10' on center, barge driven				LF						$ 4.04						$ 773	$ 386,685
26		750	RSMeans			Existing embankment repair. Riprap, machine placed for slope protection, 18" minimum, not grouted				SY						$ 120.00	$ 350.00	$ 42,000.00				$ 90	$ 67,193
27	**Hydraulic Gates**															$ 157.00	$ 350.00	$ 54,950.00					
28		3	Project Experience			Includes purchase and installation of hydraulic gates on Gate structure 2.											$ 5.20					$ 1,500,000	$ 4,500,000
29	**Demolish Old Gate 2**																						
30		20000	RSMeans 024119161050			Partial demolition of old Gate 2 structure				CF												$ 50	$ 1,008,200
31		741	RSMeans 024119180400			Selective demolition, disposal only, urban buildings with salvage value allowed, masonry construction, includes loading and 5 mile haul to dump	B3	445.00	0.11	C.Y.	$ -	$ 3.28	$ 5.38	$ 8.66	$ -	$ 2,429.63	$ 3,985.19	$ 6,414.81	$ -	$ 5.42	$ 5.90	$ 11	$ 8,385
32		247	RSMeans 024119200300			Selective demolition, dump charges, typical urban city, rubbish only, includes tipping fees only		0.00	0	Ton	$ 63.00	$ -	$ -	$ 63.00	$ 15,555.56	$ -	$ -	$ 15,555.56	$ 69.50	$ -	$ -	$ 70	$ 17,160
33	**CWC/WWC Spillways**																						
34		11111	RSMeans 312316430400			Excavation to bring site to final grade, 8 C.Y. bucket, loader, 100% fill factor, unrestricted operation	B14J	4800	0	L.C.Y.	$ -	$ 0.12	$ 0.38	$ 0.50	$ -	$ 1,333.33	$ 4,222.22	$ 5,555.56	$ -	$ 0.17	$ 0.42	$ 1	$ 6,556
35		11111	RSMeans 312323145420			Backfill to bring site to final grade, structural, common earth, 300 HP dozer, 300' haul, from existing stockpile, excludes compaction	B10M	1350	0.01	L.C.Y.	$ -	$ 0.40	$ 1.38	$ 1.78	$ -	$ 4,444.44	$ 15,333.33	$ 19,777.78	$ -	$ 0.60	$ 1.52	$ 2	$ 23,556
36		11111	RSMeans			Aggregate, sand & stone, loaded at pit, crushed bank gravel, 67% of concrete volume, incl. trucking 30-mile round trip				CY												$ 37	$ 405,889
37		11111	RSMeans 313713100200			Riprap, machine placed for slope protection, 18" minimum, not grouted				SY												$ 90	$ 995,444
38	**Spillway Bridges**																						
39		11200	RSMeans 323413101000			Fabricated pedestrian bridges, steel, trussed or arch spans, complete in place, 8' wide, 160' span, includes erection, excludes foundations	E2	255	0.22	S.F.	$ 252.81	$ 9.53	$ 6.78	$ 269.12	$ 2,831,472.00	$ 106,736.00	$ 75,936.00	$ 3,014,144.00	$ 277.61	$ 14.76	$ 7.44	$ 299.81	$ 3,357,872
40	**Forebay Dredging**																						
41		1	RSMeans 352423130100			Mechanical dredging, mobilization and demobilization, add to below, maximum	B8	0.1	560	Total	$ -	$ 13,618.30	$ 30,067.20	$ 43,685.50	$ -	$ 13,618.30	$ 30,067.20	$ 43,685.50	$ -	$ 22,459.50	$ 33,094.80	$ 55,554.30	$ 55,554
42		6000	RSMeans 352423130600			Mechanical dredging, pumped 1,000' to shore dump, all pumping uses 2,000 gallons of water per cubic yard, barge mounted dragline or clamshell, hopper dumped, maximum	B57	310	0.17	B.C.Y.	$ -	$ 3.78	$ 7.83	$ 11.61	$ -	$ 22,680.00	$ 46,980.00	$ 69,660.00	$ -	$ 6.27	$ 8.67	$ 11.07	$ 66,420
43		6000	RSMeans 024119180400			Selective demolition, disposal only, urban buildings with salvage value allowed, masonry construction, includes loading and 5 mile haul to dump	B3	445	0.11	C.Y.	$ -	$ 3.28	$ 5.38	$ 8.66	$ -	$ 19,680.00	$ 32,280.00	$ 51,960.00	$ -	$ 5.42	$ 5.90	$ 11.32	$ 67,920
44																							
45	*Subtotal Direct Construction*										**$ 329**	**$ 13,640**	**$ 30,096**	**$ 44,065**	**$ 2,932,549**	**$ 172,878**	**$ 212,847**	**$ 3,414,237**	**$ 362**	**$ 22,493**	**$ 33,127**	**$ 1,614,858**	**$ 13,598,793**
46																							
47	**Field Personnel**																						
48		26	RSMeans 013113200140			Field personnel, field engineer, engineer, senior		0	0	Week	$ -	$ 1,250.00	$ -	$ 1,250.00	$ -	$ 32,500.00	$ -	$ 32,500.00	$ -	$ 1,850.00	$ -	$ 1,850.00	$ 48,100
49		26	RSMeans 013113200160			Field personnel, general purpose laborer, average		0	0	Week	$ -	$ 1,175.00	$ -	$ 1,175.00	$ -	$ 30,550.00	$ -	$ 30,550.00	$ -	$ 1,950.00	$ -	$ 1,950.00	$ 50,700
50		26	RSMeans 014523500080			Testing and inspecting, supervision of earthwork	1 Skwk	1	8	Day	$ -	$ 221.03	$ -	$ 221.03	$ -	$ 5,746.78	$ -	$ 5,746.78	$ -	$ 367.20	$ -	$ 367.20	$ 9,547
51		26	RSMeans 014523505570			Concrete inspection technician, per day		0	0	Ea.	$ -	$ -	$ -	$ 238.56	$ -	$ -	$ -	$ 6,202.56	$ -	$ -	$ -	$ 264.12	$ 6,867
52		26	RSMeans 013113200220			Field personnel, project manager, average		0	0	Week	$ -	$ 2,075.00	$ -	$ 2,075.00	$ -	$ 53,950.00	$ -	$ 53,950.00	$ -	$ 3,025.00	$ -	$ 3,025.00	$ 78,650
53		26	RSMeans 013113200280			Field personnel, superintendent, average		0	0	Week	$ -	$ 1,925.00	$ -	$ 1,925.00	$ -	$ 50,050.00	$ -	$ 50,050.00	$ -	$ 2,800.00	$ -	$ 2,800.00	$ 72,800
54		26	RSMeans 013113200020			Field personnel, clerk, average		0	0	Week	$ -	$ 355.00	$ -	$ 355.00	$ -	$ 9,230.00	$ -	$ 9,230.00	$ -	$ 595.00	$ -	$ 595.00	$ 15,470
55		26	RSMeans 013113200290			Field personnel, timekeeper, average		0	0	Week	$ -	$ 980.00	$ -	$ 980.00	$ -	$ 25,480.00	$ -	$ 25,480.00	$ -	$ 1,625.00	$ -	$ 1,625.00	$ 42,250
56		130	RSMeans			Crew A-3J (40 ton crane and operator)														$ 2,107.20		$ 2,107.20	$ 273,936
57	*Subtotal Field Personnel*										**$ -**	**$ 7,981**	**$ -**	**$ 8,220**	**$ -**	**$ 207,507**	**$ -**	**$ 213,709**	**$ -**	**$ 14,319**	**$ -**	**$ 12,476**	**$ 598,320**
58																							
59	**Margin and Fees**																						
60		4%	RSMeans 011131200110			Construction Management																	$ 543,952
61		2.5%	RSMeans 013113900100			Performance Bond																	$ 339,970
62		1.30%	RSMeans 013113302000			Worker's Comp										$ 4,945							$ 4,945
63		0.62%	RSMeans 013113300250			Insurance																	$ 88,022
64		3.90%	RSMeans 013113400300			Main Office Expense												$ 141,490					$ 141,490
65		0.08%	RSMeans 013213500700			Scheduling and Coordination																	$ 11,358
66		5.08%	RSMeans 012163100020			Sales Tax																	$ 721,213
67	*Subtotal Margin and Fees*																						**$ 1,850,950**
68																							
69	**Allowances**																						
70		10%	RSMeans 12155500600			Contractor Inexperience																	$ 1,419,711
71		1%	RSMeans 019113000000			Commissioning, verification, training, turnover																	$ 135,988
72		15%	RSMeans 012157500020			Overtime										$ 25,932							$ 25,932
73		20%	RSMeans 012116500020			Conceptual design contingency																	$ 2,839,423
74		175%	Project Experience			Nuclear Safety-Related adjustment																	$ 24,844,948
75	*Subtotal Allowances*																						**$ 29,266,002**
76																							
77	**Engineering**																						
78		10.1%	RSMeans 011131301100			Engineering design.																	$ 1,433,908
79		10.1%	RSMeans 011131301100			Safety analysis.																	$ 1,433,908
80		5%	RSMeans 014126000000			Licensing and Permitting. Includes allocation for NRC review.																	$ 709,856
81	*Subtotal Engineering*																						**$ 3,577,673**
82																							
83	*Total Capital Cost*																						**$ 49,000,000**

ADEM Watermark

	B	C	D	G	I	K	L	M	N	O	P	Q	R	S	T	U	V	W	AA
1	**Category**	**Quantity**	**Reference**	**Item Description**	**Daily Output**	**Unit**	**Material**	**Labor**	**Equipment**	**Total**	**Ext. Mat.**	**Ext. Labor**	**Ext. Equip.**	**Ext. Total**	**Mat. O&P**	**Labor O&P**	**Equip. O&P**	**Total O&P**	**Ext. Total O&P**
2																			
3	**WBN U2 DCS**	1	ENERCON Project Experience	FW system, 250 I/O pts														$ 2,000,000	$ 2,000,000
4																			
5	**Engineering**																		
6		15.0%	RSMeans 011131301100	Engineering design, RSMeans value rounded up															
7	***Subtotal Engineering***																		
8																			
9	***Total Capital Cost***																		
10	BFN			Total Project Cost															$ 13,000,000

ADEM Watermark

	B	C	D	G	H	I	K	P	Q	R	S	T	U	V	W	AA
1	**Category**	**Quantity**	**Reference**	**Item Description**	**Crew**	**Daily Output**	**Unit**	**Ext. Mat.**	**Ext. Labor**	**Ext. Equip.**	**Ext. Total**	**Mat. O&P**	**Labor O&P**	**Equip. O&P**	**Total O&P**	**Ext. Total O&P**
2																
3	**Vacuum Priming/Breaking System**															
4		4	RSMeans Extrap 5	Vacuump pump, 21.5" Hg, 115 CFM			Ea.								$ 400,000	$ 1,600,000
5		4		2" relief valve, 22.5" Hg vacuum			Ea.								$ 2,000	$ 8,000
6		4		2" check valve			Ea.								$ 1,000	$ 4,000
7		32		2" valve			Ea.								$ 500	$ 16,000
8		2		level gage			Ea.									$ -
9		2		pressure indicator			Ea.									$ -
10		8		1/2" pressure sensor			Ea.									$ -
11		2		level sensor			Ea.								$ 50,000	$ 100,000
12		1000		2" pipe			ft									$ -
13		4		Drainer (tank)											$ 10,000	$ 40,000
14		2	ENERCON Estimate	Vacuum skid, including two pumps (21.5" Hg, 115 CFM), 600 gal vacuum tank, two relief valves (22.5" Hg vacuum), valves, piping, instrumentation	L1										$ 1,000,000	$ 2,000,000
15		38	RSMeans 221113487834	2.5" valves (primer side)	Q1	38	Ea.	$ 34,580.00	$ 601.54	$ -	$ 35,181.54	$ 1,000.00	$ 23.58	$ -	$ 1,024	$ 38,896
16		10	RSMeans 221113487874	2.5" check valves (primer side)	Q1	38	Ea.	$ 3,750.00	$ 158.30	$ -	$ 3,908.30	$ 415.00	$ 23.58	$ -	$ 439	$ 4,386
17		6	RSMeans Extrap 3	12" valves (breaker side)											$ 10,033	$ 60,198
18		6	RSMeans Extrap 3	12" valve actuators (breaker side)											$ 10,033	$ 60,198
19		1000	RSMeans 221113440620	2.5" piping allotment											$ 35	$ 35,000
20		50	RSMeans	2.5" fitting allotment											$ 500	$ 25,000
21		6	ENERCON Estimate	MCR controls for vacuum breaker and primer											$ 250,000	$ 1,500,000
22	*Subtotal Direct Construction*							**$ 34,580**	**$ 602**	**$ -**	**$ 35,182**	**$ 1,000**	**$ 24**	**$ -**	**$ 1,001,024**	**$ 3,723,678**
23																
24	**Field Personnel**															
25		9	RSMeans 013113200140	Field personnel, field engineer, engineer, senior		0	Week	$ -	$ 11,250.00	$ -	$ 11,250.00	$ -	$ 1,850.00	$ -	$ 1,850.00	$ 16,650
26		9	RSMeans 013113200160	Field personnel, general purpose laborer, average		0	Week	$ -	$ 10,575.00	$ -	$ 10,575.00	$ -	$ 1,950.00	$ -	$ 1,950.00	$ 17,550
27		9	RSMeans 014523500080	Testing and inspecting, supervision of earthwork	1 Skwk	1	Day	$ -	$ 1,989.27	$ -	$ 1,989.27	$ -	$ 367.20	$ -	$ 367.20	$ 3,305
28		9	RSMeans 014523505570	Concrete inspection technician, per day		0	Ea.	$ -	$ -	$ -	$ 2,147.04	$ -	$ -	$ -	$ 264.12	$ 2,377
29		9	RSMeans 013113200220	Field personnel, project manager, average		0	Week	$ -	$ 18,675.00	$ -	$ 18,675.00	$ -	$ 3,025.00	$ -	$ 3,025.00	$ 27,225
30		9	RSMeans 013113200280	Field personnel, superintendent, average		0	Week	$ -	$ 17,325.00	$ -	$ 17,325.00	$ -	$ 2,800.00	$ -	$ 2,800.00	$ 25,200
31		9	RSMeans 013113200020	Field personnel, clerk, average		0	Week	$ -	$ 3,195.00	$ -	$ 3,195.00	$ -	$ 595.00	$ -	$ 595.00	$ 5,355
32		9	RSMeans 013113200290	Field personnel, timekeeper, average		0	Week	$ -	$ 8,820.00	$ -	$ 8,820.00	$ -	$ 1,625.00	$ -	$ 1,625.00	$ 14,625
33	*Subtotal Field Personnel*							**$ -**	**$ 71,829**	**$ -**	**$ 73,976**	**$ -**	**$ 12,212**	**$ -**	**$ 12,476**	**$ 112,287**
34																
35	**Margin and Fees**															
36		4%	RSMeans 011131200110	Construction Management												$ 148,947
37		2.5%	RSMeans 013113900100	Performance Bond												$ 93,092
38		1.30%	RSMeans 013113302000	Worker's Comp					$ 942							$ 942
39		0.62%	RSMeans 013113300250	Insurance												$ 23,783
40		3.90%	RSMeans 013113400300	Main Office Expense							$ 4,257					$ 4,257
41		0.08%	RSMeans 013213500700	Scheduling and Coordination												$ 3,069
42		5.08%	RSMeans 012163100020	Sales Tax												$ 194,867
43	*Subtotal Margin and Fees*															**$ 468,957**
44																
45	**Allowances**															
46		10%	RSMeans 12155500600	Contractor Inexperience												$ 383,596
47		1%	RSMeans 019113000000	Commissioning, verification, training, turnover												$ 37,237
48		15%	RSMeans 012157500020	Overtime					$ 90							$ 90
49		20%	RSMeans 012116500020	Conceptual design contingency												$ 767,193
50		200%	ENERCON Estimate	Underground / confined space work												$ 224,621
51		175%	Project Experience	Nuclear Safety-Related adjustment												$ 6,712,938
52	*Subtotal Allowances*															**$ 8,125,676**
53																
54	**Engineering**															
55		10.1%	RSMeans 011131301100	Engineering design.												$ 387,432
56		10.1%	RSMeans 011131301100	Safety analysis.												$ 387,432
57		5%	RSMeans 014126000000	Licensing and Permitting. Includes allocation for NRC review.												$ 191,798
58	*Subtotal Engineering*															**$ 966,663**
59																
60	*Total Capital Cost*															**$ 13,000,000**

ADEM Watermark

	B	C	D	G	H	I	K	P	Q	R	S	T	U	V	W	AA
1	**Category**	**Quantity**	**Reference**	**Item Description**	**Crew**	**lly Out**	**Unit**	**Ext. Mat.**	**Ext. Labor**	**Ext. Equip.**	**Ext. Total**	**Mat. O&P**	**Labor O&P**	**Equip. O&P**	**Total O&P**	**Ext. Total O&P**
2	**Lift Pump Trips**															
3		0.32	ENERCON Estimate	RTD Mounts / temperature wells											$ 1,109,348	$ 358,405
4		7	ENERCON Estimate	Sun Cover											$ 100,000	$ 700,000
5		7	ENERCON Estimate	Temperature Indicating Controller Panel			EA								$ 75,000	$ 525,000
6		1400	RSMeans 260533131800	1 inch RGS Conduit for RTDs (200' per panel)(7 Circuits)	1 Elec	65	L.F.	$ 10,192.00	$ 6,748.00	$ -	$ 16,940.00	$ 8.03	$ 7.18	$ -	$ 15	$ 21,294
7		42	RSMeans 271513138506	6 PR # 18 Awg shielded cable for RTDs 200 ft each 7 circuits 3 RTDs each	1 Elec	4	C.L.F.	$ 13,891.50	$ 3,295.74	$ -	$ 17,187.24	$ 363.83	$ 116.75	$ -	$ 481	$ 20,184
8		3500	RSMeans 260533131870	2 inch RGS conduit for power (500 ft. per circuit) 7 circuits	1 Elec	45	L.F.	$ 32,410.00	$ 24,325.00	$ -	$ 56,735.00	$ 10.21	$ 10.37	$ -	$ 21	$ 72,030
9		70	RSMeans 260519200500	1-3/C # 2 cable for 120 Volt power 500 ft. each 7 required 2 ckts each	2 Elec	4.6	C.L.F.	$ 53,581.50	$ 9,512.30	$ -	$ 63,093.80	$ 841.05	$ 204.16	$ -	$ 1,045	$ 73,165
10		10500	RSMeans 260533131870	2 inch RGS conduit for lift pump interlocks 7 required, 1500 ft. avg. length ea.	1 Elec	45	L.F.	$ 97,230.00	$ 72,975.00	$ -	$ 170,205.00	$ 10.21	$ 10.37	$ -	$ 21	$ 216,090
11		140	RSMeans 260523202632	12/C # 10 AWG Cable. 7 required 2000 ft avg. length.	2 Elec	7.2	C.L.F.	$ 36,383.20	$ 12,147.80	$ -	$ 48,531.00	$ 288.23	$ 129.51	$ -	$ 418	$ 58,484
12		100	RSMeans 260519352200	Wire Lugs # 2	1 Elec	24	Ea.	$ 263.00	$ 1,308.00	$ -	$ 1,571.00	$ 2.89	$ 19.46	$ -	$ 22	$ 2,235
13		100	RSMeans 260519351640	Wire lugs # 10	1 Elec	45	Ea.	$ 95.00	$ 695.00	$ -	$ 790.00	$ 1.04	$ 10.37	$ -	$ 11	$ 1,141
14		200	RSMeans 260519351620	Wire lugs # 14	1 Elec	60	Ea.	$ 112.00	$ 1,046.00	$ -	$ 1,158.00	$ 0.61	$ 7.78	$ -	$ 8	$ 1,678
15		200	RSMeans 260519350015	Cable terminations #22 to #14	1 Elec	260	Ea.	$ 12.00	$ 242.00	$ -	$ 254.00	$ 0.07	$ 1.79	$ -	$ 2	$ 372
16		100	RSMeans 260519350045	Cable terminations #12 to # 6	1 Elec	180	Ea.	$ 44.00	$ 174.00	$ -	$ 218.00	$ 0.49	$ 2.59	$ -	$ 3	$ 308
17		2	RSMeans 260526800600	Grounding Cable bare #2 Copper	2 Elec	10	C.L.F.	$ 168.22	$ 125.04	$ -	$ 293.26	$ 92.14	$ 93.15	$ -	$ 185	$ 371
18		14	ENERCON Estimate	Switchgear Wiring Average Costs ($10,000/Swgr)(70 hours per switchgear)	1 Elec								$ 6,394.50	$ 10,000	$ 16,394.50	$ 229,523
19		1	ENERCON Estimate	Gate 2 control												$ 174,553
20	***Subtotal Direct Construction***							**$ 244,382**	**$ 132,594**	**$ -**	**$ 376,976**	**$ 1,619**	**$ 7,008**	**$ 10,000**	**$ 1,302,975**	**$ 2,454,833**
21																
22	**Field Personnel**															
23		26	RSMeans 013113200140	Field personnel, field engineer, engineer, senior		0	Week	$ -	$ 32,500.00	$ -	$ 32,500.00	$ -	$ 1,850.00	$ -	$ 1,850.00	$ 48,100
24		26	RSMeans 013113200160	Field personnel, general purpose laborer, average		0	Week	$ -	$ 30,550.00	$ -	$ 30,550.00	$ -	$ 1,950.00	$ -	$ 1,950.00	$ 50,700
25		130	RSMeans 014523500080	Testing and inspecting, supervision of earthwork	1 Skwk	1	Day	$ -	$ 28,733.90	$ -	$ 28,733.90	$ -	$ 367.20	$ -	$ 367.20	$ 47,736
26		130	RSMeans 014523505570	Concrete inspection technician, per day		0	Ea.	$ -	$ -	$ -	$ 31,012.80	$ -	$ -	$ -	$ 264.12	$ 34,336
27		26	RSMeans 013113200220	Field personnel, project manager, average		0	Week	$ -	$ 53,950.00	$ -	$ 53,950.00	$ -	$ 3,025.00	$ -	$ 3,025.00	$ 78,650
28		26	RSMeans 013113200280	Field personnel, superintendent, average		0	Week	$ -	$ 50,050.00	$ -	$ 50,050.00	$ -	$ 2,800.00	$ -	$ 2,800.00	$ 72,800
29		26	RSMeans 013113200020	Field personnel, clerk, average		0	Week	$ -	$ 9,230.00	$ -	$ 9,230.00	$ -	$ 595.00	$ -	$ 595.00	$ 15,470
30		26	RSMeans 013113200290	Field personnel, timekeeper, average		0	Week	$ -	$ 25,480.00	$ -	$ 25,480.00	$ -	$ 1,625.00	$ -	$ 1,625.00	$ 42,250
31		130	RSMeans	Crew B-11K (8 ft trencher and operator, laborer)			Day						$ 3,244.00		$ 3,244.00	$ 421,720
32	***Subtotal Field Personnel***							**$ -**	**$ 230,494**	**$ -**	**$ 261,507**	**$ -**	**$ 15,456**	**$ -**	**$ 15,720**	**$ 811,762**
33																
34	**Margin and Fees**															
35		4%	RSMeans 011131200110	Construction Management												$ 98,193
36		2.5%	RSMeans 013113900100	Performance Bond												$ 61,371
37		1.30%	RSMeans 013113302000	Worker's Comp					$ 4,720							$ 4,720
38		0.62%	RSMeans 013113300250	Insurance												$ 20,253
39		3.90%	RSMeans 013113400300	Main Office Expense							$ 24,901					$ 24,901
40		0.08%	RSMeans 013213500700	Scheduling and Coordination												$ 2,613
41		5.08%	RSMeans 012163100020	Sales Tax				$ 12,415								$ 12,415
42	***Subtotal Margin and Fees***															**$ 224,466**
43																
44	**Allowances**															
45		10%	RSMeans 12155500600	Contractor Inexperience												$ 326,659
46		1%	RSMeans 019113000000	Commissioning, verification, training, turnover												$ 24,548
47		15%	RSMeans 012157500020	Overtime					$ 19,889							$ 19,889
48		20%	RSMeans 012116500020	Conceptual design contingency												$ 653,319
49		175%	Project Experience	Nuclear Safety-Related adjustment												$ 5,716,540
50	***Subtotal Allowances***															**$ 6,740,955**
51																
52	**Engineering**															
53		10.1%	RSMeans 011131301100	Engineering design. Rate quartered for vendor-supplied items												$ 329,926
54		10.1%	RSMeans 011131301100	Safety analysis. Percentage applied to safe shutdown items												$ 329,926
55		5%	RSMeans 014126000000	Licensing and Permitting. Includes allocation for NRC review.												$ 163,330
56	***Subtotal Engineering***															**$ 823,182**
57																
58	***Total Capital Cost***															**$ 11,000,000**

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Appendix B. Closed-Cycle Cooling Construction Schedule

ADEM Watermark

| | | Year 1 | | | | | | | | | | | | Year 2 | | | | | | | | | | | | Year 3 | | | | | | | | | | | | Year 4 | | | | | | | | | | | | Year 5 | | | | | | | | | | | | Year 6 | | | | | | | | | | | | Year 7 | | | | | | | | | | | | Year 8 | | | | | | | | | | | |
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Appendix C. Fine Mesh Screens Project Cost Estimate

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Item	Description	Quantity	Unit	Unit Price	Cost	Reference
Earthwork						
Barge rental	Marine equipment rental;barge,400 ton,30'wide x 90'long, Incl. Hourly Oper. Cost.	10	Month	$ 15,259	$ 152,592	RSMeans 015433800200 STD Year 2018 Decatur, AL
Barge mobilization / demobilization	Mobilization, barge by tug boat, small	150	Mile	$ 73	$ 10,970	RSMeans 310660151500 STD Year 2018 Decatur, AL
Dredging mobilization / demobilization	Mechanical dredging, mobilization and demobilization, add to below, maximum	1	Total	$ 64,966	$ 64,966	RSMeans 352423130100 STD Year 2018 Decatur, AL
Dragline rental	Rent bucket, dragline, medium duty, 3 CY, Incl. Hourly Oper. Cost.	12	Month	$ 1,057	$ 12,687	RSMeans 015433201070 STD Year 2018 Decatur, AL
Dump truck rental	Rent truck dump 3 axle 16 ton, 12 C.Y. payload, 400 H.P., Incl. Hourly Oper. Cost.	12	Month	$ 11,261	$ 135,134	RSMeans 015433205300 STD Year 2018 Decatur, AL
Bulldozer rental	Rent dozer, crawler, torque converter, diesel 200 HP, Incl. Hourly Oper. Cost.	12	Month	$ 24,764	$ 297,164	RSMeans 015433204260 STD Year 2018 Decatur, AL
Grader attachment rental	Rent grader/dozer attachment, ripper/scarifier, rear mounted, up to 135 H.P, Incl. Hourly Oper. Cost.	12	Month	$ 1,216	$ 14,597	RSMeans 015433500520 STD Year 2018 Decatur, AL
Excavation	Excavating, bulk bank measure, in sheeting or cofferdam, clamshell, maximum	12000	B.C.Y.	$ 44	$ 531,960	RSMeans 312316424450 STD Year 2018 Decatur, AL
Dewatering	Dewatering, pumping 8 hours, attended 2 hours per day, 6" centrifugal pump, includes 20 LF of suction hose and 100 LF of discharge hose, add for additional pump	30	Day	$ 375	$ 11,250	RSMeans 312319201120 STD Year 2018 Decatur, AL
Earthwork supervision	Testing and inspecting, supervision of earthwork	50	Day	$ 456	$ 22,816	RSMeans 014523500080 STD Year 2018 Decatur, AL
Earthwork quality control	Testing and inspecting, quality control of earthwork	50	Day	$ 346	$ 17,291	RSMeans 014523500082 STD Year 2018 Decatur, AL
Dredging	Mechanical dredging, pumped 1,000' to shore dump, all pumping uses 2,000 gallons of water per cubic yard, barge mounted dragline or clamshell, hopper dumped, maximum	40000	B.C.Y.	$ 19	$ 742,000	RSMeans 352423130600 STD Year 2018 Decatur, AL
Dredge spoils hauling	Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 30 min load/wait/unload, 12 C.Y. truck, cycle 1 miles, 50 MPH, excludes loading equipment	40000	L.C.Y.	$ 1	$ 30,160	RSMeans 312323201714 STD Year 2018 Decatur, AL
Spoils pile clearing and grubbing	Clearing & grubbing, cut & chip light trees, to 6" diameter	10	Acre	$ 4,780	$ 47,803	RSMeans 311110100020 STD Year 2018 Decatur, AL
Spoils pile clearing	Clearing & grubbing, grub stumps and remove	10	Acre	$ 1,957	$ 19,571	RSMeans 311110100150 STD Year 2018 Decatur, AL
Spoils pile seeding and grading	Seeding, mechanical seeding, fine grading and seeding, with equipment, includes lime, fertilizer & seed	50000	S.Y.	$ 4	$ 183,500	RSMeans 329219130310 STD Year 2018 Decatur, AL
Dredging performance and inspection	Diver, underwater construction specialist	120	Day	$ 10,000	$ 1,200,000	Project Experience
New Screening Structure						
Tower crane	Crane crew, tower crane, static, 130' high, 106' jib, 6200 lb. capacity, monthly use, excludes concrete footing	30	Month	$ 40,482	$ 1,214,463	RSMeans 015419600100 STD Year 2018 Decatur, AL
Piledriver rental	Rent piledriving hammer steam/air 24450 ft lbs @111 bpm, Incl. Hourly Oper. Cost.	24	Month	$ 12,522	$ 300,538	RSMeans 015433202200 STD Year 2018 Decatur, AL
Piledriving leads rental	Rent leads, 90' high for pile driving hammers over 20,000 ft lbs, Incl. Hourly Oper. Cost.	24	Month	$ 2,505	$ 60,131	RSMeans 015433202300 STD Year 2018 Decatur, AL
Cofferdams	Cofferdams, barge driven, includes mobilization, temporary sheeting	105000	S.F.	$ 38	$ 3,957,450	RSMeans 315216100060 STD Year 2018 Decatur, AL
Barrier netting	Dyneema fiber netting with 3/8" mesh	105000	0	$ 10	$ 1,050,000	Pacific Netting Products
Construction equipment mobilization / demobilizatio	Mobilization or demobilization, delivery charge for equipment, hauled on 20-ton capacity towed trailer	4	Ea.	$ 660	$ 2,641	RSMeans 015436501400 STD Year 2018 Decatur, AL
Concrete truck rental	Rent pump concrete truck mounted 5" line 110' boom, Incl. Hourly Oper. Cost.	18	Month	$ 20,850	$ 375,305	RSMeans 015433102140 STD Year 2018 Decatur, AL
Structural backfill	Structural concrete, ready mix, flowable fill, structural, 1000 psi, includes ash, Portland cement Type I, aggregate, sand and water, delivered, excludes all additives and treatments	3200	C.Y.	$ 96	$ 308,736	RSMeans 033113354350 STD Year 2018 Decatur, AL
Concrete forms - slab	C.I.P. concrete forms, slab on grade, edge, wood, over 12", 4 use, includes erecting, bracing, stripping and cleaning	798	SFCA	$ 5	$ 4,118	RSMeans 031113653060 STD Year 2018 Decatur, AL
Concrete reinforcement - slab	Reinforcing steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	231	Ton	$ 1,731	$ 399,873	RSMeans 032111600600 STD Year 2018 Decatur, AL
Concrete placement - slab	Structural concrete, placing, foundation mat, with crane and bucket, over 20 C.Y., includes leveling (strike off) & consolidation, excludes material	3216	C.Y.	$ 15	$ 47,404	RSMeans 033113703000 STD Year 2018 Decatur, AL
Concrete curing	Curing, burlap, 7.5 oz., 4 uses assumed	479	C.S.F.	$ 28	$ 13,498	RSMeans 033913500015 STD Year 2018 Decatur, AL
Concrete material	Structural concrete, ready mix, heavyweight, high early, 6000 psi, includes local aggregate, sand, Portland cement (Type III) and water, delivered, excludes all additives and treatments	19531	C.Y.	$ 167	$ 3,258,357	RSMeans 033113350561 STD Year 2018 Decatur, AL
Reinforcement bar epoxy coating	Epoxy coating, for reinforcing steel, add to plain steel rebar pricing for epoxy-coated rebar	1949	Ton	$ 773	$ 1,507,181	RSMeans 032116100100 STD Year 2018 Decatur, AL
Concrete winter additive	Structural concrete, ready mix, winter mix (hot water), add	19531	C.Y.	$ 6	$ 115,819	RSMeans 033113351300 STD Year 2018 Decatur, AL
Concrete fire retarder additive	Structural concrete, ready mix, for retarder, add	19531	C.Y.	$ 4	$ 69,726	RSMeans 033113351430 STD Year 2018 Decatur, AL
Scaffolding construction / deconstruction	Scaffolding, steel tubular, regular, labor only to erect & dismantle, building exterior, wall face, 6'-4" x 5' frames, 1 to 5 stories, excludes planks	279	C.S.F.	$ 165	$ 46,152	RSMeans 015423700090 STD Year 2018 Decatur, AL
Concrete forms - walls (including retaining walls)	C.I.P. concrete forms, retaining wall, battered, job built plywood, over 8' to 16' high, 4 use, includes erecting, bracing, stripping and cleaning	46304	SFCA	$ 8	$ 360,708	RSMeans 031113855050 STD Year 2018 Decatur, AL
Scaffolding materials	Scaffolding, steel tubular, regular, frame, rent/mo, 7'-6" high x 6' wide	1886	Ea.	$ 10	$ 19,464	RSMeans 015423702250 STD Year 2018 Decatur, AL
Scaffolding planks	Scaffolding, steel tubular, regular, accessory, plank, rent/mo, 2" x 10" x 16' long	3536	Ea.	$ 10	$ 36,492	RSMeans 015423702850 STD Year 2018 Decatur, AL
Concrete reinforcement - walls (including retaining	Reinforcing steel, in place, walls, #8 to #18, A615, grade 60, incl labor for accessories, excl material for accessories	1487	Ton	$ 1,400	$ 2,082,291	RSMeans 032111600750 STD Year 2018 Decatur, AL
Concrete placement - walls (including retaining wal	Structural concrete, placing, walls, with crane and bucket, 15" thick, includes leveling (strike off) & consolidation, excludes material	13099	C.Y.	$ 93	$ 1,222,137	RSMeans 033113705400 STD Year 2018 Decatur, AL
Concrete forms - top deck	C.I.P. concrete forms, elevated slab, flat slab with drop panels, 20' to 35' high ceilings, 4 use, includes shoring, erecting, bracing, stripping and cleaning	6226	S.F.	$ 8	$ 50,742	RSMeans 031113352350 STD Year 2018 Decatur, AL
Concrete reinforcement - top deck	Reinforcing steel, in place, elevated slabs, #4 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	231	Ton	$ 1,573	$ 363,266	RSMeans 032111600400 STD Year 2018 Decatur, AL
Concrete placement - top deck	Structural concrete, placing, elevated slab, with crane and bucket, over 10" thick, includes leveling (strike off) & consolidation, excludes material	3216	C.Y.	$ 34	$ 109,505	RSMeans 033113701650 STD Year 2018 Decatur, AL
Structural testing	Field testing, for concrete building, costing $1,000,000, maximum	10	Project	$ 35,614	$ 356,136	RSMeans 014523500020 STD Year 2018 Decatur, AL
Underwater inspection - screening equipment insta	Diver, underwater construction specialist	80	Day	$ 10,000	$ 800,000	Project Experience
Security allotment	Fencing, cameras, security stations and communications	1	Ea.	$ 500,000	$ 500,000	Project Experience

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Item	Description	Quantity	Unit	Unit Price	Cost	Reference
Screening and Screenwash						
Screening equipment and controls	22 Dual-flow fine mesh traveling water screens, including bar racks, trash rakes, controls, debris baskets, and front and rear stop gates for two bays. Also including WTR supervisor to oversee installation effort	1	66 days	$ -	$ 10,531,000	WTR Quote
Screen installation	Traveling water screen installation. 1 foreman, 5 laborers, 1 crane operator, 1 oiler operator, 1 crawler crane (50 ton), 1 barge (400 ton)	1	108 days	$ -	$ 667,497	WTR Quote
Screen installation	Traveling water screen installation. 1 plumber, 1 plumber apprentice, 1 welder (300 amp)	1	24 days	$ -	$ 33,905	WTR Quote
Screen installation	Traveling water screen installation. 1 electrician, 2 electrician apprentices, includes testing	1	48 days	$ -	$ 86,861	WTR Quote
Debris wash pump	Debris wash pump. Pump, turbine pump, cast iron, 1,000 GPM, 50 H.P., 8" discharge	6	Ea.	$ 13,550.00	$ 81,300	WTR Quote
Fish wash pump	Fish wash pump. Pump, turbine pump, cast iron, 2,000 GPM, 100 H.P., 10" discharge	6	Ea.	$ 15,981.00	$ 95,886	WTR Quote
Spray system header	Pipe, steel, black, welded, 10" diameter, schedule 40, Spec. A-53, includes yoke & roll hanger assembly, sized for covering, 10' OC	670	L.F.	$ 157.08	$ 105,244	WTR Quote
Spray system header	Pipe, steel, black, welded, 12" diameter, schedule 40, Spec. A-53, includes yoke & roll hanger assembly, sized for covering, 10' OC	490	L.F.	$ 191.17	$ 93,673	WTR Quote
Spray system fittings	Pipe, fittings & valves, elbow, 45 Deg. or 90 Deg., steel, painted, grooved joint, 10" diameter, add 1 coupling (material only) per joint for installed price, incl joint coupling labor, excl joint coupling material	88	Ea.	$ 946.56	$ 83,297	WTR Quote
Spray system fittings	Pipe, fittings & valves, tee, steel, painted, grooved joint, 10" diameter, add 1 coupling (material only) per joint for installed price, incl joint coupling labor, excl joint coupling material	56	Ea.	$ 1,165.50	$ 65,268	WTR Quote
Spray system fittings	Pipe, fittings & valves, strainer, steel, painted, tee type, grooved joint, 12" pipe size, add 1 coupling (material only) per joint for installed price, incl joint coupling labor, excl joint coupling material	12	Ea.	$ 4,688.60	$ 56,263	WTR Quote
Spray system pressure reducers	Spray wash pressure-reducing valves. Valves, bronze, reducing, water pressure, high capacity, iron body, flanged, 250 psi to 25-75 psi, 4"	44	Ea.	$ 8,110.71	$ 356,871	WTR Quote
Spray system isolation valves	Spray wash isolation valves, steel, cast, silent check, globe type, flanged, 150 lb., 12"	44	Ea.	$ 8,411.30	$ 370,097	WTR Quote
FHRS piping	Pipe, plastic, fiberglass, filament wound, general service, 24" diameter, includes couplings 10' OC, and hangers 3 per 10'. Includes structural supports and tie-in to existing FHRS discharge piping.	330	L.F.	$ 328.56	$ 208,425	WTR Quote
Safety bypass piping	Pipe, steel, black, welded, 96" diameter, schedule 40, Spec. A-53, includes two rod, roll hanger & saddle, sized for covering, 10' OC	60	L.F.	$ 1,540.58	$ 92,435	WTR Quote
Normal bypass piping	Pipe, steel, black, welded, 48" diameter, schedule 40, Spec. A-53, includes two rod, roll hanger & saddle, sized for covering, 10' OC	330	L.F.	$ 781.22	$ 257,803	WTR Quote
Normal bypass valves	Valves, steel, cast, gate, flanged, 150 lb., 48"	22	Ea.	$ 51,505.90	$ 1,133,130	WTR Quote
Electrical						
Feeder cables	Feeder cables 2-7.5hp trash rake feeders 1-3/C#10	10	C.L.F.	$ 401	$ 4,007	RSMeans 260519200300 STD Year 2018 Decatur, AL
Power cables	Power cables 22-5 hp fish recovery and return dual flow band screens 1-3/C #10	120	C.L.F.	$ 401	$ 48,086	RSMeans 260519200300 STD Year 2018 Decatur, AL
Power cables	Power cables 6-60 hp screen wash pumps 1-3/C #1/0	30	C.L.F.	$ 1,381	$ 41,427	RSMeans 260519200600 STD Year 2018 Decatur, AL
Power cables	Power cables 6-125 hp FHRS pumps 1-3/C #2/	30	C.L.F.	$ 1,632	$ 48,965	RSMeans 260519200650 STD Year 2018 Decatur, AL
Power cables	Power cables #500 MCM	250	C.L.F.	$ 1,008	$ 251,930	RSMeans 260526801240 STD Year 2018 Decatur, AL
Lighting wire	Lighting wire 3/C # 12 Awg.	25	C.L.F.	$ 196	$ 4,905	RSMeans 260519209050 STD Year 2018 Decatur, AL
Cable termination	Control cable terminations #16 to #10	1000	Ea.	$ 10	$ 9,520	RSMeans 260519350050 STD Year 2018 Decatur, AL
Cable termination	Power cable termination 1/0 to 2/0	100	Ea.	$ 30	$ 3,033	RSMeans 260519350200 STD Year 2018 Decatur, AL
Control cables	Misc Control Cables 12/C#12 Awg. total 20	50	C.L.F.	$ 351	$ 17,565	RSMeans 260523202604 STD Year 2018 Decatur, AL
Grounding	Grounding rods 3/4 inch 10ft long	20	Ea.	$ 148	$ 2,959	RSMeans 260526800100 STD Year 2018 Decatur, AL
Grounding	Grounding Cable bare #500 MCM Copper	10	C.L.F.	$ 1,008	$ 10,077	RSMeans 260526801240 STD Year 2018 Decatur, AL
Lightning protection	Stranded copper lightning protection cables #500 MCM	25	C.L.F.	$ 1,008	$ 25,193	RSMeans 260526801240 STD Year 2018 Decatur, AL
Grounding	Grounding Connections Exothermic	25	Ea.	$ 333	$ 8,337	RSMeans 260526802530 STD Year 2018 Decatur, AL
Lightning protection	Lightning protection exothermic connections	25	Ea.	$ 333	$ 8,337	RSMeans 260526802530 STD Year 2018 Decatur, AL
Conduit	Conduit 1 inch RSG conduit for lighting and Misc.	2500	L.F.	$ 14	$ 35,150	RSMeans 260533131800 STD Year 2018 Decatur, AL
Cable tray	30 inch cable tray 90 sections 9 inch rung spacing	20	Ea.	$ 747	$ 14,950	RSMeans 260536101930 STD Year 2018 Decatur, AL
Lighting controls	Lighting controls	2	Ea.	$ 505	$ 1,009	RSMeans 262913100100 STD Year 2018 Decatur, AL
Control station	Control station for FHRS and screen wash pumps (20)	20	Ea.	$ 626	$ 12,518	RSMeans 262913200500 STD Year 2018 Decatur, AL
Lighting protection	Lightning protection Air terminals	20	Ea.	$ 80	$ 1,609	RSMeans 264113130400 STD Year 2018 Decatur, AL
Lighting poles	Lighting poles 10 ft., Aluminum	12	Ea.	$ 969	$ 11,632	RSMeans 265613102850 STD Year 2018 Decatur, AL
Lighting fixtures	Intake lighting fixture, LED, 144 LEDS, 120 VAC or 12 VDC, 120 watt	12	Ea.	$ 1,044	$ 12,523	RSMeans 265619550120 STD Year 2018 Decatur, AL
Concrete reinforcement - slab	Reinforcing steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	10	Ton	$ 1,731	$ 17,311	RSMeans 032111600600 STD Year 2018 Decatur, AL
Concrete placement - slab	Structural concrete, placing, foundation mat, with crane and bucket, over 20 C.Y., includes leveling (strike off) & consolidation, excludes material	160	C.Y.	$ 15	$ 2,358	RSMeans 033113703000 STD Year 2018 Decatur, AL
Concrete material	Structural concrete, ready mix, heavyweight, high early, 6000 psi, includes local aggregate, sand, Portland cement (Type III) and water, delivered, excludes all additives and treatments	200	C.Y.	$ 167	$ 33,366	RSMeans 033113350561 STD Year 2018 Decatur, AL
Electrical substation buildings	500 kVA, 4.16 kV/480-volt three-phase dry type transformer and 480 V/208-120-volt AC dry type transformers	3	Ea.	$ 294,000	$ 882,000	Project Experience
Subtotal Direct Construction					**$ 37,954,310**	

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Item	Description	Quantity	Unit	Unit Price	Cost	Reference
Clerk	Field personnel, clerk, average	156	Week	$ 740	$ 115,440	RSMeans 013113200020 STD Year 2018 Decatur, AL
Field engineer	Field personnel, field engineer, engineer, average	156	Week	$ 2,300	$ 358,800	RSMeans 013113200120 STD Year 2018 Decatur, AL
Project manager	Field personnel, project manager, average	156	Week	$ 3,750	$ 585,000	RSMeans 013113200200 STD Year 2018 Decatur, AL
Superintendent	Field personnel, superintendent, average	156	Week	$ 3,500	$ 546,000	RSMeans 013113200260 STD Year 2018 Decatur, AL
Timekeeper	Field personnel, timekeeper, average	156	Week	$ 2,025	$ 315,900	RSMeans 013113200290 STD Year 2018 Decatur, AL
Subtotal Field Personnel					**$ 1,921,140**	
Construction management	Construction management fees, $50,000,000 maximum	4.00%	Project		$ 1,595,018	RSMeans 011131200350 STD Year 2018 Decatur, AL
Scheduling and coordination	Scheduling, rule of thumb, CPM scheduling, large job ($50 million+)	0.03%	Job		$ 11,963	RSMeans 013213500650 STD Year 2018 Decatur, AL
Main office expense	Main office expense, average for General Contractors as a percentage of annual volume, annual volume over $10,000,000	3.90%	% Vol.		$ 711,297	RSMeans 013113400300 STD Year 2018 Decatur, AL
Insurance	Insurance, all-risk, maximum	0.62%	Job		$ 247,228	RSMeans 013113300250 STD Year 2018 Decatur, AL
Worker's comp	Workers' compensation & employer's liability, range of 35 trades in 11 states, excl. wrecking, average	11.53%	Payroll		$ 770,277	RSMeans 013113302100 STD Year 2018 Decatur, AL
Performance bond	Performance Bond, for buildings, maximum	2.50%	Job		$ 996,886	RSMeans 013113900100 STD Year 2018 Decatur, AL
Sales tax	Taxes, state, maximum	7.50%	%		$ 312,471	RSMeans 012163100050 STD Year 2018 Decatur, AL
Subtotal Adjustments					**$ 4,645,140**	
Conceptual design contingency	Contingencies, at conceptual design stage	20.00%	Project		$ 7,590,862	RSMeans 012116500020 STD Year 2018 Decatur, AL
Nuclear allowance	Non-safety Nuclear Adjustment	30.00%	Project		$ 9,054,000	Project Experience
Nuclear safety-related allowance	Adjustment for seismic class I structure	175.00%	Project		$ 13,605,040	Project Experience
Contractor inexperience	General contractor management, inexperienced, add, modifications to total project cost summaries	10.00%	Project		$ 3,795,431	RSMeans 012155500600 STD Year 2018 Decatur, AL
Commisioning, verification, training, turnover	Systems design assistance, operation, verification, testing and training	1.00%	Job		$ 379,543	RSMeans 017413200040 STD Year 2018 Decatur, AL
Subtotal Contingencies					**$ 34,424,877**	
Engineering	Engineering design	10.10%	Contrct		$ 3,833,385	RSMeans 011131301100 STD Year 2018 Decatur, AL
Safety Analysis	Safety analysis	2.00%	Contrct		$ 759,086	RSMeans 011131301100 STD Year 2018 Decatur, AL
Permitting	Permits rule of thumb, most cities, maximum	2.00%	Job		$ 759,086	RSMeans 014126500100 STD Year 2018 Decatur, AL
Subtotal Engineering					**$ 5,351,558**	

Grand Total **$ 84,300,000**

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Appendix D. Fine Mesh Screens Project Schedule

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		Year 1												Year 2												Year 3												Year 4												Year 5												Year 6											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
Pre-Construction																																																																																						
	Detailed engineering design and safety analysis																																																																																							
	Permitting																																																																																							
	Procurement																																																																																							
Construction																																																																																								
	Mobilization																																																																																							
	Excavation and dredging																																																																																						
	Sheet piling and dewatering, bays 1-11																																																																																						
	Screening structure construction, bays 1-11																																																																																						
	Sheet piling removal																																																																																						
	Sheet piling and dewatering, bays 12-22																																																																																						
	Screening structure construction, bays 12-22																																																																																						
	Screen installation, bays 12-22																																																																																					
	Sheet piling removal																																																																																					
	Screen installation, bays 1-11																																																																																				
	Install controller and connect power																																																																																				
	Install FHRS																																																																																				
	Testing, commissioning, and cleanup																																																																																				

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Appendix E. Fine Mesh Screens Conceptual Drawings

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WEST ACCESS CONTROL PORTAL BLDG
153.6'
157.0'
TRANSFORMER YARD
TURBINE BLDG
HYDROGEN TRAILER PORT
CAS BLDG
UARD OUSE
SERVICE BLDG
OFFICE BLDG
℄ CNDS WTR STOR TANKS
RADWASTE
HPCI ROOM
DIESEL GEN BLDG
STAND-BY GAS TREATMENT BUILDING
REACTOR BLDG
DIESEL GEN BLDG
HPCI ROOM
VENT VAULT (3 TYP)
OFF GAS TRMT BLDG
RADWASTE EVAP BLDG
CAD TANK
HPCI ROOM
℄ PMPS
INTAKE PUMP STA
UPPER DEPLOYMENT PAD
EXISTING INTAKE CHANNEL
LOWER DEPLOYMENT PAD
ECOLOCHEM BLDG
NEW SUBSTATION 40' x 50'
℄ STACK
GATE STR 1B
EQUIPMENT ACCESS LOCK
CAD TANK
GATE STR 1A
GATE STR 1
INTAKE CHANNEL EXPANSION
RETAINING WALL (TYP.)
NEW FISH TROUGH
NEW SCREENING STRUCTURE 334' x 65'
FLOW
EXISTING FISH TROUGH
℄ COOL WATER CHANNEL
DIESEL HPFP HOUSE
℄ GATE STRUCTURE NO.2
TOP OF DIKE
℄ GATE STR NO.3
FLOW
TENNESSEE RIVER-WHEELER LAKE
℄ UNIT 1 & N-S BASELINE N 38°-00'-00" E

COMPANION DWGS:
0-10E201-01,-02
10E201-03 THRU -06
0-10K300-3

NOT FOR CONSTRUCTION

REV	DESCRIPTION	DRN	CHK	REV	APP	DATE
0	INITIAL ISSUE					

ENERCON
KENNESAW, GA 30144

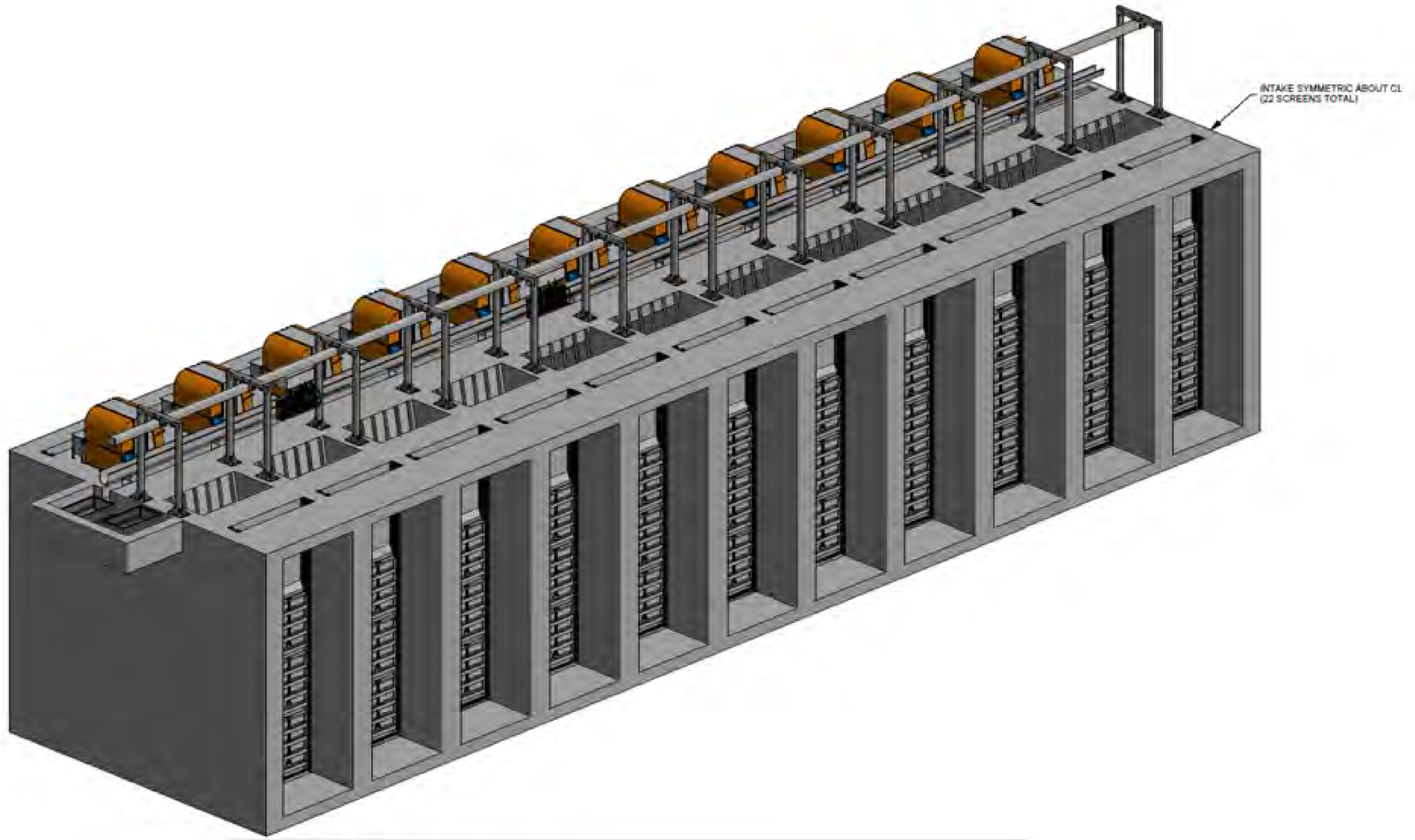
TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT

OVERVIEW OF FINE MESH SCREEN MODIFICATIONS

SIZE	DWG NO.	REV
D	TVACRP00001-M-001	0
SCALE	NONE	SHEET 1 of 1

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ISOMETRIC VIEW
(12 BAYS SHOWN)

NOTES:

1. 12 SCREENS SHOWN. INTAKE SYMMETRIC ABOUT THE CL (24 SCREENS TOTAL).

WTR® WATER SCREENING SOLUTIONS

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TITLE **P21-462 ENERCON - NUCLEAR PLANT**
RAW WATER INTAKE
FISH RECOVERY & RETURN DUAL FLOW SCREENS

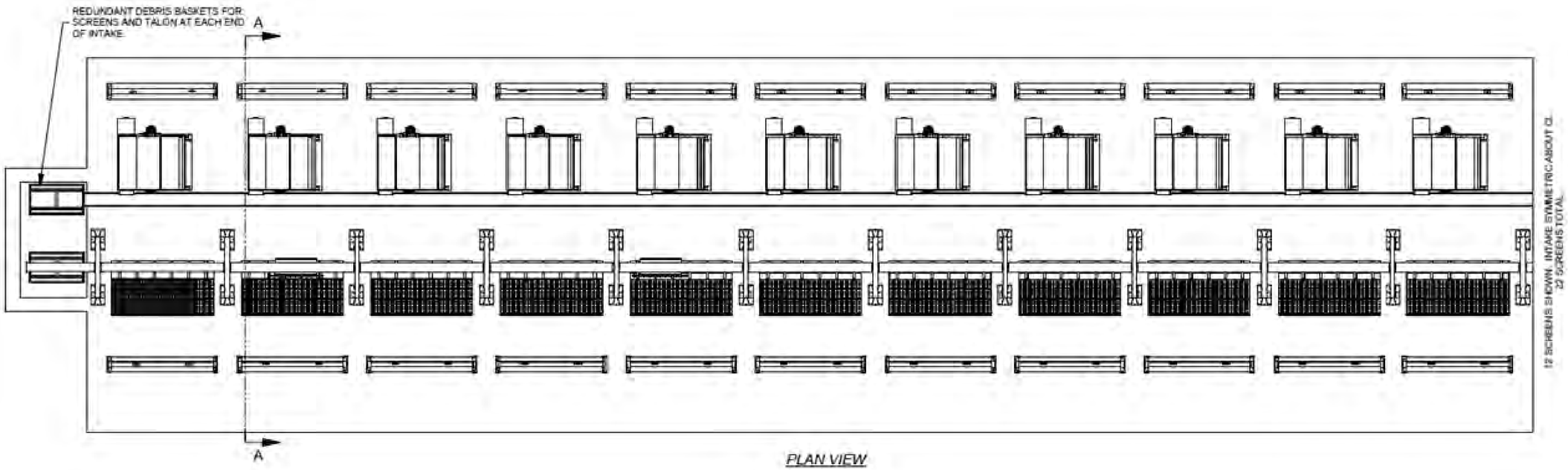
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ABA	WAR		3/9/2021

DOCUMENT NUMBER	SHEET	REV
P21-462 GA	1 OF 8	**A**

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PLAN VIEW

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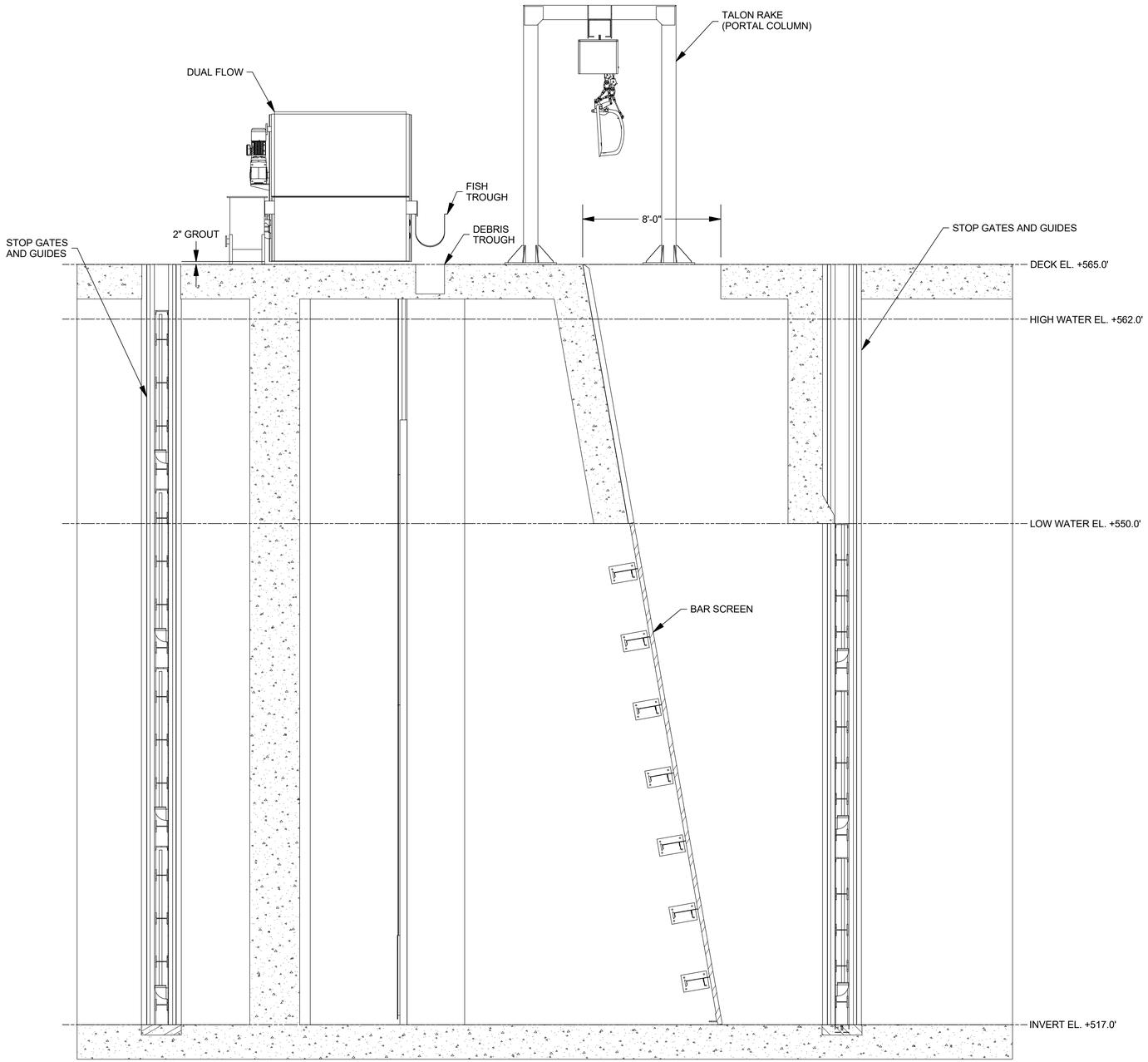
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SECTION A-A

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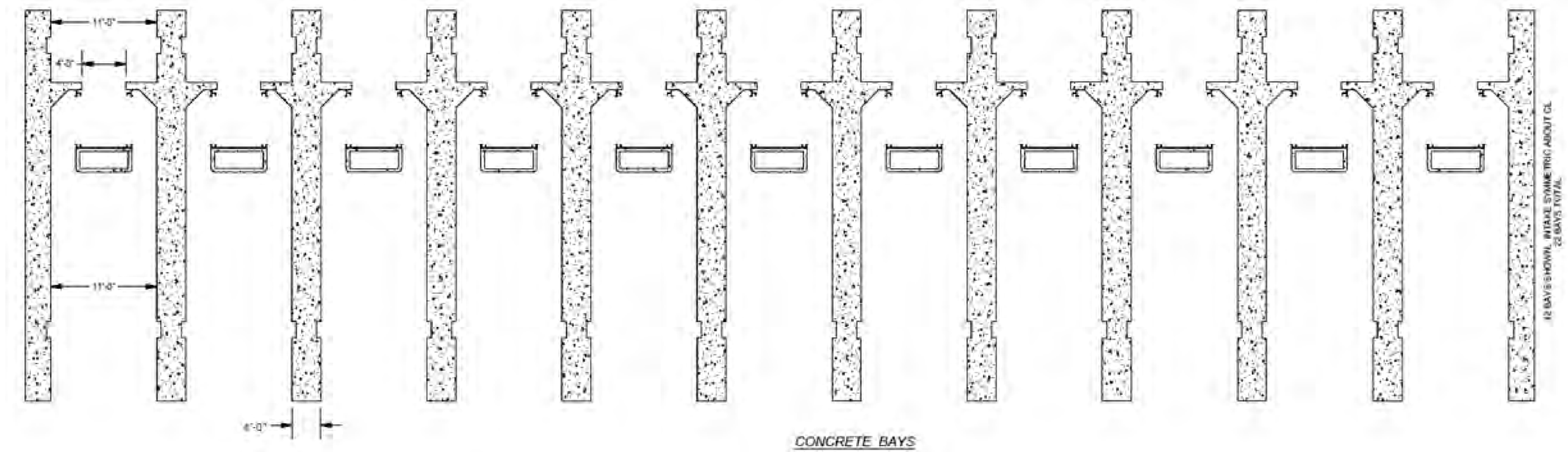
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CONCRETE BAYS

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TITLE **P21-462 ENERCON - NUCLEAR PLANT**
RAW WATER INTAKE
FISH RECOVERY & RETURN DUAL FLOW SCREENS

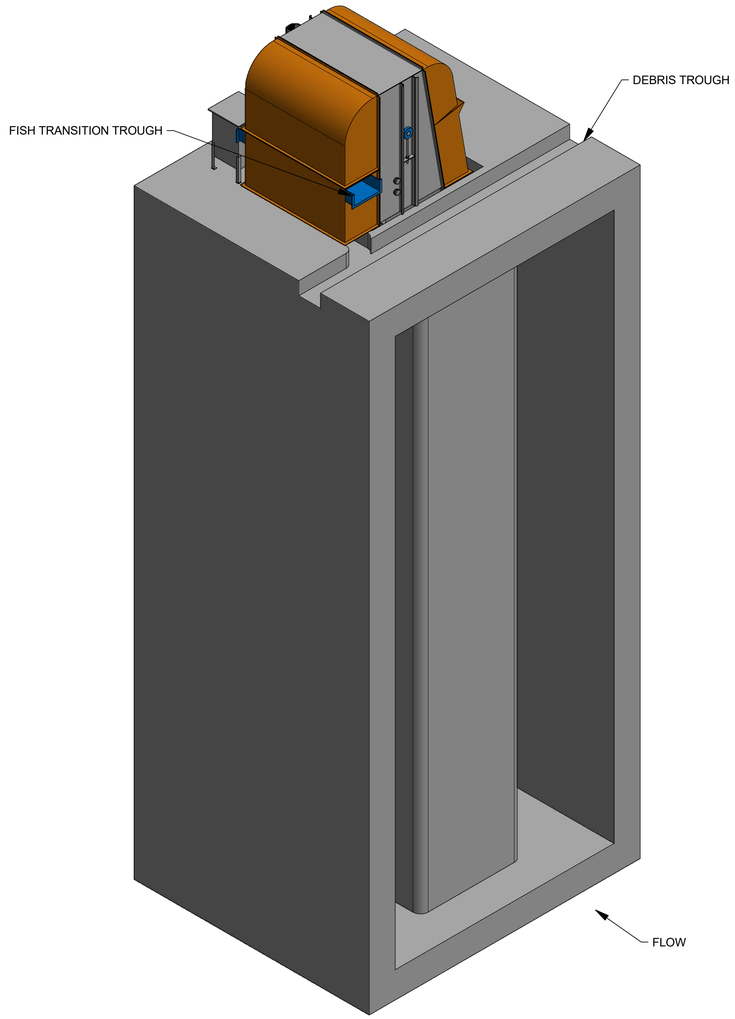
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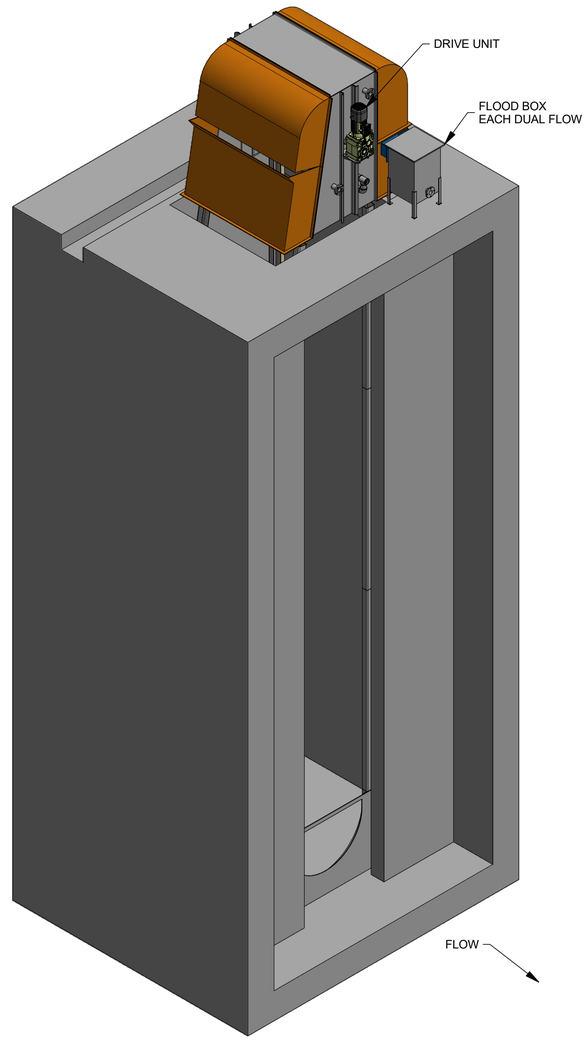
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ISOMETRIC FRONT
(DUAL FLOW)



ISOMETRIC BACK
(DUAL FLOW)

REV	REVISION DESCRIPTION	ECN	DESIGNER	APPROVER	DATE
A	INITIAL RELEASE	///	///	///	2017-11-01

REFERENCE DOCUMENTS

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FISH RECOVERY & RETURN DUAL FLOW SCREENS

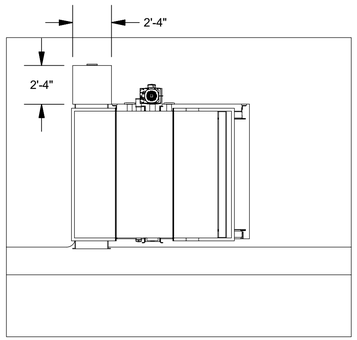
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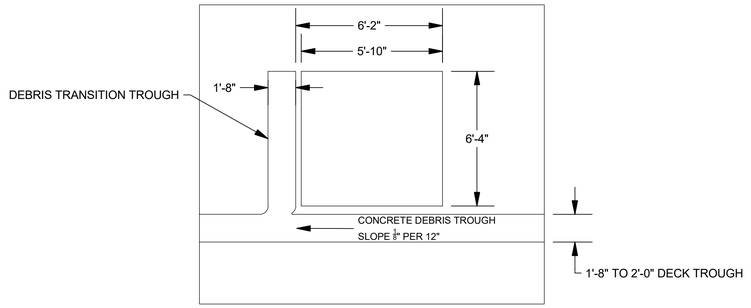
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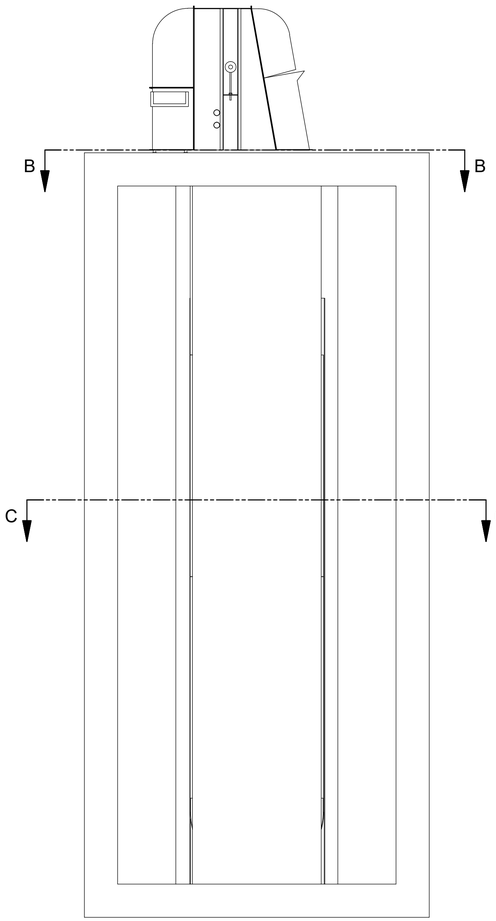
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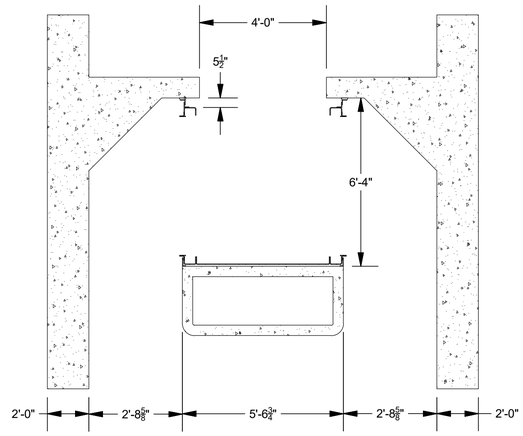
TOP VIEW



SECTION B-B
INTAKE OPENING
(DUAL FLOW REMOVED FOR CLARITY)



FRONT VIEW



SECTION C-C

WATER SCREENING SOLUTIONS

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RAW WATER INTAKE
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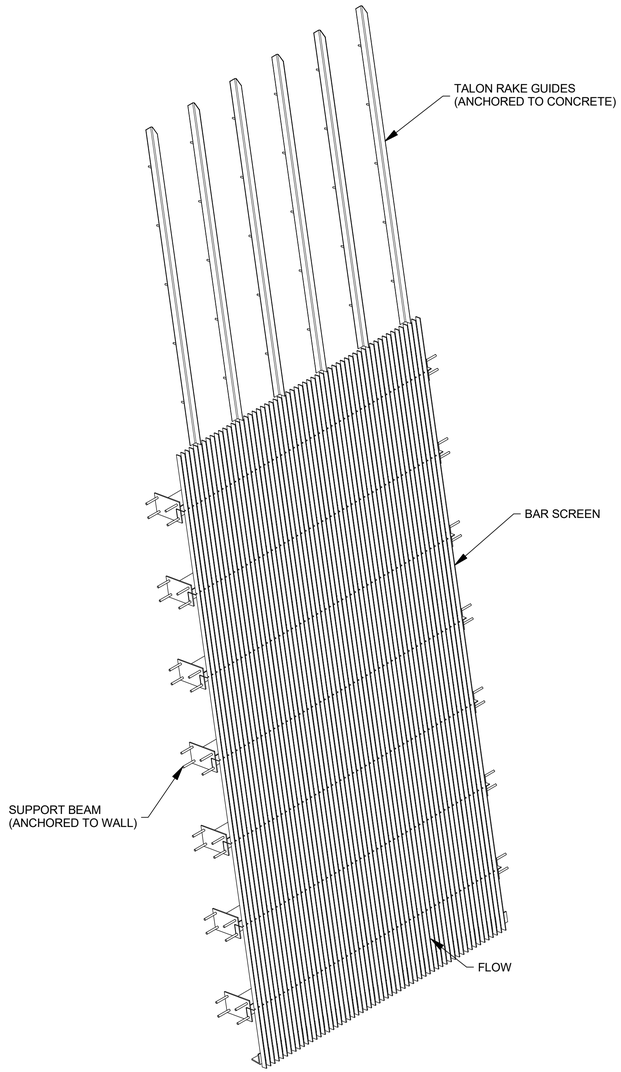
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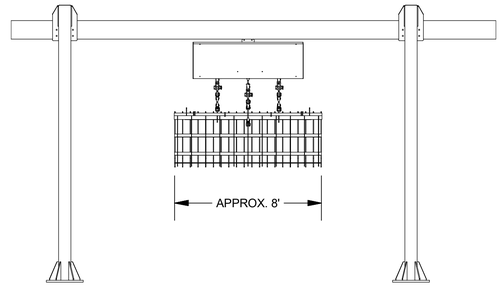
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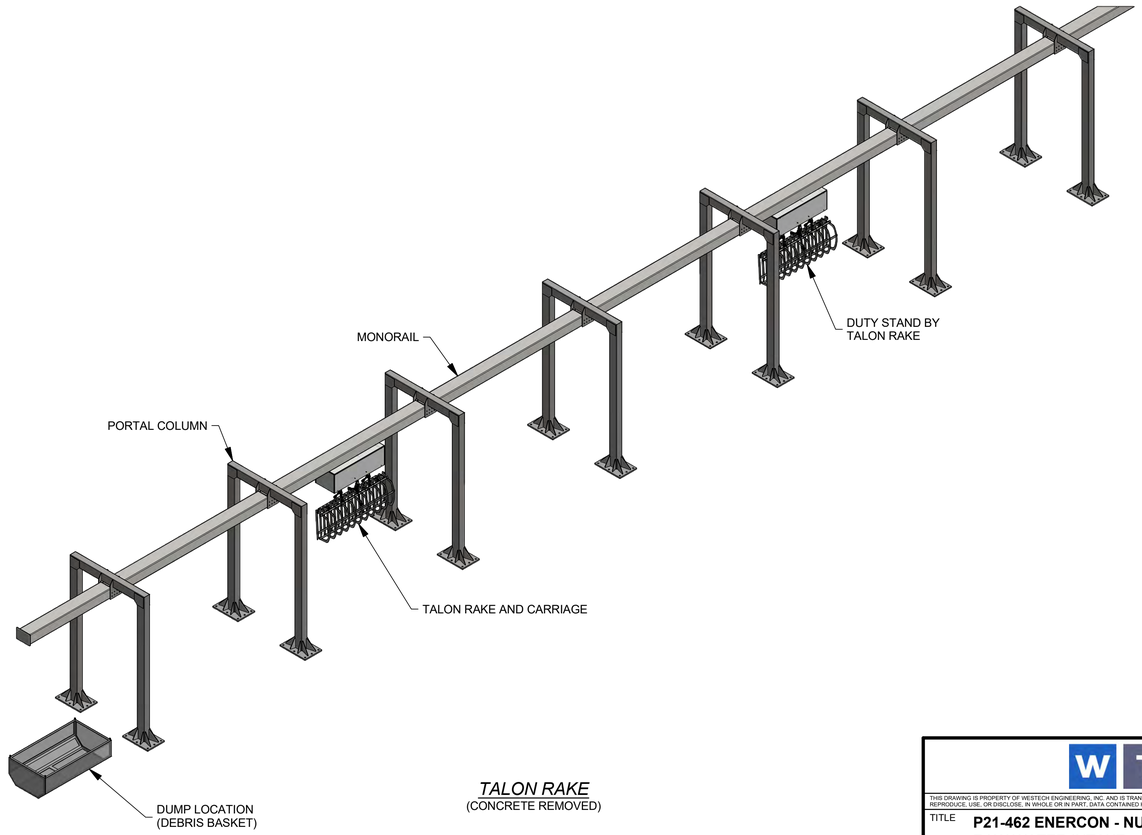
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BAR SCREEN
(CONCRETE REMOVED)



TALON FRONT VIEW



TALON RAKE
(CONCRETE REMOVED)

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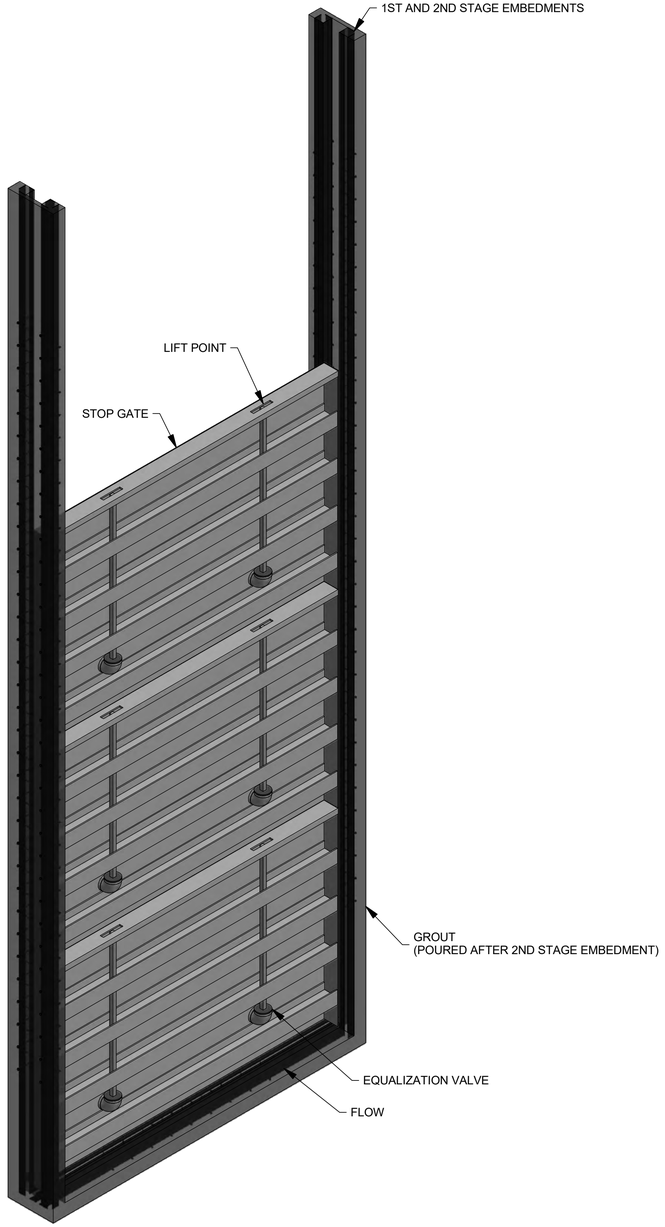
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RAW WATER INTAKE
FISH RECOVERY & RETURN DUAL FLOW SCREENS

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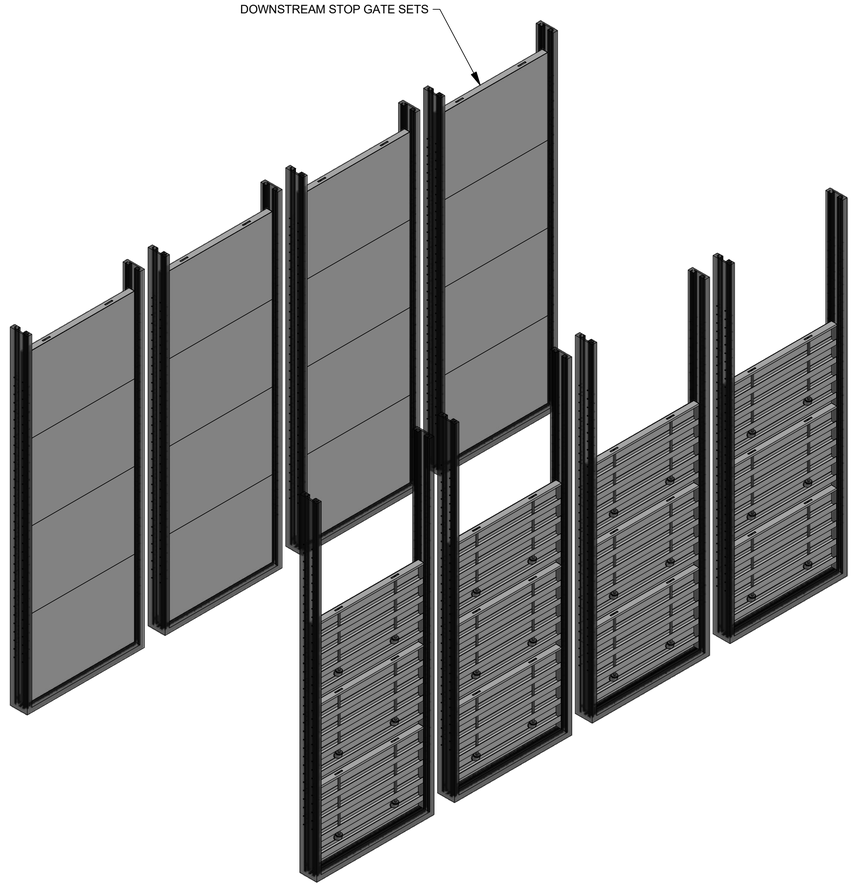
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STOP GATE TYPICAL ARRANGEMENT



STOP GATES AND GUIDES
(CONCRETE REMOVED / 8 SETS SHOWN)

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RAW WATER INTAKE
FISH RECOVERY & RETURN DUAL FLOW SCREENS

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ABA	WAR		3/9/2021	
DOCUMENT NUMBER			SHEET	REV
P21-462 GA			8 OF 8	**A**

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Appendix F. Fine Mesh Screen Vendor Quote

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WTR® WATER SCREENING SOLUTIONS

A WesTech Company

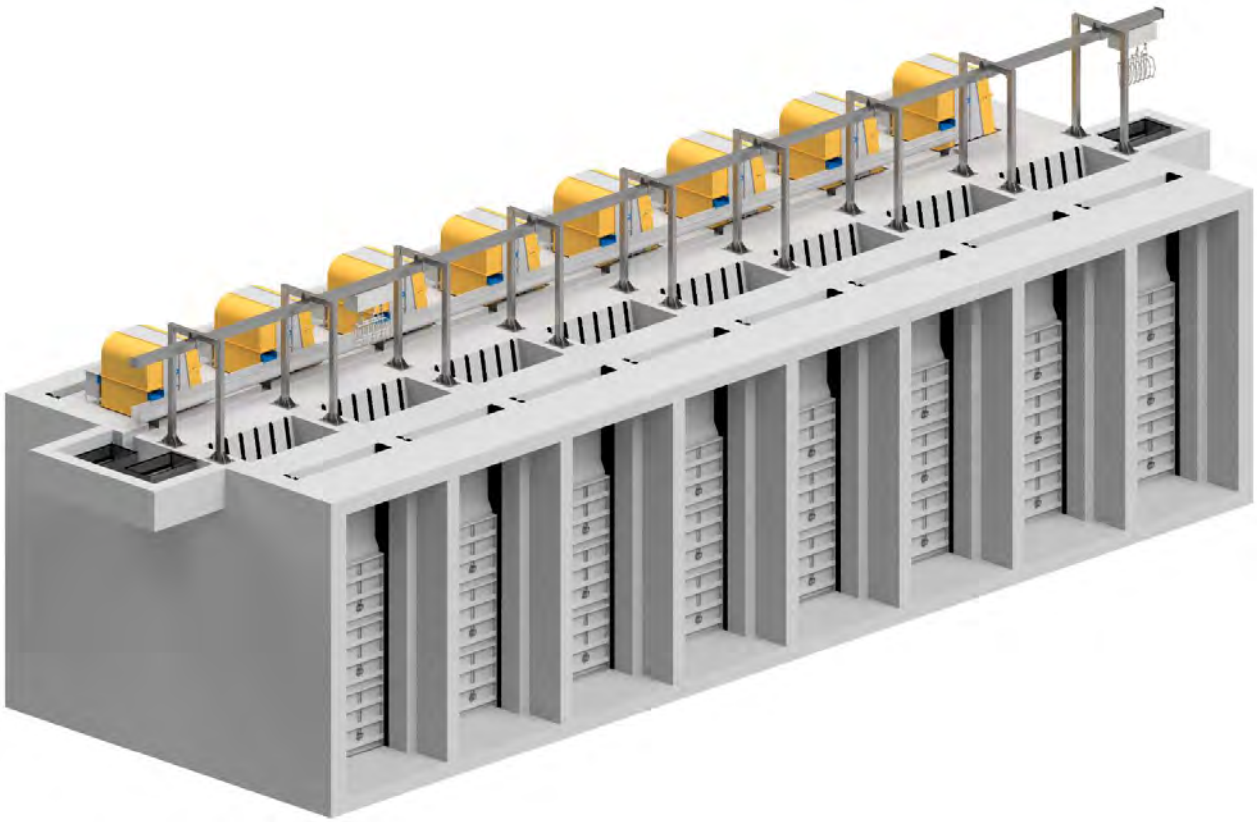
WTR® ENGINEERING, LLC
3605 S. West Temple, Suite 200, Salt Lake City, UT 84115
Phone: 801-713-9933, E-mail: info@wtrengineering.com
Website: www.wtrengineering.com

BUDGET PROPOSAL – P21-462 R0
April 8th, 2021

ENERCON
Excellence—Every project. Every day

Confidential Nuclear Power Plant Raw Water Intake

WTR Intake System with Fish Recovery and Return Screens



(Above image for proposal purposes only – see applicable attached drawings)

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Customer Contact & Request Information:

Customer: ENERCON
Attn: Caleb Clement

Office:
Cell: (865) 809-6547
Email: cclement@enercon.com

Customer Reference Information: (By document file number)

Preliminary Data: Web Inquiry 05Mar21 Tannaz Alemzadeh
Additional Data: Emails of 07Mar21 & 08Mar21 Tannaz Alemzadeh

---

WTR Engineering, LLC Contact Details:

Ref. No.: P21-462 R0

Contact: Trent T. Gathright
Director Business Development
Phone: (C) 832-890-9120
(O) 801-713-9931
Skype: trent.gathright
Email: tgathright@wtrengineering.com

WTR Representative Contact Details:

Company: Pure Process
Contact: Bert Gardner
Phone: (C) (770) 356-8722
Email: bert@pureprocess.co

Dear Mr. Clement,

We, WTR Engineering, are pleased to provide the following budget proposal based on the data provided (as mentioned in 'Customer Reference Information'), as well as similar industry standard specifications and as further detailed by WTR Engineering. We are offering Stop Gates, Bar Screens, Raking Machines, Fish Recovery & Return Dual Flow Band Screens and Controls.

We have attached equipment specifications, which should provide you will all the necessary data along with the basis of our offer. We have also attached an outline drawing, which is very preliminary, but will provide you a representation of the intake size. Included, are the following commercial conditions and considerations:

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I. Equipment and Deliverables:

X	Stop Gates, Guides, Lift Beam, Storage Racks	X	Debris Baskets
X	Bar Screens and Apron Guides	X	Engineering Submittal Drawings
X	Bar Screen Raking Machines (Talon Rake®)	X	Documentation and O&M Manuals
X	Dual Flow Band Screens – FRR Style	X	Delivery Ex-Works Shipping Point
X	Controls for Rakes & Band Screens	X	Field Service (see daily rate provided)

II. Budget Pricing:

a. Design, engineering submittals, O&M manuals, manufacture, supply and delivery ex-works shipping point of the following as described in the attached specifications. **The below is based on a new intake structure to accommodate the items shown:**

Item	Description	Price – US Dollars
1	**Stop Gates:** • Two (2) Inlet Gates & Two (2) Outlet Gates of epoxy coated carbon steel • Twenty-two (22) sets of Inlet & Outlet Guides of 304/304L Stainless Steel • Two (2) Lifting Beams of epoxy coated carbon steel • One (1) storage rack for 14 gate sections and 2 lift beams of mainly epoxy coated carbon steel	$ 2,080,000.00
2	**Bar Screens:** • Twenty-two (22) sets Apron Wall Guides of epoxy coated carbon steel • Twenty-two (22) Bar Screens, 11'-0" wide x 33'-0" high, 1-5/8" clear openings of epoxy coated carbon steel construction	$ 1,430,000.00
3	**Bar Screen Raking Machines:** • Two (2) Bar Screen Raking Machines (Talon Rake®) • 1,500 Lb. Capacity, 8'-0" wide Talon Rakes to clean Twenty -two (22) Bar Screens • 317 ft. of Monorail with twenty-three (23) double leg columns	$ 820,000.00
4	**Dual Flows:** • Twenty-two (22) Fish Recovery & Return, Frameless Dual Flow Band Screens • 5'-0" Effective width x 48'-0" deep with 0.5mm mesh • Mainly carbon steel construction with polyester mesh	$ 5,808,000.00
5	**Controls:** • Control System for automatic control of Two (2) Bar Screen Raking Machines and Twenty-two (22) Dual Flow Band Screens	$ 240,000.00
6	**Debris Baskets:** • Four (4) Debris Baskets of 3.0m^3 capacity • Mainly 304/304L stainless steel construction with 0.5mm polyester mesh	$ 54,000.00

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b. Field Service can be purchased on a daily domestic rate of $1,300.00 USD per day plus travel, living, and per diem expenses. This service can be used for installation supervision, start-up, commissioning and site training. Please refer to attached "Field Service Rate & Information Sheet – 2021"

c. Freight has currently NOT been included based on the unknown destination.

III. Validity and Price Basis:

a. Price Validity - This budget proposal should be considered as valid for three (3) months based on normal industry circumstances. After such time, please check with WTR Engineering, LLC for changes such as materials and labor rates.

b. Price Basis - Pricing is based on specifications and requirements as noted in the specifications referenced above, as well as WTR Engineering, LLC common industry standards for similar equipment. Pricing may be affected by additional specifications beyond the requirement referenced and WTR Engineering, LLC standards.

Pricing is also based on the indicated progress payment milestones, payment terms and delivery scheme mentioned herein. Any requested modification of these may alter the price stated herein. In the event of any delay by customer that extends our supply period beyond the agreed delivery time, we reserve the right to claim extra costs involved including material, labor, transportation, storage, insurance, etc.

c. Progress Payments - Our budget proposal is based on the following progress payment milestones with partial shipments allowed:

10%	Of contract value upon order placement
10%	Of contract value upon submission of engineering submittals
30%	Of contract value upon receipt of raw material at fabrication facility
45%	Of contract value upon delivery to agreed point or as made ready for delivery if delayed by purchaser
5%	Of contract value upon completion of installation by others or 180 days after made ready for shipment, whichever occurs first

d. Payment Terms - Full payment for each progress payment milestone shall be due and payable net thirty (30) days from receipt of invoice. Unpaid invoices are subject to a service charge of 2% per month.

Order acceptance is subject to review and acceptance by WTR Engineering, LLC contracts and accounting departments. Purchaser shall remit payment for invoices received from WTR Engineering, LLC in accordance with the payment terms and milestones stated above, unless delay is related to the performance of WTR Engineering, LLC.

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IV. Delivery and Freight:

WTR Engineering can deliver the drawings, data and equipment within the indicated schedule of working weeks from our receipt of your acceptance of our order acknowledgement, including all instructions and information enabling the contract to proceed without delay and subject to confirmation based on the following:

Submittal of General Arrangement Drawings and Catalog Data	10 Weeks
Review of Drawings by Purchaser Note 1	4 Weeks
Preparation of details and release for procurement and fabrication	8 Weeks
Material Ordering, Fabrication and Manufacturing	16-18 Weeks
Testing, Packaging and Preparation for Shipment	2 Weeks
Total Weeks Note 2 and 3	**40-42 Weeks Note 3**

Note 1 Any increase in review time will extend delivery by equal amount.
Note 2 May be adjusted to meet purchaser requirements.
Note 3 **Based on first two (2) screens. Two (2) screens will follow each two (2) weeks thereafter until all screens shipped**.

Freight currently is **not included as the final destination is unknown.**

V. Terminal Points:

- Stop Gate guides to civil works
- Stop Gates to stop gate guides
- Lifting Beam attachment hooks to Stop Gates
- Stop Gate storage rack mounting feet to foundations
- Bar Screen Apron Wall Guides to civil works
- Bar Screen support beams to civil works
- Bar Screens to Bar Screen support beams
- Talon Traveling Rake structure supports to civil works, main incoming power to monorail box
- Talon Rake head to bar screens
- Dual Flow screen guides to civil works
- Dual Flow screen transition troughs to return troughs
- Dual Flow screen housings to upper civil works
- Dual Flow spray wash inlet flanges
- Control Panel supply, input and output terminals
- Free standing Control Panels to civil works, wall mounted panels to customer panel stands
- All motor terminal boxes
- Integrated terminal boxes on limit switches, pressure transmitters, sensors, etc.
- Debris Baskets to sump in civil works
- Debris Basket lifting eyes to customer slings / chains / shackles

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VI. **Out of Scope** (not included in supplier scope)

- Freight to site
- Unloading at site or site assembly
- Storage (manufacturing location or job site)
- Any building, foundation, grouting, civil work or civil work changes
- Interconnecting piping, fittings or pipe supports exterior to band screens
- Spray wash pumps, spray water, strainers, automatic or manual valves
- Installation, construction, erection, supervision, or commissioning beyond daily rate
- Lifting equipment, slings, chains, shackles or lugs
- Interconnecting conduit, wiring, cables and glands
- Control panel ventilation units, shades or covers
- Main breaker, main power fuses, area lighting
- System operating software and software license
- Access ladders, hand railing, flooring, grating, grating supports or channel covers
- Anti-frost lagging, heat tracing or piping insulation
- Dumpsters or debris receptacles
- Cathodic protection equipment
- Spare parts (unless noted as included)
- State, federal, local taxes or use taxes

VII. Additional Information Attached:

X	WTR Field Service Rate & Information	X	WTR General Brochure
X	WTR Standard Terms and Conditions	X	WTR Stop Gate Brochure
X	WTR Equipment Specifications	X	WTR Talon Rake Brochure
X	WTR Outline Drawings (for reference)	X	WTR Fish Recovery & Return Brochure

VIII. Terms and Conditions:

WTR Engineering, LLC Standard Terms and Conditions are attached. These terms and conditions replace and supersede any terms, conditions and warranties included in Purchaser or Owner requests for quotation, Specifications or Contract Documents and cannot be changed without written approval from an authorized representative of WTR Engineering LLC.

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IX. Warranty:

Equipment manufactured or sold by WTR Engineering, LLC, [WTR] once paid for in full, is backed by the following warranty:

For the benefit of the original user, WTR warrants all new equipment manufactured by WTR Engineering, LLC to be free from defects in material and workmanship, and will replace or repair, F.O.B. its factories or other location designated by it, any part or parts returned to it which WTR's examination of such, shall show to have failed under normal use and service by the original user within one (1) year following initial start-up, or eighteen (18) months from shipment to the purchaser, whichever occurs first.

Such repair or replacement shall be free of charge for all items except for those items such as consumable and the like, normally replaced during maintenance, with respect to which, repair or replacement shall be subject to a pro-rata charge based upon WTR's estimate of the percentage of normal service life realized from the part. WTR's obligation under this warranty is conditioned upon its receiving prompt notice of claimed defects, which shall in no event be later than thirty (30) days following expiration of the warranty period, and is limited to repair or replacement as aforesaid.

This warranty is expressly made by WTR and accepted by purchaser in lieu of all other warranties, including warranties of merchantability and fitness for particular purpose, whether written, oral, express, implied, or statutory. WTR neither assumes nor authorizes any other person to assume for it any other liability with respect to its equipment. WTR shall not be liable for normal wear and tear, corrosion, or any contingent, incidental, or consequential damage or expense due to partial or complete inoperability of its equipment for any reason whatsoever.

This warranty shall not apply to equipment or parts thereof which have been altered or repaired outside of a WTR factory or authorized location, or damaged by improper installation, application, or maintenance, or subjected to misuse, abuse, neglect, accident, or incomplete adherence to all manufacturer's requirements, including, but not limited to, Operations & Maintenance Manual guidelines & procedures.

This warranty applies only to equipment made or sold by WTR Engineering, LLC.
WTR Engineering, LLC makes no warranty with respect to parts, accessories, or components purchased by the customer from others. The warranties which apply to such items are those offered by their respective manufacturers.

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Field Service Rate Sheet

Effective until December 31, 2021

Domestic United States and Canada

Standard Travel Day	8 Hour Day	$1,300.00
Standard Labor Day	8 Hour Day	$1,300.00
Saturday	8 Hour Day	$1,800.00
Sunday and Holidays	8 Hour Day	$2,400.00
Overtime	Per Hour after 8 Hours	$225.00
Overtime Saturday, Sunday, Holiday	Per Hour after 8 Hours	$300.00

International

Standard Travel Day	8 Hour Day	$1,800.00
Standard Labor Day	8 Hour Day	$1,800.00
Saturday	8 Hour Day	$2,700.00
Sunday and Holidays	8 Hour Day	$3,600.00
Overtime	Per Hour after 8 Hours	$350.00
Overtime Saturday, Sunday, Holiday	Per Hour after 8 Hours	$450.00

1. Unless otherwise specified, expenses are charged at actual cost plus 10%
2. Travel and living expenses will be invoiced at actual cost plus 10% with included documentation for the expenses.
3. All international travel reservations for lodging and travel to/from airports, hotel, and jobsite will be made with the assistance of the customer requesting service.

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WATER SCREENING SOLUTIONS

Terms and Conditions

Terms and Conditions appearing in any order based on this proposal which are inconsistent herewith shall not be binding on WTR Engineering LLC The sale and purchase of equipment described herein shall be governed exclusively by the foregoing proposal and the following provisions:

1. SPECIFICATIONS: WTR Engineering LLC is furnishing its standard equipment as outlined in the proposal and as will be covered by final approved drawings. The equipment may not be in strict compliance with the Engineer's/Owner's plans, specifications, or addenda as there may be deviations. The equipment will, however, meet the general intention of the mechanical specifications of these documents.

2. ITEMS INCLUDED: This proposal includes only the equipment specified herein and does not include erection, installation, accessories, nor associated materials such as controls, piping, etc., unless specifically listed.

3. PARTIES TO CONTRACT: WTR Engineering LLC is not a party to or bound by the terms of any contract between WTR Engineering LLC's customer and any other party. WTR Engineering LLC's undertakings are limited to those defined in the contract between WTR Engineering LLC and its direct customers.

4. PRICE AND DELIVERY: All selling prices quoted are subject to change without notice after 30 days from the date of this proposal unless specified otherwise. Unless otherwise stated, all prices are F.O.B. WTR Engineering LLC or its supplier's shipping points. All claims for damage, delay or shortage arising from such equipment shall be made by Purchaser directly against the carrier. When shipments are quoted F.O.B. job site or other designation, Purchaser shall inspect the equipment shipped, notifying WTR Engineering LLC of any damage or shortage within forty-eight hours of receipt, and failure to so notify WTR Engineering LLC shall constitute acceptance by Purchaser, relieving WTR Engineering LLC of any liability for shipping damages or shortages.

5. PAYMENTS: All invoices are net 30 days. Delinquencies are subject to a 1.5 percent service charge per month or the maximum permitted by law, whichever is less on all past due accounts. Pro rata payments are due as shipments are made. If shipments are delayed by the Purchaser, invoices shall be sent on the date when WTR Engineering LLC is prepared to make shipment and payment shall become due under standard invoicing terms. If the work to be performed hereunder is delayed by the Purchaser, payments shall be based on the purchase price and percentage of completion. Products held for the Purchaser shall be at the risk and expense of the Purchaser. Unless specifically stated otherwise, prices quoted are for equipment only. These terms are independent of and not contingent upon the time and manner in which the Purchaser receives payment from the owner.

6. PAYMENT TERMS: Credit is subject to acceptance by WTR Engineering LLC's Credit Department. If the financial condition of the Purchaser at any time is such as to give WTR Engineering LLC, in its judgment, doubt concerning the Purchaser's ability to pay, WTR Engineering LLC may require full or partial payment in advance or may suspend any further deliveries or continuance of the work to be performed by the WTR Engineering LLC until such payment has been received.

7. ESCALATION: If shipment is, for any reason, deferred by the Purchaser beyond the normal shipment date, or if material price increases are greater than 5% from proposal date to material procurement date, stated prices set forth herein are subject to escalation. The escalation shall be based upon increases in labor and material and other costs to WTR Engineering LLC that occur in the time period between quotation and shipment by WTR Engineering LLC Purchaser agrees to this potential escalation regardless of contradicting terms in the contract, except when an agreed upon escalation adder is included in the price.

(a) The total quoted revised price is based upon changes in the indices published by the United States Department of Labor, Bureau of Labor Statistics. Labor will be related to the Average Hourly Earnings indices found in the Employment and Earnings publication. Material will be related to the Metal and Metal Products Indices published in Wholesale Prices and Prices Indices.

(b) Price revision for items furnished to, and not manufactured by WTR Engineering LLC, which exceed the above escalation calculation, will be passed along by WTR Engineering LLC to Purchaser based upon the actual increase in price to WTR Engineering LLC for the period from the date of quotation to the date of shipment by WTR Engineering LLC Any item that is so revised will be excluded from the index escalation calculations set forth in subparagraph (a) above.

8. APPROVAL: If approval of equipment submittals by Purchaser or others is required, a condition precedent to WTR Engineering LLC supplying any equipment shall be such complete approval.

9. INSTALLATION SUPERVISION: Prices quoted for equipment do not include installation supervision. WTR Engineering LLC recommends and will, upon request, make available, at WTR Engineering LLC's then current rate, an experienced installation supervisor to act as the Purchaser's employee and agent to supervise installation of the equipment. Purchaser shall at its sole expense furnish all necessary labor equipment, and materials needed for installation.

Responsibility for proper operation of equipment, if not installed by WTR Engineering LLC or installed in accordance with WTR Engineering LLC's instructions, and inspected and accepted in writing by WTR Engineering LLC, rests entirely with Purchaser; and any work performed by WTR Engineering LLC personnel in making adjustment or changes must be paid for at WTR Engineering LLC's then current per diem rates plus living and traveling expenses.

WTR Engineering LLC will supply the safety devices described in this proposal or shown in WTR Engineering LLC's drawings furnished as part of this order but excepting these, WTR Engineering LLC shall not be required to supply or install any safety devices whether required by law or otherwise. The Purchaser hereby agrees to indemnify and hold harmless WTR Engineering LLC from any claims or losses arising due to alleged or actual insufficiency or inadequacy of the safety devices offered or supplied hereunder, whether specified by WTR Engineering LLC or Purchaser, and from any damage resulting from the use of the equipment supplied hereunder.

10. ACCEPTANCE OF PRODUCTS: Products will be deemed accepted without any claim by Purchaser unless written notice of non-acceptance is received by WTR Engineering LLC within 30 days of delivery if shipped F.O.B. point of shipment, or 48 hours of delivery if shipped F.O.B. point of destination. Such written notice shall not be considered received by WTR Engineering LLC unless it is accompanied by all freight bills for said shipment, with Purchaser's notations as to damages, shortages and conditions of equipment, containers, and seals. Non-accepted products are subject to the return policy stated below.

11. TAXES: Any federal, state, or local sales, use or other taxes applicable to this transaction, unless specifically included in the price, shall be for Purchaser's account.

12. TITLE: The equipment specified herein, and any replacements or substitutes therefore shall, regardless of the manner in which affixed to or used in connection with realty, remain the sole and personal property of WTR Engineering LLC until the full purchase price has been paid. Purchaser agrees to do all things necessary to protect and maintain WTR Engineering LLC's title and interest in and to such equipment; and upon Purchaser's default, WTR Engineering LLC may retain as liquidated damages any and all partial payments made and shall be free to enter the premises where such equipment is located and remove the same as its property without prejudice to any further claims on account of damages or loss which WTR Engineering LLC may suffer from any cause.

13. INSURANCE: From date of shipment until the invoice is paid in full, Purchaser agrees to provide and maintain at its expense, but for WTR Engineering LLC's benefit, adequate insurance including, but not limited to, builders risk insurance on the equipment against any loss of any nature whatsoever.

14. SHIPMENTS: Any shipment of delivery dates recited represent WTR Engineering LLC's best estimate but no liability, direct or indirect, is assumed by WTR Engineering LLC for failure to ship or deliver on such dates.

WTR Engineering LLC shall have the right to make partial shipments; and invoices covering the same shall be due and payable by Purchaser in accordance with the payment terms thereof. If Purchaser defaults in any payment when due hereunder, WTR Engineering LLC may, without incurring any liability therefore to Purchaser or Purchaser's customers, declare all payments immediately due and payable with maximum legal interest thereon from due date of said payment, and at its option, stop all further work and shipments until all past due payments have been made, and/or require that any further deliveries be paid for prior to shipment.

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If Purchaser requests postponements of shipments, the purchase price shall be due and payable upon notice from WTR Engineering LLC that the equipment is ready for shipment; and thereafter any storage or other charge WTR Engineering LLC incurs on account of the equipment shall be for the Purchaser's account.

If delivery is specified at a point other than WTR Engineering LLC or its supplier's shipping points, and delivery is postponed or prevented by strike, accident, embargo, or other cause beyond WTR Engineering LLC's reasonable control and occurring at a location other than WTR Engineering LLC or its supplier's shipping points, WTR Engineering LLC assumes no liability in delivery delay. If Purchaser refuses such delivery, WTR Engineering LLC may store the equipment at Purchaser's expense. For all purposes of this agreement such tender of delivery or storage shall constitute delivery.

15. WARRANTY: WTR ENGINEERING LLC WARRANTS EQUIPMENT IT SUPPLIES ONLY IN ACCORDANCE WITH THE WARRANTY EXPRESSED IN THE ATTACHED PROPOSAL AGAINST DEFECTS IN WORKMANSHIP AND MATERIALS WHICH IS MADE A PART HEREOF. SUCH WARRANTY IN LIEU OF ALL OTHER WARRANTIES, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSE, WHETHER WRITTEN, ORAL, EXPRESSED, IMPLIED OR STATUTORY, WTR ENGINEERING LLC SHALL NOT BE LIABLE ANY CONTINGENT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES FOR ANY REASON WHATSOEVER.

16. PATENTS: WTR Engineering LLC agrees that it will, at its own expense, defend all suits or proceedings instituted against Purchaser and pay any award of damages assessed against it in such suits or proceedings, so far as the same are based on any claim that the said equipment or any part thereof constitutes an infringement of any apparatus patent of the United States issued at the date of this Agreement, provided WTR Engineering LLC is given prompt notice in writing of the institution or threatened institution of any suit or proceeding and is given full control of the defense, settlement, or compromise of any such action; and Purchaser agrees to give WTR Engineering LLC needed information, assistance, and authority to enable WTR Engineering LLC so to do. In the event said equipment is held or conceded to infringe such a patent, WTR Engineering LLC shall have the right at its sole option and expense to a) modify the equipment to be non-infringing, b) obtain for Purchaser the license to continue using said equipment, or c) accept return of the equipment and refund to the Purchaser the purchase price thereof less a reasonable charge for the use thereof. WTR Engineering LLC will reimburse Purchaser for actual out-of-pocket expenses, exclusive of legal fees, incurred in preparing such information and rendering such assistance at WTR Engineering LLC's request. The foregoing states the entire liability of WTR Engineering LLC, with respect to patent infringement; and except as otherwise agreed to in writing, WTR Engineering LLC assumes no responsibility for process patent infringement.

17. SURFACE PREPARATION AND PAINTING: If furnished, shop primer paint is intended to serve only as minimal protective finish. WTR Engineering LLC will not be responsible for the condition of primed or finish painted surfaces after equipment leaves its shops. Purchasers are invited to inspect paint in shops for proper preparation and application prior to shipment. WTR Engineering LLC assumes no responsibility for field surface preparation or touch-up of shipping damage to paint. Painting of fasteners and other touch-up to painted surfaces will be by Purchaser's painting contractor after mechanism installation.

Motors, gear motors, and other components not manufactured by WTR Engineering LLC will be painted with that manufacturer's standard paint system. It is WTR Engineering LLC's intention to ship major steel components as soon as fabricated, often before drive, motors, and other manufactured components. Unless Purchaser can ensure that shop primed steel shall be field painted within thirty (30) days after arrival at the job site, WTR Engineering LLC encourages the Purchaser to order these components without primer.

WTR Engineering LLC's prices are based on paints and surface preparations as outlined in the main body of this proposal. In the event that an alternate paint system is selected, WTR Engineering LLC requests that Purchaser's order advise of the paint selection. WTR Engineering LLC will then either adjust the price as may be necessary to comply or ship the material unpainted if compliance is not possible due to application problems or environmental controls.

18. CANCELLATION, SUSPENSION, OR DELAY: After acceptance by WTR Engineering LLC, this proposal, or Purchaser's order based on this proposal, shall be a firm agreement and is not subject to cancellation, suspension, or delay except upon payment by Purchaser of appropriate charges which shall include all costs incurred by WTR Engineering LLC to date of cancellation, suspension, or delay plus a reasonable profit. Additionally, all charges related to storage and/or resumption of work, at WTR Engineering LLC's plant or elsewhere, shall be for Purchaser's sole account; and all risks incidental to storage shall be assumed by Purchaser.

19. RETURN OF PRODUCTS: No products may be returned to WTR Engineering LLC without WTR Engineering LLC's prior written permission. Said permission may be withheld by WTR Engineering LLC at its sole discretion.

20. BACKCHARGES: WTR Engineering LLC will not approve or accept backcharges for labor, materials, or other costs incurred by Purchaser or others in modification, adjustment, service, or repair of WTR Engineering LLC-furnished materials unless such back charge has been authorized in advance in writing by a WTR Engineering LLC employee, by a WTR Engineering LLC purchase order, or work requisition signed by WTR Engineering LLC

21. INDEMNIFICATION: Purchaser agrees to indemnify WTR Engineering LLC from all costs incurred, including but not limited to court costs and reasonable attorney fees, from enforcing any provisions of this contract, including but not limited to breach of contract or costs incurred in collecting monies owed on this contract.

22. ENTIRE AGREEMENT: This proposal expresses the entire agreement between the parties hereto superseding any prior understandings, and is not subject to modification except by a writing signed by an authorized officer of each party.

23. MOTORS AND MOTOR DRIVES: In order to avoid shipment delays of WTR Engineering LLC equipment, the motor drives may be sent directly to the job site for installation by the equipment installer. Minor fit-up may be required.

24. EXTENDED STORAGE: Extended storage instructions will be part of information provided to shipment. If equipment installation and start-up is delayed more than 30 days, the provisions of the storage instructions must be followed to keep WARRANTY in force.

25. LIABILITY: Professional liability insurance, including but not limited to, errors and omissions insurance, is not included. In any event, liability for errors and omissions shall be limited to the lesser of $100,000USD or the value of the particular piece of equipment (not the value of the entire order) supplied by WTR Engineering LLC against which a claim is sought.

26. ARBITRATION NEGOTIATION: Any controversy or claim arising out of or relating to the performance of any contract resulting from this proposal or contract issued, or the breach thereof, shall be settled by arbitration in accordance with the Construction Industry Arbitration Rules of the American Arbitration Association, and judgment upon the award rendered by the arbitrator(s) may be entered to any court having jurisdiction.

ACCEPTED BY PURCHASER

Customer Name: _____

Customer Address: _____

_____

_____

Contact Name: _____

Contact Phone: _____

Contact Email: _____

Signature: _____

Printed Name: _____

Title: _____

Date: _____

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Ref. P21-462 R0

SPECIFICATION FOR FISH RECOVERY & RETURN
DUAL FLOW BAND SCREENS AND CONTROLS

I. GENERAL DESCRIPTION

The Dual Flow Band Screen(s) will be of the Fish Recovery & Return [FRR] style, (or "improved Ristroph" style), designed to fit the new civil works structure and prevent debris larger than the mesh opening from passing downstream of the screen. The flow pattern will be of the out-to-in type. The unscreened flow approaches the outside of ascending and descending mesh panels, passing the screened flow to the inside of the screen and exiting a common opening downstream. Debris larger than the mesh open will be retained on the outside of the mesh panels and prevent "debris carry-over". Juvenile marine life will be captured in the hydraulically optimized fish recovery bucket for discharge in the fish transition trough on the descending side. Captured debris will be discharged in the debris transition trough on the descending side. The Dual Flow Band Screen will primarily consist of a Guide System, Mesh Panels, Carrier Chains, Spray System, Head Shaft, Drive System and Splash Housings. The Screen(s) will include a Control System described herein.

The Guide System will be designed to attach to the upstream & downstream walls of the civil works structure. The Guide System will be the support for the "carrier loop", consisting of the Mesh Panels and Carrier Chains. The Guide System will include specialized tracks with replaceable wear bars to support the carrier loop. The Guide System will also include a specialized semi-circular track at the invert to guide the screening band from descending to ascending and avoid the use of submerged sprockets. The Guide System will be reinforced and of suitable thickness to withstand the indicated static and operating differentials as well as corrosion allowance. The Guide System will include a head section, mounted above the deck level to support the Head Shaft, Drive System and Splash housings.

The Mesh Panels will be of unitized construction, designed for continuity throughout the carrier loop. The Mesh Panels will consist of a support frame, mesh insert, seals (where required), mesh retaining clamps and mesh retaining fasteners. The support frame will be high strength and specially designed to provide high open area with an integrated, water tight, hydraulically optimized fish bucket to eliminate vortices. Plastic frames, slotted plastic mesh or add on buckets are not allowed. The support frame will be suitably designed to withstand the indicated static and running differentials. The ends of the support frames will mate with the frames to prevent debris from entering the chain tracks. The mesh inserts will incorporate the indicated aperture (mesh opening) and be replaceable as an insert if damaged. Panel to panel seals will be utilized, (where required by finer mesh apertures), to seal the gap between support frames. The Mesh Panels will be rotated via the Carrier Chains.

As the band of Mesh Panels rotate, the marine life captured in the bucket and debris collected on the screen panels will be lifted above deck level. As the band articulates over the head sprockets, the recovered marine life within the fish bucket will be continually wetted by low pressure outside fish sprays. As the band begins to descend, gravity and low pressure inside fish sprays will direct the marine life into the fish transition trough and flow into the main fish return trough located above deck. The final trough returning the fish to the source water will be by others.

As the band continues to descend, the mesh will be washed by inside higher pressure debris sprays. Debris will be washed into a debris transition trough and flow into the main debris trough formed in the civil structure. The debris trough will discharge via gravity flow to the debris basket or other receptacle for separation.

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The Carrier Chains will be of unitized construction, designed for continuity throughout the carrier loop. The Carrier Chains will consist of sidebars, rollers, bushings, pins and spacers. The side bars will be of adequate strength and thickness to transmit the required torque during starting and operating differentials. The sidebars will be straight, block link style, connect by bushings. Suitable spacers will maintain proper spacing between sidebars and allow for Mesh Panel retaining fasteners to pass through. Bushings will include oversized rollers designed to increase chain life and decrease drive power. Links will be connected by pins passing through the bushings to form a continuous chain.

The Head Shaft will be designed to drive the Carrier Chains and revolve the carrier loop. The Head Shaft will include a solid shaft, dual (two) head sprockets, roller bearings and adjustment screws. The solid shaft will extend out one end of the head section to accommodate the driving gear and be adequately sized to transmit the torque required to drive the carrier loop under starting and running differentials. The solid shaft will support the two (2) head sprockets. The head sprockets will include specially designed, full length rims to drive the Carrier Chains via the sidebars. The head sprockets will include teeth to maintain the centers of the carrier loop during operation. The solid shaft will rotate in roller bearings to reduce maintenance and drive torque. The roller bearings will include machined housings for connection of adjustment screws. The adjustment screws will allow for the Head Shaft to be lowered for maintenance and raised when required to maintain proper chain tension.

Multiple Spray Systems will also be incorporated in the head section, designed to wash the screening band as it passes the respective discharge points above the transition troughs. Washing will be by a series of spray nozzles mounted on the inside fish sprays, outside fish sprays and debris sprays located inside the screen head section. The fish, debris and portions of spray wash water will be deposited into the respective transition troughs and will discharge to the fish return trough and main debris trough. The fish transition trough will be continual flooded to maintain a min. 2” wetted depth. The fish return trough and main debris trough will discharge via gravity continual bottom slope. Spray nozzles will be attached to the spray pipe by quickly removable threaded connections for ease of changing or cleaning. The spray pipes will be fitted with removable end caps for periodic flushing purposes. A smaller line will be tapped from the debris spray pipe and routed to the debris transition trough to aid in trough flushing of heavy debris.

The Drive System will be designed to rotate the Head Shaft during periods of operation. The Drive System will be adequately sized to start and run the screen under the indicated differential levels. The Drive System will include an electric motor, gear box and torque arm. The electric motor will use power from the customer’s power supply to drive the gear box. The gear box will be mounted on the Head Shaft and be prevented from excess movement by a torque arm. The torque arm will mount to the gear box and transmit torque to the head section.

The Splash Housings will be designed to prevent excess aerosol from escaping the head section during periods of operation. The Splash Housings will be light weight to be removable for maintenance. The Splash Housings will cover the ascending and descending sides of the head section. The ascending side will be split to allow for upper and lower removal. The descending housing will also include the indicated number of transparent access doors to monitor operation. The descending side will also include deflectors to direct the fish, collected screenings and wash water to the respective return trough.

The Control System will monitor the activities of the Dual Flow Screen and allow for operation in several modes, including “Off”, “Auto” and “Manual” via a selector switch.

> “Off” is as the name implies, the screen will not operate and it is normally only used during maintenance.

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"Automatic" operation has four options to begin a cleaning cycle. Once a cycle is started, the screen will rotate and the wash valve will open. Upon completion of the cycle (1 1/3 revolutions minimum), the screen will stop and the spray wash will continue for a short time to flush the debris trough. If during the cycle the wash valve fails to open an alarm is indicated, however the screen will continue to rotate. A cleaning cycle will be a minimum of 1 1/3 revolutions to allow for a different set of screen panels to be submerged before the next cleaning cycle, to minimize local corrosion.

Option 1: Run - Operator selects the run command on the HMI.

Option 2: Cycle time clock will start a clean cycle at predetermined frequencies. These can be set for a specific time of day or a specific time interval.

Option 3: Differential level. There are four preset set points for the differential: speed 1, speed 2, speed 3 and off. When the preset start differential (Speed 1) is reached, the screen will start in slow speed and continue in this speed until the differential is below the off setpoint, it will run a minimum of 1 1/3 revolutions and stop.

If the differential continues to rise to the second differential setpoint, the screen will switch to the next higher programed speed (Speed 2) and continue in this speed until it is below the off setpoint, where it will again run 1 1/3 revolutions.

If the differential continues to rise to the third setpoint, the screen will switch to the highest speed and send an alarm that the differential is high and needs operator attention. Once the differential is below the off setpoint, the screen will run 1 1/3 revolutions and stop.

Option 4: Main Control Room. The main control room can initiate a start remotely.

"Manual" will allow for operator control via the control panel mounted HMI. The operator will be able to run the screen forward and reverse and select between three preset speeds. They will also be able to close the spray wash valve for inspection or maintenance.

Please see separate "SPECIFICATION FOR CONTROL SYSTEM" attached for additional information.

II. SITE DATA

Site Name	Confidential SE Nuclear Plant
Water Source	Fresh Water River
Location (Indoors / Outdoors)	Outdoors
Deck Elevation	+ 565'
High Water Elevation	+ 562'
Mean Water Elevation	+ 556'
Low Water Elevation	+ 550'
Invert (channel bottom) Elevation	+ 517
Intake Depth	48'-0"
Maximum Immersion	45'-0"
Minimum Immersion	33'-0"

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III. HYDRAULIC DATA

Flow per Dual Flow Screen	96,821 GPM
Velocity in channel approaching screen*	0.59 ft/sec
Velocity through side entrances*	1.31 ft/sec
Velocity through mesh apertures*	1.47 ft/sec
Velocity through screen exit *	1.60 ft/sec
*** Velocities based on Flow, Low Water Elevation / Minimum Immersion**	
Head Loss across side entrances – 100% clean	0.5”
Head Loss across mesh aperture – 100% clean	0.7”
Head Loss across the screen exit – 100% clean	1.3”
Total Head Loss across Dual Flow – 100% clean	2.5”
Total Head Loss across Dual Flow – 75% clean	3.1”
Total Head Loss across Dual Flow – 50% clean	5.0”
*** Head Losses based on Flow, Low Water Elevation / Minimum Immersion and above Velocities**	

IV. DUAL FLOW GENERAL DATA

Quantity of Dual Flow Screens (duty + stand by)	Twenty-two (22) Duty Screens
Duty Rating	Continuous Duty
Channel Width at Screen Chamber	11’-0”
Inlet/Front Opening Width	2’-5 7/8”
Mesh Panel Effective Width	5’-0”
Exit Opening Width	4’-4 ½”
Mesh Insert Aperture Size & Wire Diameter	0.5mm & 0.2mm ø
Carrier Chain Pitch	24”
Number of Screen Panels	Fifty-seven (57)
Carrier Loop Nominal Rotation Speed	20 ft/min (high speed)
Height of Screen Above Deck	9’-0”
Overall Screen Width @ Deck	6’-4”
Overall Screen Breath @ Deck	6’-4”
Estimated Weight – Assembled Screen	22,500 Lbs.

V. SPRAY SYSTEM DATA

Number of Inside Fish Spray Headers	Two (2)
Number of Outside Fish Spray Headers	Two (2)
Number of Debris Spray Headers	Two (2)
Diameter of Inside Fish Spray Headers	2” ø
Diameter of Outside Fish Spray Headers	2” ø
Diameter of Debris Spray Headers	3” ø
Spray Nozzle Type	Vee Jet
Nozzle Qty for Inside Fish Spray Headers	12 Upper / 12 Lower
Nozzle Qty for Outside Fish Spray Headers	12 Upper / 13 Lower
Nozzle Qty for Debris Spray Headers	9 Upper / 8 Lower
Pressure - Fish Spray Headers – Min. / Max.	5 / 10 PSI

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Pressure - Fish Flood Box – Min. / Max.	3 to 10 PSI
Pressure - Debris Spray Headers – Min. / Max.	30 / 40 PSI
Water Volume – Fish Spray Headers	212 GPM @ 7.5 PSI
Water Volume – Fish Flood Box / Transition	260 GPM @ 7.5 PSI through fish headers
Water Volume – Debris Spray Headers	159 GPM @ 35 PSI
Total Water Volume Required for 22 Screens:	
Water Volume – Fish Recovery	10,392 GPM @ 7.5 PSI
Water Volume – Debris Removal	3,496 GPM @ 35 PSI
Spray Pipe End Connections	Flanged
Spray Wash Water Prefiltration Requirements	Strained to 1/32”

VI. DRIVE SYSTEM DATA

Electric Motor Size	5.0 Hp
Electric Motor Power – Voltage / Phase / Hertz	460 V / 3 PH / 60 HZ
Electric Motor Type	Inverter Duty
Electric Motor Speed - RPM	1800 RPM
Electric Motor Enclosure	TEFC
Electric Motor Insulation Class	F
Electric Motor NEMA / IEC Design	NEMA Design B
Electric Motor Torque Limiter Type	Current Sensing within VFD
Gear Box Type	Helical bevel
Gear Box Reduction Ration	1093:1
Gear Box Output Speed - RPM	1.64 RPM
Drive Starting Head Loss Capability	4.4 ft.
Drive Operating (Running) Head Loss Capability	1.8 ft.

VII. MATERIALS OF CONSTRUCTION

ITEM	**MATERIAL**
Guide System	
• Head Section	Carbon Steel, ASTM A-36
• Roller Support Tracks	Carbon Steel, ASTM A-36
• Roller Wear Bars	Carbon Steel, ASTM A-36
Mesh Panels	
• Support Frame	Carbon Steel, ASTM A-36
• Mesh Inserts	Polyester
• Panel Seals	Neoprene
• Mesh Retaining Clamps	Carbon Steel, ASTM A-36
Carrier Chains	
• Sidebars	Carbon Steel, AISI 1040
• Rollers	Carbon Steel, AISI 8620
• Bushings	Carbon Steel, AISI 8620
• Pins	Carbon Steel, AISI 8620
• Spacers	Carbon Steel

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Spray System	
• Spray Pipes	Carbon Steel – Galvanized
• Spray Nozzles	Brass
• Spray Pipe Support Brackets	Carbon Steel, AISI 8620
Head Shaft	
• Solid Shaft	Carbon Steel, AISI 1040/1045
• Head Sprockets	Carbon Steel, ASTM A-36
• Sprocket Rims	Carbon Steel – AR Wear Plate
• Roller Bearings	Anti-Friction
• Bearing Housing	Carbon Steel, ASTM A-36
• Adjustment Screws	Stainless Steel, Gr. 3030
• Adjustment Nuts	Brass
Splash Housings	
• Ascending – Upper / Lower	Stainless Steel, Gr. 304/304L
• Descending – Upper / Lower	Stainless Steel, Gr. 304/304L
• Doors	Marine Grade
• Transition Fish Trough	Stainless Steel, Gr. 304/304L
• Transition Debris Trough	Concrete – within civil works
• Fish Return Trough	By Others
• Debris Return Trough	Concrete – within civil works
Fastener Nut / Bolts	
• Head Section and Roller Tracks	Stainless Steel, Gr. 18-8
• Mesh Retaining to Support Frames	Stainless Steel, Gr. 18-8
• Mesh Panels to Carrier Chains	Stainless Steel, Gr. 18-8
• Drive System Torque Arm	Stainless Steel, Gr. 18-8
• Splash Housings to Head Section	Stainless Steel, Gr. 18-8

VIII. PROTECTION / COATINGS

Please note that items of stainless steel, brass, bronze, high density plastic or other corrosion resistant materials will not receive additional coatings. Other materials listed below will be protected or coated as indicated below:

ITEM	PROTECTION
Guide System – Head Section / Lower Guides	Coating System No. 1
Mesh Panel – Support Frames / Debris Elevators, Mesh Retaining Clamps	Coating System No. 1
Mesh Panel – Mesh Inserts	None - Polyester
Carrier Chain – Sidebars	Coating System No. 2
Spray System – Support Brackets	Coating System No. 1
Head Shaft – Solid Shaft	Coating System No. 3
Head Shaft – Head Sprockets	Coating System No. 1
Head Shaft – Bearing Housings	Coating System No. 1
Head Shaft – Sprocket Rims	Coating System No. 1
Drive Motor / Reducer	Manufacturers standard coating
Splash Housings – Ascending / Descending	None - SS

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Coating Systems:

1. Carbon Steel blast cleaned to SSPC SP 10 and coated with multiple coats of marine grade high solids epoxy to 10-12 mils average dry film thickness.
2. Carbon Steel Sidebars – one coat rust preventive coating
3. Carbon Steel - Brush cleaned and 3-4 mils epoxy shaft coating

IX. PACKING

The Dual Flow Screens will be bundled and banded in sections suitable for the method of transport as follows:

- The Guide System will be broken down in manageable section for site assembly to include roller tracks and supports. The Head Section will also be broken down for site assembly to include front and rear posts, cross braces and shields.
- The Mesh Panels will be individually assembled, bundled and banded to include the support frame, mesh inserts & mesh retaining clamps. The panel seals will ship loose for attachment during basket insertion.
- The Carrier Chains will be coiled, bundled and banded in manageable links of +/- 10 ft. for insertion during screen assemble
- The Spray Headers will be bundled and banded to include the spray nozzles. The support brackets will ship loose for insertion during screen assemble.
- The Head Shaft will be preassembled to include the sprockets, sprocket rims, bearings and shields.
- The Drive System will be crated for protection.
- The Splash Housings will be individually crated for protection.
- Assembly fasteners will be boxed and identified.

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Ref. P21-462 R0

SPECIFICATION FOR DEBRIS BASKETS

I. GENERAL DESCRIPTION

The Debris Baskets are designed to receive coarse debris from the Talon Rake® and wash water with debris from the Band Screen wash water troughs. The Debris Baskets will sit in a self-draining sump below deck level, at each end of the intake. Debris will be transported by the Talon Rake and wash water with debris from the Band Screens will flow by gravity.

The Debris Baskets will be rectangular, 5 sided (open top), consisting of a frame with lifting points and one sloped end. The Debris Baskets will include a filter element, designed to retain debris recovered from the rake and Bands, while allowing gravity drainage. The drained water should be returned to a point upstream of the screens.

The Debris Baskets are designed to be manually removed (via the owner's crane) for removal of accumulated debris. Upon operator observation, the Debris Basket is to be lifted from the sump via connection points. When the operator has positioned the Debris Basket over the discharge point, two connections on the non-sloped end may be disconnected. The operator will continue to lift the Debris Basket and the debris sill slide out the sloped end of the basket. The operator may now lower the basket and re-establish 4 connection points. The Debris Basket may then be transported to a washing point if further wash from owner's intake deck hose is required. The Debris Basket may then be returned to the sump.

II. SITE DATA

Site Name	Confidential SE Nuclear Plant
Water Source	Fresh Water River
Location (Indoors / Outdoors)	Outdoors
Deck Elevation	+ 565'

III. DEBRIS BASKET DATA

Quantity of Debris Baskets	Four (4)
Debris Basket Volume	3.0 m^3 (3.9 yd^3)
Debris Basket Length	10.0 ft.
Debris Basket Width	5.5 ft.
Debris Basket Height	2.7 ft.
Debris Basket Filter Size	0.5mm
Debris Basket Filter Element	Polyester Mesh
Debris Basket Weight – Empty	1,400 Lbs.
Debris Basket Weight – Full	3,969 Lbs.

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IV. MATERIALS OF CONSTRUCTION

ITEM	MATERIAL
Debris Basket Frame	Stainless Steel, Gr. 304 / 304L
Debris Basket Filter Element	Polyester
Fasteners	18-8 SS

V. PROTECTION

ITEM	PROTECTION
Debris Basket	None

VI. PACKING

The Debris Baskets will be boxed and suitable protected for the method of transport.

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Ref. P21-462 R0

SPECIFICATION FOR
STOP GATES

I. GENERAL DESCRIPTION

The Stop Gates are designed to allow various sections of an intake structure to be dewatered, thus facilitating equipment maintenance, inspection or removal in a non-immersed condition. The Stop Gates will be stored in a vertical storage rack adjacent to the intake for "on demand" use as required by the operating conditions. Stop Gates will be inserted / removed under equal water level conditions with no upstream / downstream water differential.

A concrete apron wall (wall extending from the deck level to below a designated water level), is to be incorporated into the civil works structure, (designed and supplied by others). Each set of Stop Gates will extend from the invert (channel bottom) elevation to just above the bottom of the corresponding apron wall. This will reduce the overall height and weight of stacked gates sections for dewatering.

The Stop Gates will be manufactured in various heights and various widths, depending on the opening to be inserted. The Stop Gates will be constructed of heavy beam sections spanning the width of each channel. The beam sections will be covered by a skin plate of suitable thickness to withstand the required water differential, when combined with the beams. The Stop Gate sections will utilize heavy corrosion resistant, high durometer neoprene seals which will work in conjunction with Guide Frames, permanently embedded within the civil works structure.

The Guide Frames, consisting of Upper, Lower and Side Guide Frames, will be installed in two phases to ensure the most accurate seal for the specific gate. The first phase will incorporate oversized plates that are to be embedded in the civil works during the primary construction of the intake. The oversizing of the plates will accommodate some liberality in respect to accuracy of location and concrete tolerance, yet ensure a positive seal after phase two. The oversized plates will be situated in strategic locations to mesh with the Upper, Lower and Side Guide Frames. The second phase will consist of attaching the Upper, Lower and Side Guide Frames to the embedded plates. Once attached, actual gate sections are to be lowered into place and the Guide Frames finely adjusted prior to the incorporation of high strength grout / second phase concrete to encapsulate the embedded plates and permanently incorporate all Guide Frames into the intake civil works.

When a Stop Gate is required to be removed or inserted, the task is simplified by means of a semi-automatic attaching / detaching lifting beam. This is commonly referred to as an "Automatic Lifting Beam". The Automatic Lifting Beam will incorporate lifting hooks to attach to each gate section, as well as a sensing rod, designed to prevent the lifting beam from disengaging until properly seated. When a gate is attached to the Lifting Beam for insertion, a counter weight is shifted to the 'detach' position, however the gate will not detach until the sensing rod is engaged. The operator lowers the gate into position. Once the gate is seated on the invert or atop another gate section, the sensing rod will interact with the lifting beam and allow the hooks to disengage with the gate section, without the need to send a diver into the water. When a gate is to be removed, the above process is reversed and the counterweight shifted to the 'attach' position.

Once the beam is attached to the upper most gate section, an operator will make a small lift to open the Equalizing Valves. The Equalizing Valves will allow water to flow from the flooded side to the dewatered side. This eliminates the requirement to pump water back into the dewatered side. Once the water levels are completely equal on the upstream and downstream sides of the gates, all gate sections may be removed and returned to the storage rack.

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A Storage Rack will provide for the Stop Gates and Lifting Beam to be stored in a convenient, non-immersed location. The gates will be stored in a near vertical positon, aligned in various slots along the length of the Storage Rack. The Storage Rack will include any necessary access ladders and handrails to facilitate operator use with the owner's crane. All slings, shackles, chains or cables for attachment from the owner's crane to the Lifting Beam are to be provided 'by others'.

Lift recommendations – we suggest accommodating 2 x the heaviest gate section for calculating lifting requirements. This would allow for gates sticking in the guides, minor marine growth and other factors that affect the weight of the stop gates.

II. SITE DATA

Site Name	Confidential SE Nuclear Plant
Water Source	Fresh Water River
Location (Indoors / Outdoors)	Outdoors
Deck Elevation	+ 565'
High Water Elevation	+ 562'
Mean Water Elevation	+ 556'
Low Water Elevation	+ 550'
Bottom of Apron Wall Elevation – Upstream of Screens	+ 550'
Invert (bottom) Elevation	+517'

III. STOP GATE DATA

Gate Ref. Location	Inlet	Outlet
Equipment Tag No.		
Number of Gates	Two (2)	Two (2)
Number of Guides	Twenty-two (22)	Twenty-two (22)
Width (nominal)	11'-0"	11'-0"
Height (total nominal)	33'-0"	44'-0"
Seal Directions	On-seating	On-seating
Design Differential -Static	45'-0"	45'-0"
Equalizing Valves	Yes	Yes
No. Sections/gate	Three (3)	Four (4)
Section height/gate	11'-0"	11'-0"
Weight / heaviest section	9,280 Lbs.	10,110 Lbs.
Lifting beam width	11'-0"	11'-0"
Lifting beam weight	1,483 Lbs.	1,483 Lbs.
No. Lifting beams	One (1)	One (1)
No. Storage Racks	One (1) Common	One (1) Common
Storage Rack Access Ladder	Yes	Yes
Storage Rack Walkway	Yes	Yes

*** Suggest using 2X this weight to accommodate gates sticking in the guides**

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IV. MATERIALS OF CONSTRUCTION

ITEM	MATERIAL
Stop Gate	
•Main Construction	Carbon Steel, ASTM A-36
•Seals	Neoprene – high durometer
•Seal Securing Clamps	Carbon Steel
•Seal / Clamp Securing Fasteners	18-8 SS
•Guide Rollers / Guide Blocks	Nylon No. 6 / UHMW
•Equalizing Valves	304 SS
•Equalizing Valve Seal	Neoprene
•Valve and Sensing Rod Guide	UHMW
Embedded Guides	
•Phase 1 Embeds	Carbon Steel, ASTM A-36
•Frames – Phase 2 (upper, lower, sides)	304/304L SS
•Frame Adjusting Studs, Washer and Nut	18-8 SS
Lifting Beam	
•Main Construction	Carbon Steel, ASTM A-36
•Fasteners	18-8 SS
Storage Rack	
•Storage Rack Main Construction	Carbon Steel, ASTM A-36
•Storage Rack Fasteners	18-8 SS

V. PROTECTION

ITEM	PROTECTION
Stop Gates	Coating System No. 1
Stop Gate Guides	None - SS
Phase 1 Embeds	None – Embedded in concrete
Lifting Beam	Coating System No. 1
Storage Rack	Coating System No. 1

Coating Systems:

1. Carbon Steel blast cleaned to SSPC SP 10 and coated with multiple coats of marine grade high solids epoxy to 10-12 mils average dry film thickness.

VI. LEAKAGE

Although complete gate sealing is anticipated, based on minor corrosion that may occur over the years, biological and marine growth on the guides and other uncontrollable factors, a leakage rate of 0.2 l/sec per meter of perimeter seal length should be accommodated with sump pumps when a chamber is dewatered.

VII. PACKING

The Stop Gates will be bundled and banded in sections suitable for the method of transport. The Upper, Lower and Side Guide Frames will be bundled and banded in groups suitable for the method of transport. The Phase 1 embedment's, fasteners and anchors will be boxed and identified.

ADEM Watermark

Ref. P21-462 R0

SPECIFICATION FOR BAR SCREENS

I. GENERAL DESCRIPTION

The Bar Screens are designed to prevent coarse debris larger than the vertical bar spacing from passing downstream. Water borne debris will be retained on the upstream portion of the Bar Screen for removal by the designated cleaning mechanism. The Bar Screens will consist of solid, rectangular bars, evenly spaced, in a vertical orientation at the inclination described in the data tables below.

The Bar Screen bars will be welded to horizontal straps and fabricated in removable vertical sections suitable for handling. The sections will be vertically mounted to horizontal beams spanning the width of the designated channel. The horizontal beams will be permanently mounted to the sides of the intake channel at designated spaces. The size of the beams will be sufficient to support the Bar Screens sections and the indicated differential head loss created by fouling / capturing debris.

A concrete apron wall (wall extending from the deck level to below a designated water level), is to be incorporated into the civil works structure, (designed and supplied by others). The Bar Screens will extend from the invert (channel bottom) elevation to just above the bottom of the apron wall.

II. SITE DATA

Site Name	Confidential SE Nuclear Plant
Water Source	Fresh Water River
Location (Indoors / Outdoors)	Outdoors
Deck Elevation	+ 565’
High Water Elevation	+ 562’
Mean Water Elevation	+ 556’
Low Water Elevation	+ 550’
Bottom of Apron Wall Elevation	+ 550’
Invert (channel bottom) Elevation	+ 517’
Maximum Immersion	45’-0”
Minimum Immersion	33’-0”

III. HYDRAULIC DATA

Flow per Bar Screen	96,821 GPM
Velocity through clean Bar Spaces *	0.73 ft/sec
Head Loss across Bar Screen – 100 % clean*	0.1”
Head Loss across Bar Screen – 75 % clean *	0.2”
Head Loss across Bar Screen – 50 % clean *	0.7”
* Data based on minimum immersion percent cleanliness indicated	

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IV. BAR SCREEN DATA

Quantity of Bar Screens	Twenty-two (22)
Bar Screen opening (width x height)	11'-0" x 33'-6"
Bar Screen inclination angle	10^{o}
Clear space between bar	1-5/8"
Bar size (thickness x width)	3/8" x 2"
Spacing Pitch	2"
Static Headloss Design - maximum	5'-0"
Estimated Weight – Vertical Sections	6,210 Lbs.
Estimated Weight – Horizontal Beams	3,842 Lbs.

V. MATERIALS OF CONSTRUCTION

ITEM	**MATERIAL**
Bar Screens	
•Bars	Carbon Steel, ASTM A-36
•Bar Screen straps	Carbon Steel, ASTM A-36
Horizontal Supports	
•Horizontal beams	Carbon Steel, ASTM A-36
•Fasteners - straps to beams	18-8 SS
•Anchors – beams to civil works	304 SS
•Anchor nuts and washers	18-8 SS

VI. PROTECTION

ITEM	**PROTECTION**
Bar Screen bars	Coating System No. 1
Bar Screen horizontal beams	Coating System No. 1
Bar Screen fasteners	None - SS
Bar Screen beam anchors	None - SS
Bar Screen anchor nuts & washers	None - SS

Coating Systems:

1. Carbon Steel blast cleaned to SSPC SP 10 and coated with multiple coats of marine grade high solids epoxy to 10-12 mils average dry film thickness.

VII. PACKING

The Bar Screen sections will be bundled and banded in sections suitable for the method of transport. The horizontal support beams will be bundled and banded in groups suitable for the method of transport. The fasteners and anchors will be boxed and identified.

ADEM Watermark

Ref. P21-462 R0

SPECIFICATION FOR
TALON RAKE® AUTOMATING RAKING MACHINES

I. GENERAL DESCRIPTION

The Talon Rake will be designed to fit the civil works structure, capture debris retained by the Bar Screens and transport debris to the designated discharge location. The Talon Rake will operate from an overhead structure and rake while descending. The Talon Rake will consist of a Monorail, Support Columns, Traverse Carriage, Carriage Electrification, Rake Head and Control System. The Rake will normally rest in a "parked" position. When a start signal is received, an audible and visual warning is given, the Rake will traverse to the first cleaning zone, perform a rake cycle and transport the capture debris to the designated discharge. The Rake will then traverse to the next cleaning zone and repeat, until all cleaning zones have been accessed. Further details on control modes are described below.

The Monorail will consist of a uniformly shaped track, spanning across the cleaning zones, discharge and park locations. The Monorail will be fabricated from heavy structural steel, formed as an upside down "U" to protect Carriage Components from adverse environmental conditions. Designs utilizing open "I" beam construction are not allowed. The Monorail will be supported at strategic locations by Support Columns

The Support Columns will be heavy structural shapes. The Support Columns will be fabricated to include thick plate "baseplates" for attachment to the civil works deck via designated anchors.

The Monorail/Support Columns and Anchors are designed for the dead and live loads imposed. The loads consist of; dead weight, operating, wind and seismic.

The Traverse Carriage will include all the mechanical components to traverse the carriage and operate the Talon Rake Head. The Traverse Carriage will include a four-sided cover, carriage frame, traverse motor drive, hoist motor drive, hoisting shaft assembly and hydraulic opening/closing mechanisms. The Traverse Carriage will communicate its position to the Control System via specially designed targets located at strategic cleaning / discharging points throughout the track. The Traverse Carriage will be powered by a Carriage Electrification system.

The Carriage Electrification system will include a specifically designed festoon system to power the Traverse Carriage. The festoon system will be fed by the site main power and transfer power to the Traverse Carriage by festoon cables supported by festoon cars traveling within the monorail.

The Rake Head is suspended from the Traverse Carriage by wire ropes and will include special rear tines, designed to penetrate the Bar Screens as the Rake Head descends. During operation, the Rake Head will be positioned above a cleaning zone. When the Rake Head descends, the rear tines will engage the Bar Screens. Upon encountering the Bar Screens, the rear tines will penetrate the spaces between the bars. As the tines descend, debris retained by the Bar Screen will be moved forward into the jaws of the Rake Head. When the Rake Head reaches the designated depth, the Rake Head will close via hydraulic cylinders, suitable for submerged service. Upon closing, the Rake Head will ascend above deck level, engage the Traverse Carriage and debris will be transported to the designated discharge location. When traversing, the Rake Head is prevented from lateral movement by restrictors located on the Traverse Carriage. During the descent of the Rake Head, if an insubmersible load is encountered, the rake will be prevented from further descent by load sensing switches monitoring cable tension. The rake will close and resume the normal cycle.

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When all cleaning zones have been cleaned the rake will return to any zone that did not reach the lower limit and repeat the cleaning process. If after a selected number of times without reaching the lower limit the unit will continue to any additional locations and then return to the dump/designated park location. The cleaning zone(s) not fully cleaned will be indicated on the HMI.

The Control System will monitor the activities of the Talon Rake utilizing a PLC and allow for operation in several modes, including “Off”, “Auto” and “Manual”.

OFF - When the controls are switched to the “Off” mode, this is as the name implies and the unit will not function in Automatic or Manual mode.

AUTO - When the controls are switched to “Auto”, multiple inputs are utilized to allow the Talon Rake to function automatically. When any of the start signals listed below is received, audible and visual alarms will actuate. The audible alarm (horn) will sound for a predetermined period to alert nearby personnel that the Talon Rake is beginning and automatic cycle. The visual alarm (flashing light mounted to Traverse Carriage) will continue to illuminate if the unit is in automatic mode. Start signals can be provided as follows:

- Time clock within the PLC that can start the unit at predetermined times of Day
- Interval time within the PLC that can start the unit based on time interval
- Differential control upon sensing excess differential across the Bar Screens
- Manual initiation of an automatic cycle via a pushbutton
- Remote start from plant controls

MANUAL – When the controls are switched to “Manual”, this will allow the manual wireless remote to control the movements of the rake to include:

- Traverse Carriage - Traverse towards Clean or towards Dump
- Rake Head – Lower the Rake Head or raise the Rake Head
- Rake Head – Open the Rake Head or Close the Rake Head

SAFETY FEATURES – The Control System includes several safety features such as:

- If an insubmersible load is encountered, the rake will be prevented from further descent by load sensing switches monitoring cable tension.
- The Carriage will not traverse unless the Rake Head is engaged with the Traverse Carriage
- If the hoist senses an overload, the unit will trip off and an alarm will annunciate
- Overtravel switches for the Rake Head up/down limits, the unit will trip off and an alarm will annunciate
- Overtravel switch for the carriage travel, the unit will trip off and an alarm will annunciate
- Watchdog timers for Rake Head and carriage travel, the unit will trip off if the expected time is exceeded and an alarm is annunciated
- Program sequence errors, the unit will trip off and an alarm will annunciate

INPUT FEATURES – The features below are standard, additional site specific features are available:

- Cleaning Zone/Cleaning Pick - On/Off
- Partial Depth Cleaning – On/Off
- Continuous mode – On/Off
- Duty/Standby on multiple units

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MONITORING FEATURES – The control system will monitor the following activities:

- Hours of operation for traverse drives
- Hours of operation for hoist drives
- Hours of operation for closing drives
- Switches to monitor "on / off" of various cleaning and discharge positons
- Maintenance requirements
- Various "Faults"

Please see separate "SPECIFICATION FOR CONTROL SYSTEM" attached for additional information.

II. SITE DATA

Site Name	Confidential SE Nuclear Plant
Water Source	Fresh Water River
Location (Indoors / Outdoors)	Outdoors
Deck Elevation	+ 565'
High Water Elevation	+ 562'
Mean Water Elevation	+ 556'
Low Water Elevation	+ 550'
Bottom of Apron Wall Elevation	+ 550'
Invert (channel bottom) Elevation	+ 517'
Maximum Immersion	45'-0"
Minimum Immersion	33'-0"

III. HYDRAULIC DATA – BAR SCREENS
(please refer to the accompanying Bar Screen specification)

IV. TALON RAKE GENERAL DATA

Number of Talon Rakes / Duty & Standby	Two (2) Rakes – Duty / Standby
Capacity Work Load (Safe Hoist Capacity)	1,500 Lbs.
Rake Head Effective Width	8'-0"
Monorail Continuous Length (straight + curved)	317'-0"
Discharge Height Above Deck	8'-0"
Support Column Quantity (single + double leg)	Twenty-three (23) Double Leg Columns
Traverse Carriage Weight	2,200 Lbs.
Traverse Carriage Lateral Speed	60 ft/min
Rake Head Weight	1,100 Lbs.
Rake Head Lowering / Hoisting Speed	60 ft/min

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V. HOIST DRIVE DATA

Electric Motor Size	7.5 Hp
Electric Motor Power – Voltage / Phase / Hertz	460 V / 3 Ph / 60 Hz
Electric Motor Speed - RPM	1800
Electric Motor Enclosure	TEFC
Electric Motor Insulation Class	F
Electric Motor NEMA / IEC Design	NEMA Design B
Electric Motor Torque Limiter Type	Current monitor
Gear Box Type	Helical bevel

VI. TRAVERSE DRIVE DATA

Electric Motor Size	2 Hp
Electric Motor Power – Voltage / Phase / Hertz	460 V / 3 Ph / 60 Hz
Electric Motor Speed - RPM	1800
Electric Motor Enclosure	TEFC
Electric Motor Insulation Class	F
Electric Motor NEMA / IEC Design	NEMA Design B
Gear Box Type	Current monitor

VII. CLOSING MECHANISM DATA

Electric Motor Size	2 Hp
Electric Motor Power – Voltage / Phase / Hertz	460 V / 3 Ph / 60 Hz
Electric Motor Speed - RPM	1800
Electric Motor Enclosure	TEFC
Electric Motor Insulation Class	Class F
Electric Motor NEMA / IEC Design	NEMA Design B
Hydraulic Cylinders	Two (2)
Hydraulic Pressure	1300 PSI
Hydraulic Fluid	Biodegradable

VIII. MATERIALS OF CONSTRUCTION

ITEM	**MATERIAL**
Monorail	
• Structural Track Members	Carbon Steel – ASTM A-36
Support Columns	
• Single Leg Columns	Carbon Steel
• Double Leg Columns	Carbon Steel
• Column Baseplate	Carbon Steel

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Traverse Carriage	
• Carriage Cover	304 Stainless Steel
• Carriage Frame	Carbon Steel – ASTM A-36
• Hoist Shaft	AISI 1040/1045
• Hoist Sheaves	Carbon Steel – ASTM A-36
• Hoist Wire Ropes	316 Stainless Steel
Carriage Electrification	
• Electrification Rail	PVS
• Rail Mounts	Plated Steel
Rake Head	
• Front and Rear Tines	Carbon Steel – ASTM A-36
• Engagement Stabilizer	UHMW
Fastener Nut / Bolts	
• Monorail to Support Columns	Carbon Steel – Zinc Plated
• Support Column Foundation Anchors	316 Stainless Steel

IX. PROTECTION / COATINGS

Please note that items of stainless steel, brass, bronze, high density plastic or other corrosion resistant materials will not receive additional coatings. Other materials listed below will be protected or coated as indicated below:

ITEM	PROTECTION
Monorail Structural Track	Coating System 1
Support Columns and Baseplates	Coating System 1
Traverse Carriage Cover	None - SS
Traverse Carriage Frame	Coating System 1
Hoist Shaft	Coating System 3
Electrification Rail Mounts	Plated Steel
Rake Head	Coating System 1

Coating Systems:

1. Carbon Steel Hot Dip Galvanized to ASTM A-123
2. Not Used
3. Carbon Steel - Brush cleaned and 1-3 mils epoxy shaft coating

X. PACKING

The Talon Rake will be bundled and banded in sections suitable for the method of transport as follows:

- The Monorail will be broken down in manageable sections for site assembly.
- The Support Columns of single leg type will be preassembled. Double leg columns will be bundled for site assembly.
- The Traverse Carriage will be crated for protection.
- The Rake Head will be crated for protection.
- The Carriage Electrification system will be individually boxed for protection.
- Assembly fasteners / anchors will be boxed and identified.

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REF: P21-462 R0

**SPECIFICATION FOR CONTROL PANEL
FOR TALON RAKE® AND DUAL FLOWS**

A. GENERAL DESCRIPTION

The control panels will house the controls for the Talon Rake®, Dual Flow Screens and differential instruments. Multiple panels will control the Dual Flow Screens, one panel for the Talon Rake and one panel will monitor water levels and calculate differentials via the system PLC. The differential instruments will be field mounted with signals sent to the control panel.

An HMI interface will be provided with custom screens for the operation, monitoring and maintenance of each piece of equipment. All panel mounted door devices will have a minimum rating equal to the enclosure rating. See detail specifications for operation of each piece of equipment.

B. TALON TRAVELING RAKE – See the details of the Talon Rake specification for operation

The control panel will provide all control components necessary for operation of the unit.

C. DUAL FLOW SCREEN – See the details of the Dual Flow specification for operation

The control panel will provide all control components necessary for operation of the screens

D. DATA

Number of Rakes Controlled	Two (2)
Number of Bar Screens Raked	Twenty-two (22)
Dump Locations	One (1) each end
Number of Dual Flows Controlled	Twenty-two (22)
Number of Control Panels	Later
Location	Outdoors
Enclosure	NEMA 4
Mounting	Free Standing
Power In	460 V / Ph 60 HZ
Depth	Later
Width	Later
Height	Later
PLC *	Allen Bradley
HMI *	Allen Bradley
Pilot Devices *	IDEC
Transformer *	Square D
Panel Disconnect *	ABB
Motor Contactors *	ABB
VFD *	ABB
Differential Instruments*	Mercoid
Estimated Weight	Later

* Manufacturers are shown for general information and are subject to change at design time to an equivalent supplier.

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E. FIELD MOUNTED INSTRUMENTS

Water Level Indication	2 upstream / 2 downstream = 4 total
Water Level Indicator Type	Ultrasonic Transmitter (4-20 Ma)

F. ACCESSORIES

None required or furnished

G. PROTECTION

Stainless or corrosion resistant plastics will not be coated.

Items will be supplied in the manufacturers standard finish suitable for the application.

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WTR® Fish Recovery and Return Screens

Pump and Condenser Protection





Fish Recovery and Return Screens to Meet US EPA 316(b)

WTR® WATER SCREENING SOLUTIONS

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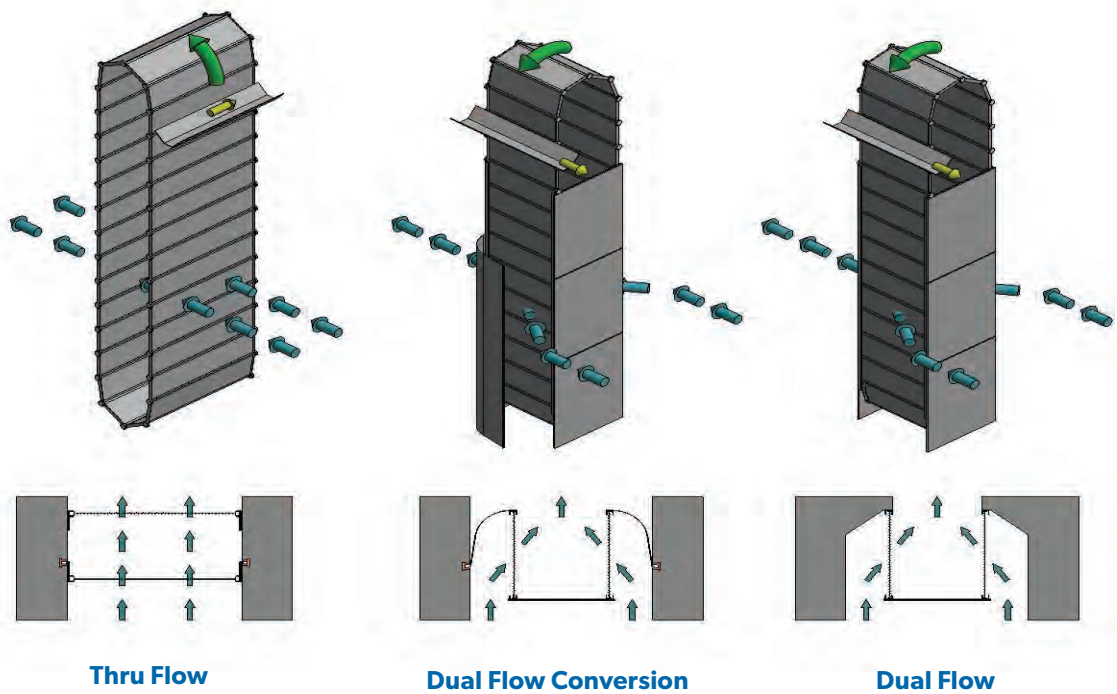
Fish Recovery and Return Screens

The US EPA Clean Water Act, Section 316(b) allows for numerous different compliance methods to meet Best Technology Available (BTA) requirements for impingement mortality standards. One of the more cost effective means of compliance is based on option 5, allowing the owner to "operate a modified traveling screen that the EPA or other permitting authority determines is the best technology available for impingement reduction."

WTR's team members have been involved with 316(b) since 1977 and were instrumental in the development of the hydraulically optimized fish bucket for fish recovery, also known as a "modified Ristroph screen." This revolutionary design significantly decreased impingement mortality while increasing the rate at which otherwise impinged fish were extracted. The hydraulically optimized fish recovery bucket has been deemed one of the Best Technologies Available for meeting impingement mortality standards.

WTR's Fish Recovery and Return (FRR) Screens are one of the most cost effective means for compliance under 316(b), Sec. 5 and are available for new intakes or retrofit into existing facilities. WTR's FRR Screens are designed to automatically and reliably filter incoming water and discharge recovered marine life and debris into the appropriate handling trough. Screens can be designed to handle typical waterborne debris as well as unusual grasses, seaweed, jellyfish and many different types of debris. WTR's FRR Screens are available in various flow patterns, including Thru Flow (TF), Dual Flow Conversion (DFC), and Dual Flow (DF).

All flow patterns are available as Fish Recovery and Return to meet 316(b) environmental requirements. Specialized watertight, hydraulically optimized fish recovery buckets allow for the quick recovery of juvenile marine life. Marine organisms are elevated to the head section, where gentle fish sluice sprays aid in discharging them into a return trough for reinsertion to their indigenous environment. After the fish sprays, the screen continues rotation past higher pressure debris sprays, washing the captured screenings into a separate debris trough for discharge, separation, or disposal.



Fish Recovery Screen Flow Patterns

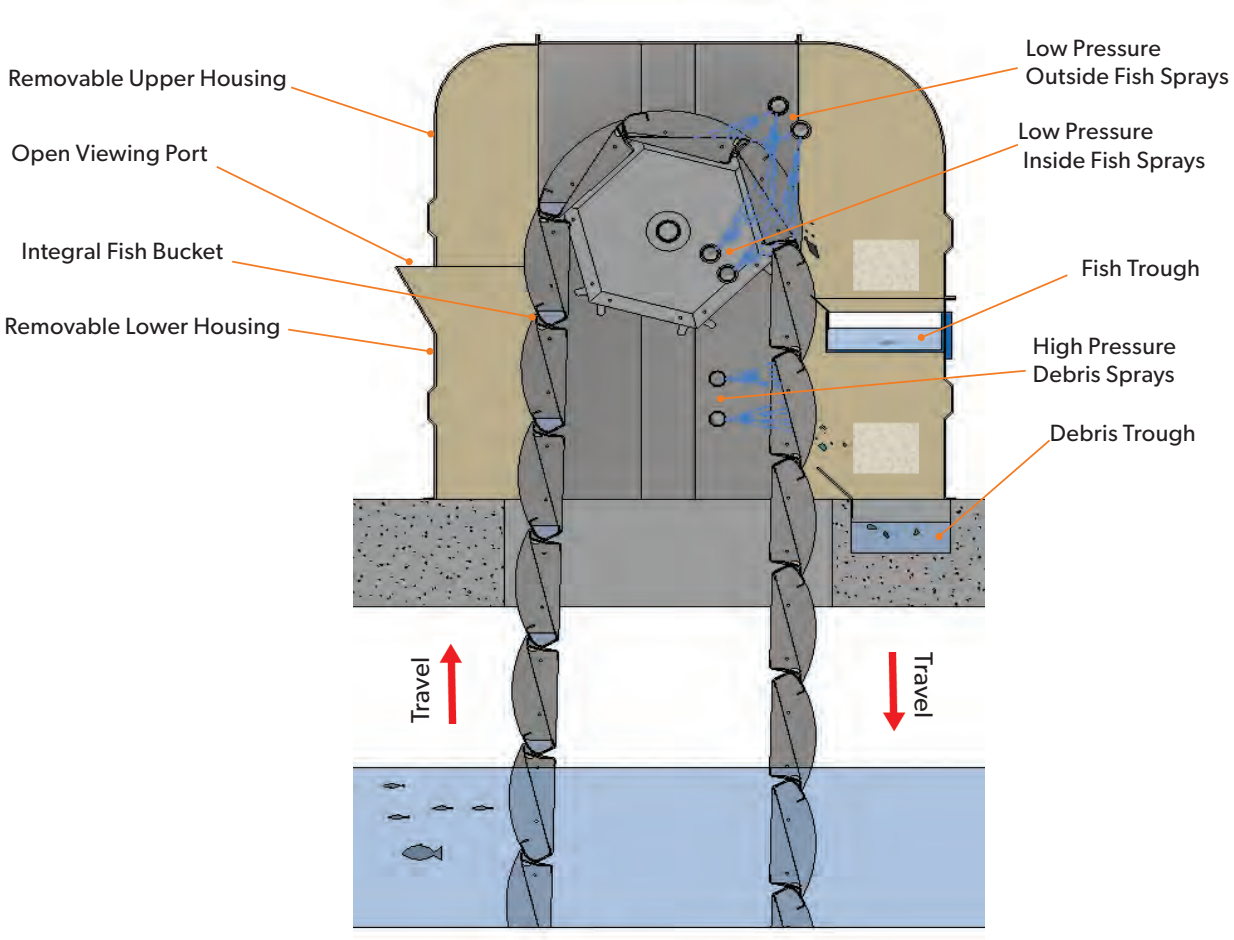
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Features:

- Screens built to site specific conditions for flow, mesh aperture, debris and marine life handling.
- Hydraulically optimized fish buckets and high net panel efficiency reduce velocity and head loss.
- Descending discharge with inclined mesh reduces spray water and enhances marine discharge.
- Materials of mainly Carbon Steel (epoxy coated or galvanized) or Stainless Steel (304L, 316L, Duplex or other).
- Mesh opening is typically 2mm or sizes from 0.5mm to 9.5mm (0.019" to 0.375") square opening are available.
- Variable Frequency Drive (VFD) motors incorporate multiple speeds, provide flexibility and user interface.

COMPONENT OPTIONS

- Shaft mounted drive to reduce maintenance and eliminate shear pins, drive chain, sprockets and bulky chain guards.
- Smooth top mesh inserts in square or rectangular openings to provide greater open area.
- Oversized, non-lubricated carrier chain rollers, pins and bushings to reduce horsepower and extend chain life.
- Dual spray headers to provide positive, overlapping coverage for debris removal and flushing.
- Full rim sprockets to drive the carrier chain via the sidebars, to extend chain life and reduce joint wear.
- Anti-friction take up bearings for continuous operation to decrease maintenance attention.
- Chain tensioning from deck level to provide instant access for adjustment and eliminate ladders and platforms.
- Roll around boot section for positive tracking to eliminate submerged sprockets with constant jamming.
- Panel-to-panel seals and frame-to-panel seals to eliminate bypassing for fine mesh applications.
- Manual or automatic self flushing spray headers and debris trough to prevent debris accumulation.
- Replaceable track wear bars to extend frame life and ease future overhauling of main chain guide tracks.
- Control systems for Differential Control (ultra-sonic or radar) with HMI touchscreen or via DCS monitoring.



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Fish Recovery Screen Sizing Data

Plant / Site Name _____

Site Location _____ (City, State, Country)

Construction ☐ New ☐ Existing ☐ New Expansion

Water Source ☐ Fresh ☐ Brackish ☐ Sea ☐ Cooling Pond

Number of Channels _____ ☐ Indoor ☐ Outdoor ☐ Covered

Flow Rate per Channel _____ GPM _____ M^3/sec _____ MGD

Channel Width (each) _____ Feet _____ Meters

Deck Elevation or Depth _____ Feet _____ Meters

Hi Water Elev. or Depth _____ Feet _____ Meters

Lo Water Elev. or Depth _____ Feet _____ Meters

Invert / Bottom Elev. _____ Feet _____ Meters

Desired Mesh Opening _____ Inch _____ mm

Desired Flow Pattern ☐ Thru Flow ☐ Dual Flow Conversion ☐ Dual Flow

Desired Materials _____ Mesh _____ Panels _____ Main Frame

Typical Debris Expected _____

Typical Marine Life _____

Upstream Bar Screen ☐ Yes ☐ No Clear Bar Opening _____ In. _____ mm

Main Power _____ Voltage _____ Phase _____ Hertz ☐ Hazardous

Approx. Distance From
Last Screen to Fish Return Point _____ Feet _____ Meters

Special Options _____

CONTACT DETAILS

Company Name _____

Contact Person Name _____

Email and Phone Number _____

Represented by:

WTR® WATER SCREENING SOLUTIONS

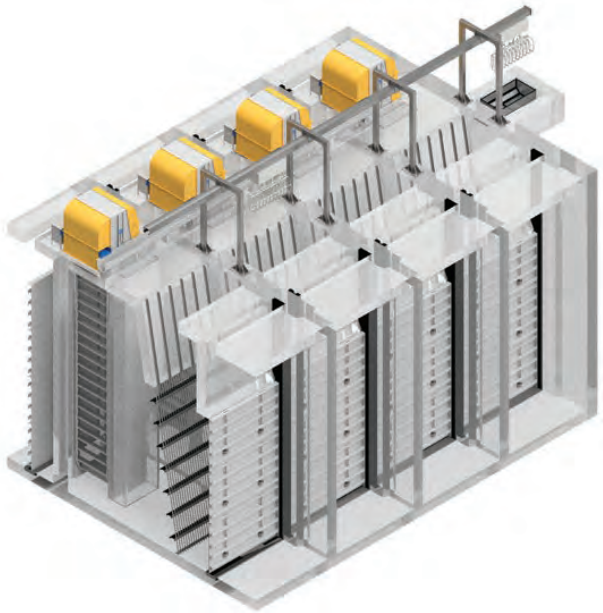
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WTR® Stop Gates and Lifting Beams

Intake Dewatering and Maintenance





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Stop Gates and Lifting Beams

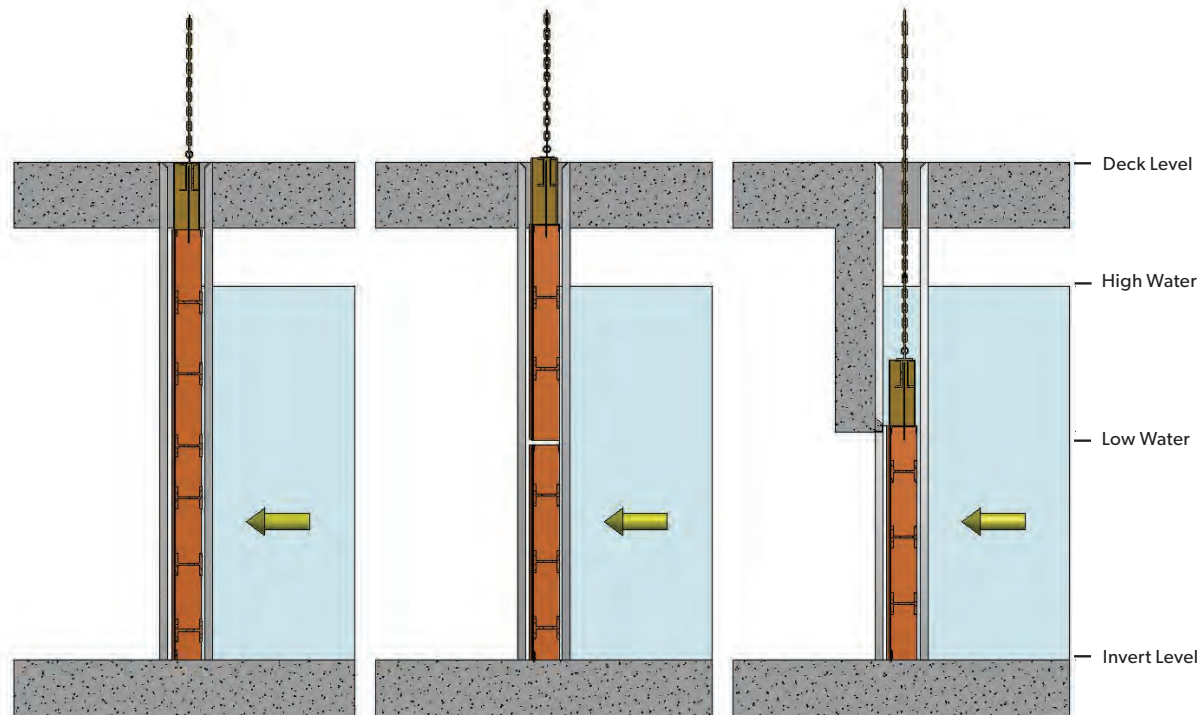
WTR's Stop Gates and Lifting Beams are an essential component to support dewatering of intake structures for maintenance, inspection or isolation. Stop Gates, (AKA Stop Logs), are used in all types of applications where maintenance under dry conditions is required, inspection of the structure is necessary or a flow stream needs to be isolated. Applications include power plant raw water intakes (fossil and nuclear), industrial raw water, potable drinking water, irrigation and numerous other types of plants.

Unlike Sluice or Slide Gates, Stop Gates are unique. In lieu of being "fixed" and subjected to constant submergence and corrosion, (common with Sluice and Slide Gates), Stop Gates are stored above the water. Since most raw water intakes do not require frequent dewatering, Stop Gates are utilized only when required.

WTR Stop Gates are designed to provide superior sealing of intakes via a dedicated guide location and installation process. Our multi stage guide embedment process during construction of the intake assures proper fit and mating of the gates with the guides. Gates are installed with the water balanced on either side. When dewatering of the intake begins, the "on-seating head" will create a tight seal providing minimal or no leakage.

WTR Stop Gates are also designed to work in conjunction with a dedicated Lifting Beam, which allows for controlled engagement and disengagement of gate sections. This eliminates the need for divers in the water to connect and disconnect gate sections during insertion or removal. When inserted in the guide slot, the bias of the Lifting Beam will not allow disengagement of a gate section until properly seated, as confirmed by a sensing rod. When placed in the opposite bias, the Lifting Beam will engage with the upper most gate section for extraction.

Stop Gates can be supplied in single piece / full height configurations, multiple sections to reduce overhead lifting height or apron wall design to minimize gate height and quantity. Other options include balancing valves, dual direction guides, access ladders and above or below deck storage racks.



Stop Gate Optional Arrangements

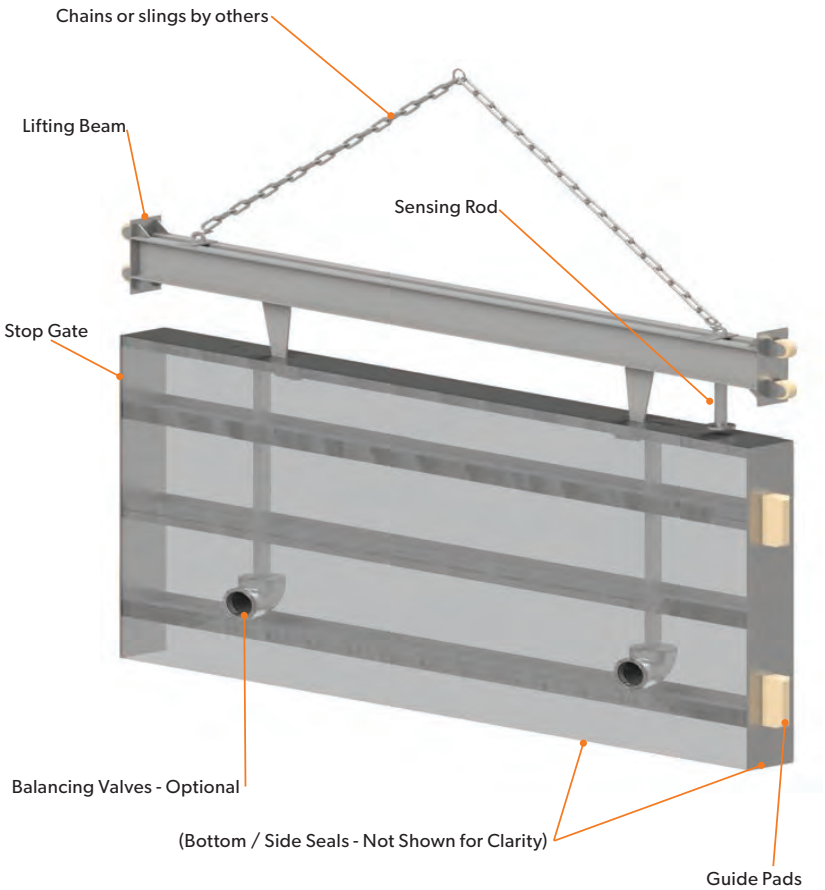
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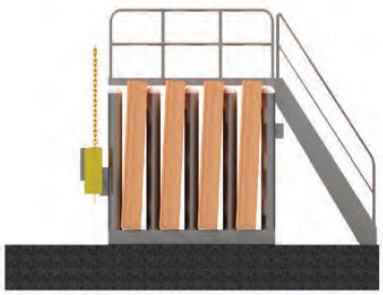
Features:

- Stop Gates are built to site specific conditions, typically from 3ft. (1m) to 20ft. (6m) wide.
- Gates are normally supplied in Epoxy Coated Carbon Steel. Options for alternate materials are available.
- Each gate includes guidance rollers to prevent binding during insertion or removal under balanced water levels.
- Gates include side and bottom seals of high durometer neoprene for positive sealing.
- Designed for "on-seating head" to create an increasingly tighter seal to prevent leakage.
- Guides located in a dedicated slot, installed in a multi stage process to assure positive fit with Stop Gates.
- Guides are available in 316L SS, Duplex or Super Duplex and should be included in the intake cathodic protection system.
- Gate Lifting Beam accommodates submerged engagement and disengagement from gate sections.
- Lifting Beam operates in conjunction with sensing rod on gate to confirm seating prior to Lifting Beam disengagement.
- Lifting Beams are normally supplied in epoxy coated carbon steel. Options for alternate materials are available.

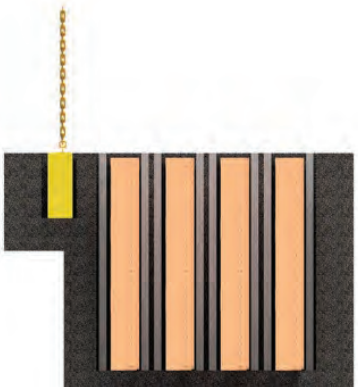
Options

- Single piece / full height gates.
- Multiple section gates to reduce required lifting height.
- Apron wall design to minimize overall gate height and quantity of gates.
- Balancing valves to allow for gravity refilling of intake.
- Dual direction guides to accommodate sealing in either direction by reversing the gate.
- Built in access ladders to allow for descending into the intake.
- Storage racks located above the deck with access ladder or below the deck within a sump.





Above Deck Storage



Below Deck Storage

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Stop Gate Sizing Data

(please complete for each channel width)

Plant / Site Name _____

Site Location _____ (City, State, Country)

Construction ☐ New ☐ Existing ☐ New Expansion ☐ Hazardous Area

Water Source ☐ Fresh ☐ Brackish ☐ Sea ☐ Closed Cycle

Number of Channels _____ ☐ Indoor ☐ Outdoor ☐ Covered Area

Flow Rate per Channel _____ GPM _____ M^3/sec _____ MGD

Channel Width (each) _____ Feet _____ Meters

Deck Elevation or Depth _____ Feet _____ Meters

Hi Water Elev. or Depth _____ Feet _____ Meters

Low Water Elev. or Depth _____ Feet _____ Meters

Invert / Bottom Elev. _____ Feet _____ Meters

Desired Arrangement ☐ One Piece ☐ Full Height Sec. ☐ Apron Wall Sec.

Desired Options ☐ Balancing Valves ☐ Dual Direction Guides ☐ Access Ladders

Desired Storage Rack ☐ Yes ☐ Above Deck ☐ Below Deck

Desired Guide Materials ☐ 316L SS ☐ Duplex SS ☐ Super Duplex ☐ Other _____

Desired Lift Beam Materials ☐ CS Coated ☐ 316L SS ☐ Duplex SS ☐ Other _____

Special Options _____

CONTACT DETAILS _____

Company Name _____

Contact Person Name _____

Email and Phone Number _____

WTR® WATER SCREENING SOLUTIONS
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Salt Lake City, Utah, USA

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WTR® Talon Rake® and Bar Screens

Traveling Screen and Pump Protection



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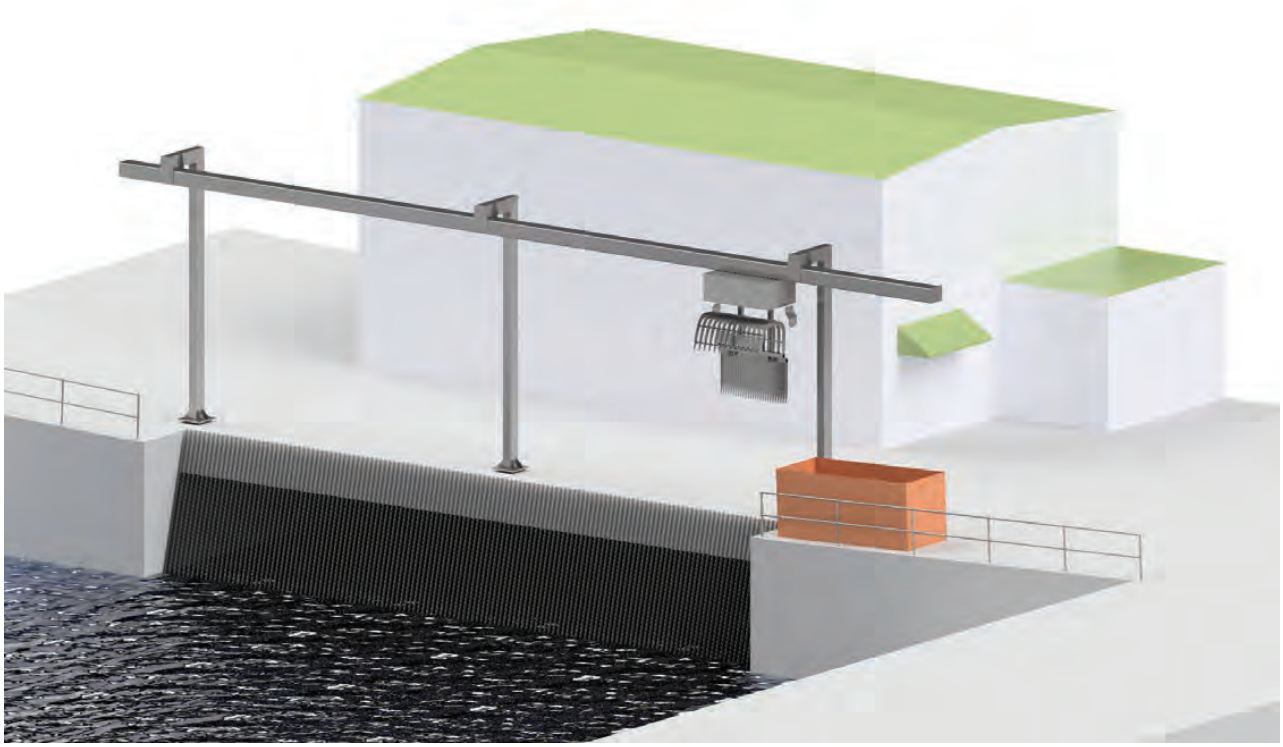
Talon Rake and Bar Screens

WTR's Talon Rake (monorail based automatic raking machine) and Bar Screens are one of the most economical means of protecting downstream equipment such as Traveling Screens, Drum Screens or Pumps. Talon Rakes can be used in all types of applications where debris accumulation on the Bar Screens is common and protection of downstream equipment is essential. Applications include power plant raw water (fossil, nuclear, hydro), industrial raw water, storm water, flood control pumping stations, domestic sewage treatment, potable water intake, irrigation and numerous other plant types.

Coarse debris in the flow can overwhelm and damage rotating screens or cause serious pump issues. Logs, branches, leaves, trash and common aquatic vegetation can blind various systems. Talon Rakes are designed to automatically clean bar screens and deposit debris at a designated dump location. The dump location is variable and can be off the deck or some distance away. The raking cycle can be started automatically by either differential control, built in timer, plant DCS or manual initiation. A hand held manual remote control is also provided to accommodate specific area cleaning or unusual debris removal.

Talon Rakes utilize no permanently submerged moving components. Rakes are typically supported by columns (single or double leg) at various locations for adaptation to new or existing sites. This provides a clear deck and allows direct discharge into debris receptacles. On the start signal, the Talon & Carriage will travel to the first cleaning point, clean a specific area, travel to the discharge location, dump and return to the next cleaning point. The process is continuous until all designated areas are cleaned.

HMI touch screen control allows for various areas to be turned on / off for cleaning. Other options such as partial depth cleaning for floating debris or site specific conditions are available with user friendly interface. Controls and Drives can be supplied for hazardous locations.



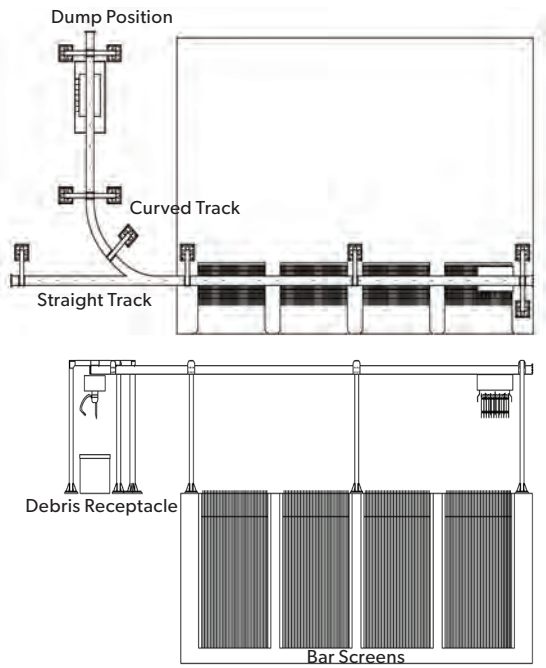
•Straight Track •Curved Track •Inclined Racks •Vertical Racks

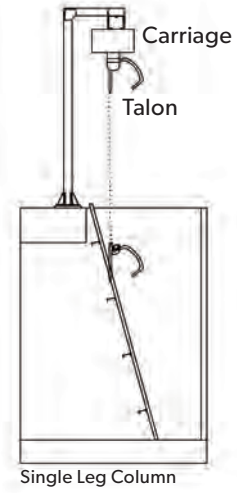
Talon Rake and Bar Screens

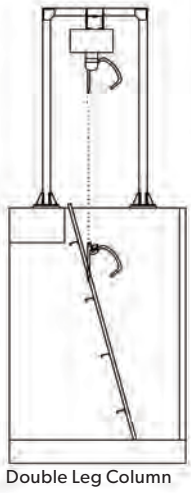
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Features:

- Bar Screens are built to site specific channel dimensions; typical single screens are 5ft. (1.5m) to 20ft. (6m) wide. Bar Screens may be individual (fixed or removable) or continuous width with specialized supports.
- Bar Screen materials can be Carbon Steel (galvanized or epoxy coated) or Stainless Steel (304L, 316L, Duplex or other).
- Talon Rakes use no permanent moving components below the deck or in the water. Any maintenance required is performed above the deck.
- Talon Rake heads can be Galvanized, Stainless Steel or Aluminum Bronze (for hazardous areas).
- Support structures (monorail and columns) are typically hot dip galvanized steel. Stainless Steel is also available.
- The Talon Rake uses a dedicated carriage electrification system avoiding windblown festoon loops.
- Talon Rakes provide positive debris retention by mechanical closure eliminating hydraulics and fluids in the water.
- Specially shaped monorail provides higher strength and protection of carriage drive components.
- Advanced controls via HMI touch screen interface with PLC can provide instant change of various control settings (bays on/off, partial depth, etc.), viewing of component status, run times, maintenance requirements and faults.
- Wireless remote control allows manual movement of rake for special debris, loading of debris or maintenance.







Model No.	TR-750		TR-1500		TR-3000		TR-5000	
	US	SI	US	SI	US	SI	US	SI
Capacity Work Load	750 Lbs.	340 kg	1,500 Lbs.	680 kg	3,000 Lbs.	1,360 kg	5,000 Lbs.	2,268 kg
Min. Clear Bar Space	1.25 inch	32 mm	1.50 inch	38 mm	1.50 inch	38 mm	2.00 inch	51 mm
Talon Rake widths	5.0 ft.	1.5 M	8.0 ft.	2.4 M	10.0 ft	3.0 M	15.0 ft.	4.6 M
Talon Rake weight	750 Lbs.	340 kg	1,200 Lbs.	544 kg	1,900 Lbs.	862 kg	2,400 Lbs.	1,088 kg
Hoist Motor Size	3 hp	2.2 kW	5 hp	3.7 kW	10 hp	7.5 kW	12.5 hp	9.3 kW
Hoist Speed	60 ft/min	18.2 M/min	60 ft/min	18.2 M/min	60 ft/min	18.2 M/min	50 ft/min	15.2 M/min
Traverse Motor-straight	1 hp	0.75 kW	1 hp	0.75 kW	1.5 hp	1.1 kW	2.0 hp	1.5 kW
Traverse Motor-curved	2 @ 1 hp	2 @ 0.7 kW	2 @ 1 hp	2 @ 0.7 kW	2 @ 1.5 hp	2 @ 1.1 kW	2 @ 2 hp	2 @ 1.5 kW
Traverse Speed - single	60 ft/min	18.2 M/min	60 ft/min	18.2 M/min	45 ft/min	13.7 M/min	30 ft/min	9.1 M/min
Traverse Speed - dual	60 & 120 ft/min	18.2 & 36.4 M/min	60 & 120 ft/min	18.2 & 36.4 M/min	45 & 90 ft/min	13.7 & 27.4 M/min	30 & 60 ft/min	9.1 & 18.2 M/min

Talon Rake and Bar Screen Data

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Talon Rake and Bar Screen Sizing Data

Plant / Site Name _____

Site Location _____ (City, State, Country)

Water Source _____ Fresh _____ Brackish _____ Sea _____ Waste _____ Storm

Number of Channels _____

Flow Rate per Channel _____ GPM _____ M^3/sec _____ MGD

Channel Width (each) _____ Feet _____ Meters

Total Width of Intake _____ Feet _____ Meters

Deck Elevation or Depth _____ Feet _____ Meters

Hi Water Elev. or Depth _____ Feet _____ Meters

Lo Water Elev. or Depth _____ Feet _____ Meters

Invert / Bottom Elev. _____ Feet _____ Meters

Desired Clear Bar Space _____ Inch _____ mm

Bar Screen Information _____ (new/existing) _____ (vertical/incline^0)

Desired Materials _____ Bar Screen _____ Talon

Typical Debris Expected _____

Main Power _____ Voltage _____ Phase _____ Hertz ☐ Hazardous

Special Options _____

CONTACT DETAILS

Company Name _____

Contact Person Name _____

Email and Phone Number _____

WTR® WATER SCREENING SOLUTIONS

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info@wtrengineering.com
Salt Lake City, Utah, USA

Represented by:

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Certificate US95/0255.00

The management system of

WesTech Engineering, Inc.

3665 South West Temple
Salt Lake City, UT 84115, United States

has been assessed and certified as meeting the requirements of

ISO 9001:2015

For the following activities:

The Design, Supply, Sales, and Service of Water and Waste Water Treatment and Liquid-Solid Separation Equipment.

Further clarifications regarding the scope of this certificate and the applicability of ISO 9001:2015 requirements may be obtained by consulting the organization.

This certificate is valid from 20 October 2020 until 20 October 2023 and remains valid subject to satisfactory surveillance audits. Recertification audit due a minimum of 60 days before the expiration date. Issue 12. Certified since June 1995.

The audit leading to this certificate commenced on 20/07/2020. Previous issue certificate validity date was until 20/10/2020.

This is a multi-site certification. Additional site details are listed on subsequent pages.

Authorized by:

Dan Seal
Technical Accreditation Manager, Certification & Business Enhancement North America
SGS North America, Inc.
201 Route 17 North, Rutherford, NJ 07070, USA
t (201) 508-3000 f (201) 935-4555 www.us.sgs.com

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Certificate US95/0255.00, continued

WesTech Engineering, Inc.

ISO 9001:2015

Issue 12

Detailed scope (applicable to all sites):

The Design, Supply, Sales, and Service of Water and Waste Water Treatment and Liquid-Solid Separation Equipment.

Additional facilities:

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600 Arrasmith Trail, Ames, IA 50010, United States

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Appendix G. Compliance and Social Costs

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Social Costs and Compliance Costs of Entrainment Reducing Technologies at Browns Ferry Nuclear Plant Based on Adjustments of Facility Costs

Tennessee Valley Authority

20 January 2022

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This report was prepared by National Economic Research Associates, Inc. (NERA) for the Tennessee Valley Authority in support of 40 CFR Section 122(r)10 Submittal for NPDES Permit No. AL0022080.

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I. Introduction and Background

This report provides estimates of the social costs of installing and operating two potential cooling water intake structure ("CWIS") alternatives for reducing entrainment at Browns Ferry Nuclear Plant ("BFN"). The social cost estimates provided in this report are based upon adjustments of the facility costs that are developed in the two BFN technology assessments prepared by ENERCON, one for a closed-cycle recirculating system and one for 0.5 millimeter ("mm") fine-mesh screens. (ENERCON 2022) We refer to these two technologies collectively as the CWIS alternatives. The report also provides estimates of compliance costs, as explained below.

A. Clean Water Act Requirements

The final rule promulgated by the U.S. Environmental Protection Agency ("EPA") to regulate CWIS under Section 316(b) of the Clean Water Act ("Final Section 316(b) Rule", EPA 2014b) requires regulated existing facilities to submit an engineering study of the technical feasibility and costs of candidate entrainment control technologies. The following are sections that describe the requirements for this §122.21 (r)(10) study (subsequently "(r)(10) study" or "(r)(10 requirements").

> *The owner or operator of an existing facility that withdraws greater than 125 mgd AIF must develop for submission to the Director an engineering study of the technical feasibility and incremental costs of candidate entrainment control technologies. In addition, the study must include the following:*
>
> > *(i) Technical feasibility. An evaluation of the technical feasibility of closed-cycle recirculating systems as defined at 40 CFR 125.92(c), fine mesh screens with a mesh size of 2 millimeters or smaller, and water reuse or alternate sources of cooling water. In addition, this study must include:*
> >
> > > *(A) A description of all technologies and operational measures considered (including alternative designs of closed-cycle recirculating systems such as natural draft cooling towers, mechanical draft cooling towers, hybrid designs, and compact or multi-cell arrangements);*
> >
> > > *(B) A discussion of land availability, including an evaluation of adjacent land and acres potentially available due to generating unit retirements, production unit retirements, other buildings and equipment retirements, and potential for repurposing of areas devoted to ponds, coal piles, rail yards, transmission yards, and parking lots;*
> >
> > > *(C) A discussion of available sources of process water, grey water, wastewater, reclaimed water, or other waters of appropriate quantity and quality for use as some or all of the cooling water needs of the facility; and*

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(D) Documentation of factors other than cost that may make a candidate technology impractical or infeasible for further evaluation.

(ii) Other entrainment control technologies. An evaluation of additional technologies for reducing entrainment may be required by the Director.

(iii) Cost evaluations. The study must include engineering cost estimates of all technologies considered in paragraphs (r)(10)(i) and (ii) of this section. Facility costs must also be adjusted to estimate social costs. All costs must be presented as the net present value (NPV) and the corresponding annual value. Costs must be clearly labeled as compliance costs or social costs. The applicant must separately discuss facility level compliance costs and social costs, and provide documentation as follows:

(A) Compliance costs are calculated as after-tax, while social costs are calculated as pre-tax. Compliance costs include the facility's administrative costs, including costs of permit application, while the social cost adjustment includes the Director's administrative costs. Any outages, downtime, or other impacts to facility net revenue, are included in compliance costs, while only that portion of lost net revenue that does not accrue to other producers can be included in social costs. Social costs must also be discounted using social discount rates of 3 percent and 7 percent. Assumptions regarding depreciation schedules, tax rates, interest rates, discount rates and related assumptions must be identified;

(B) Costs and explanation of any additional facility modifications necessary to support construction and operation of technologies considered in paragraphs (r)(10)(i) and (ii) of this section, including but not limited to relocation of existing buildings or equipment, reinforcement or upgrading of existing equipment, and additional construction and operating permits. Assumptions regarding depreciation schedules, interest rates, discount rates, useful life of the technology considered, and any related assumptions must be identified; and

(C) Costs and explanation for addressing any non-water quality environmental and other impacts identified in paragraph (r)(12) of this section. The cost evaluation must include a discussion of all reasonable attempts to mitigate each of these impacts.

B. Objectives of This Report

This report provides the results of adjusting the facility costs developed by ENERCON to estimate the relevant social costs for the two CWIS alternatives. The report represents compliance with the

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requirement in (r)(10) Section (iii) that facility costs be adjusted to estimate social costs. Although the bulk of the report concerns these adjustments to estimate social costs, the report also provides estimates of compliance costs as specified in (r)(10) Section (iii). The report does not provide estimates of the social costs for non-water quality environmental and other impacts related to the (r)(12) study as specified in (r)(10) Section (iii)(C).

C. Browns Ferry Nuclear Plant

BFN is owned and operated by the Tennessee Valley Authority ("TVA") and is located on the eastern shore of the Tennessee River on Wheeler Reservoir in Athens, Limestone County, Alabama. BFN has three nuclear generating units with a total design electrical rating of 3,300 megawatts ("MW"), with Unit 1 in operation since 1973, Unit 2 in operation since 1974, and Unit 3 in operation since 1976. The current permits from the Nuclear Regulatory Commission ("NRC") for the three units end by July 2, 2036.[1]

BFN is subject to compliance with the Final Section 316(b) Rule. The current entrainment compliance requirements are specified in National Pollutant Discharge Elimination System Permit No. AL-0022080 ("NPDES Permit") issued by the Alabama Department of Environmental Management ("ADEM") effective September 1, 2016. The NPDES Permit requires BFN's CWIS to reflect the Best Technology Available ("BTA") for minimizing adverse environmental impacts from entrainment and impingement. Since the annual intake flow ("AIF") for BFN is substantially greater than 125 Million Gallons per Day ("MGD"), an engineering study of the technical feasibility and costs of entrainment control technologies for BFN is required as specified above as the (r)(10) study.

D. Cooling Water Intake Structure Alternatives

As described in the overall (r)(10) study prepared by ENERCON (ENERCON 2022), the following two CWIS alternatives are evaluated at BFN.

1. 0.5-mm fine mesh traveling water screens ("fine-mesh screens")
2. Closed cycle recirculating system ("CCRS")

The facility costs of these two alternatives are evaluated relative to the existing CWIS, which includes 0.25 inch x 0.30 inch traveling mesh screens. Thus, the various components of facility costs are estimated as additional costs for each of the two CWIS alternatives relative to the existing CWIS. These two CWIS technologies are being considered as BTA alternatives for reducing entrainment mortality at BFN under the Final Section 316(b) Rule.

E. Organization of the Report

The remainder of this report is organized as follows. Section II provides information on the methodology for modifying facility costs to estimate social costs, including identification of the

[1] This date marks the end of the Unit 3 permit. The Unit 1 permit ends on December 20, 2033 and the Unit 2 permit ends on June 28, 2034.

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major components of facility costs and the social discount rates used to translate social cost values for specified years into net present value and annualized social cost estimates. Section III provides social cost estimates for capital costs. Section IV provides social cost estimates for operating and maintenance costs. Section V provides social cost estimates for energy costs. Section VI provides qualitative assessments of social costs for administrative costs. Section VII concludes with a summary of the total social costs based upon the adjustments of facility costs as described in the prior sections. Section VIII provides estimates of compliance costs. Section IX provides a summary of the estimates of social costs and compliance costs based on the methodologies outlined in the report.

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II. Overview of Methodology to Adjust Facility Costs to Social Costs

A. Components of Facility Costs for Which Social Costs Are Estimated

The two major categories of social costs related to facility costs are typically: (1) capital costs; and (2) operating and maintenance (O&M) costs (EPA 2014c, p. 8-8). The (r)(10) study requirements in Section (iii)(A), as provided above, list three additional facility-level cost categories that should be accounted for in evaluating the social cost of the CWIS alternatives—energy penalty costs, installation downtime costs, and administrative costs. According to analyses by ENERCON, installation of both CWIS alternatives would occur during planned outages to avoid BFN downtime costs and thus the facility costs do not include installation downtime costs (Enercon 2022, Section 5.6 and Section 13).

We develop estimates and assessments for the following four categories of facility costs.

1. *Capital costs*. These include social costs associated with acquiring, constructing, and installing equipment.

2. *Operation and maintenance (O&M) costs.* These include annual recurring social costs associated with operation and maintenance of the equipment, excluding costs related to annual energy losses (which are treated separately).

3. *Energy costs*. These include the social costs related to reductions in energy provided by BFN to the grid due to the CWIS alternatives.

4. *Administrative costs*. These include the social costs incurred by TVA and ADEM to administer the CWIS alternatives.

B. Baseline Scenario

The facility costs developed by ENERCON are measured relative to a baseline scenario that reflects the future CWIS circumstances if neither of the CWIS alternatives were implemented, which ENERCON concludes would be the current configuration. The current CWIS configuration at BFN is characterized as follows:

- Operation of 18 through-flow traveling water screens with 0.25 inch by 0.3 inch mesh, each equipped with a high-pressure screen-wash spray to clean the screen; and

- Nine condenser circulating water (CCW) pumps, 12 residual heat removal service water (RHRSW) pumps.

Since the current configuration at BFN satisfies the compliance requirements to meet impingement standards under 40 CFR 125.94(c), it is assumed that this configuration would continue in the future in the absence of installation of either of the two CWIS alternatives to reduce entrainment

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losses. The current CWIS system in place at BFN thus represents the baseline conditions for the facility costs developed by ENERCON and thus the baseline conditions for our estimates of the social costs and the compliance costs of the CWIS alternatives based on adjustments to these facility costs.

C. Cooling Water Intake System Alternatives

As noted above, the two CWIS alternatives being evaluated in the (r)(10) study are: (1) the 0.5 mm fine-mesh screens, and (2) the CCRS. Table 1 provides summary facility information developed by ENERCON for these two CWIS alternatives including the implementation and operation schedule for each alternative. As noted, ENERCON estimates that installation of both the fine-mesh screens and the CCRS would be contained within regularly scheduled maintenance outages, and thus there are no downtime costs associated with the installation of either technology. Note that the operation end date is assumed to be July 2036, the end date for the current NRC permits.

Table 1: CWIS Alternatives Facility Information

	0.5 mm Fine-Mesh Screens	Closed-Cycle Recirculating System
Technology Overview	• Construct new screening structure in front of the existing intake structure • Intake channel expansion to allow utilization of entire width of new screening structure • Install 22 dual-flow screens to be shared by all units • Construct fish handling and return (FHRS) system to transport fish back to Wheeler Reservoir	• Replacements of three cooling towers • Upgrades to water distribution, lift pumps, and discharge valves of cooling towers • New Gate 2 structure to accommodate the CCW flow rate of all three units
Installation Start Date	1/1/2022	1/1/2022
Installation End Date	12/31/2027	12/31/2029
Operation Start Date	1/1/2028	1/1/2030
Operation End Date	7/2/2036	7/2/2036

Note: Assumes a January 1, 2022 project start date for all technologies.
Source: ENERCON 2022, Appendix B and Appendix D.

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D. Discounting of Social Costs

The (r)(10) Section (iii) requirements indicate that social costs should be presented as the net present value ("NPV") and the corresponding annual value (which is usually referred to as the "annualized value" to distinguish it from annual cost estimates for any given year). The (r)(10) Section (iii) requirements also indicate that social costs incurred in various years must be discounted using social discount rates of 3 percent and 7 percent in calculating the NPV and annualized social cost estimates. Thus, based upon the facility cost information provided by ENERCON (ENERCON 2022, Section 8 and Section 14), we developed estimates of the NPV and annualized social costs of the two CWIS alternatives using these two social discount rates.

For purposes of these social cost estimates, the costs are assumed to begin on January 1, 2022 and end on July 2, 2036. The analysis start date reflects the assumed permit reissuance date for BFN. The analysis end date reflects the end date of the Unit 3 NRC operating permit, which has the latest end date of any of the three BFN units. The NPV and annualized cost values are calculated as of January 1, 2022.

III. Capital Social Costs

Capital costs consist of the labor and material costs associated with the acquisition, construction, and installation of the CWIS alternatives. The ENERCON facility capital cost information in divided into three phases: (a) permitting, (b) engineering, and (c) procurement/construction. This section summarizes ENERCON's facility estimates of the total "overnight" capital costs and provides estimates of the NPV and annualized costs, both of which account for the timing of these expenditures and the translation of the facility costs into estimates of social costs based on the two discount rates. For ease of comparison to the social benefits, the social costs are measured in 2018 dollars.

A. Overnight Capital Facility Costs

Overnight capital costs are engineering estimates of the complete costs of installing the necessary structures and equipment using current prices for materials, equipment, and labor. These calculations assume the installation could be completed immediately (i.e., "overnight"). Thus, they exclude interest charges during construction, which engineering cost estimates sometimes include; discounting implicitly incorporates the effects of such interest charges because earlier expenditures receive more weight in the present value calculations.

ENERCON developed estimates of overnight costs for the three phases of development of the two CWIS alternatives (ENERCON 2022, Appendix A and Appendix C). Table 2 summarizes the overnight capital costs of installation of 0.5 mm fine-mesh screens and CCRS.

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Table 2: Overnight Facility Capital Costs (Millions, 2018$)

Technology	Overnight Engineering Costs	Overnight Permitting Costs	Overnight Construction Costs	Total Overnight Capital Costs
0.5 mm Fine-Mesh Screens	$4.59	$0.76	$78.95	$84.30
Closed-Cycle Recirculating System	$17.44	$7.50	$282.99	$307.94

Note: All dollar values are in millions of real 2018 dollars. Overnight capital costs exclude interest and escalation costs because these are implicitly incorporated in the present value calculations. Construction costs for the CCRS include approximately $20 million in cost savings from avoided costs for existing travelling water screens.
Source: ENERCON 2022, Appendix A and Appendix C; U.S. Bureau of Economic Analysis ("BEA") Implicit Price Deflator 2021 (BEA 2021)

B. Timing and Discounted Capital Social Costs

In order to be translated into estimates of discounted social costs, the facility costs developed by ENERCON need to be allocated to specific future periods (i.e., months in a given year) and these monthly costs need to be discounted using the two social discount rates. ENERCON developed project information on the timing of the three phases of the capital costs for the two CWIS technologies to be used in the social cost analyses (ENERCON 2022, Appendix B and Appendix D). We use this information on timing to estimate the expenditures that would be incurred in each year. Table 3 provides the preliminary project schedule including assumptions on permitting, engineering, and construction timing. We assume that expenditures for the various project phases would be spread evenly over the months between the start date and the end date.

Table 3: Project Schedules for Facility Costs

	0.5 mm Fine-Mesh Screens	Closed-Cycle Recirculating System
Project Start Date	1/1/2022	1/1/2022
Project End Date	12/31/2027	12/31/2029
Engineering Start Date	1/1/2022	1/1/2022
Engineering End Date	6/30/2023	6/30/2023
Permitting Start Date	1/1/2023	1/1/2024
Permitting End Date	12/31/2023	12/31/2024
Construction Start Date	7/1/2023	1/1/2023
Construction End Date	12/31/2027	12/31/2029

Note: Assumes a January 2022 project start date across all technologies. Project duration values reflect the total length of the project (start of engineering through start of operation). Construction phases include procurement.
Source: ENERCON 2022, Appendix B and Appendix D

Using these project schedules and the assumption that expenditures are spread evenly across the months of each of the project periods, we develop estimates of the NPVs and annualized costs of

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capital costs. As required for the (r)(10) study in Section (iii)(A) above, social costs are calculated as pre-tax and thus no tax adjustments are made to translate expenditures into social costs.

Table 4 shows the NPV and annualized values social cost estimates of capital costs for the CWIS alternatives using the two social discount rates. For the 0.5 fine-mesh screens, the NPV of social capital costs ranges from about $66.7 million using a 7 percent discount rate to about $76.0 million using a 3 percent discount rate. For the CCRS alternative, the NPV of social capital costs ranges from about $233.7 million using a 7 percent discount rate to about $272.3 million using a 3 percent discount rate.

Table 4: Net Present Value and Annualized Capital Social Costs (Millions, 2018$)

	Net Present Value		Annualized Cost	
Technology	**3%**	**7%**	**3%**	**7%**
0.5 mm Fine-Mesh Screens	$76.03	$66.73	$6.35	$6.98
Closed-Cycle Recirculating System	$272.31	$233.71	$22.75	$24.46

Note: All dollar values are in millions of real 2018 dollars. Present values are calculated as of January 1, 2022 for costs incurred from 2022 to 2036. Annualized costs are calculated based on the study period of January 1, 2022 to July 2, 2036.
Source: Table 2, Table 3, and NERA calculations as explained in text.

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IV. Operating and Maintenance Social Costs

Both the 0.5 mm fine-mesh screens and the CCRS involve installation of equipment that would require ongoing annual upkeep and thus will entail operating and maintenance ("O&M") costs. ENERCON developed facility cost estimates for the additional annual O&M costs for each of the two CWIS alternatives. For purposes of adjusting these estimates to develop social cost estimates, we assume that the fine-mesh screens and CCRS alternatives would be operational starting the month after the end of the construction phase; since construction is assumed to end in December for both CWIS alternatives, we assume O&M costs would begin in January of the following year.

Because the O&M costs do not vary with the level of plant operation, following standard convention for cost studies, we refer to these costs as annual fixed O&M costs. The social cost calculations assume the annual fixed O&M costs are spread evenly over the months of each of the relevant years.

A. Operation Schedules and Annual Fixed O&M Facility Costs

Table 5 provides estimates of the annual fixed O&M facility costs as well as the operation schedules for each CWIS alternative, i.e., the assumed start date and the ending date for the analysis.

Table 5: O&M Schedule and Annual Fixed O&M Facility Costs (Millions, 2018$)

Technology	Operation Start Date	Operation End Date	Annual Fixed O&M Costs
0.5 mm Fine-Mesh Screens	1/1/2028	7/2/2036	$0.16
Closed-Cycle Recirculating System	1/1/2030	7/2/2036	$0.97

Note: Assumes a January 2022 project start date for both alternatives. 0.5 mm fine-mesh screens would become operational in January 2028 and the CCRS would become operational in January 2030, the month after the completion of construction.
Source: ENERCON 2022, Section 8.2 and 14.1.2; BEA 2021

B. Discounted Fixed O&M Social Costs

Table 6 provides social cost estimates—presented as NPV and annualized costs—for the fixed O&M costs for the two CWIS alternatives, 0.5 mm fine-mesh screens and CCRS. As noted, the calculations assume the annual fixed costs are spread equally over the 12 months of each year. For the final year (2036), the calculations assume that half of the annual fixed costs are incurred and are spread evenly over the six full months of operation in that year. As with capital costs, no tax adjustments are involved to adjust facility costs to social costs.

For the fine-mesh screens, the NPV of fixed O&M social costs ranges from about $0.7 million for a 7 percent discount rate to about $1.0 million for a 3 percent discount rate. For the CCRS, the NPV of fixed O&M social costs ranges from about $3.0 million for a 7 percent discount rate to about $4.5 million for a 3 percent discount rate.

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Table 6: Net Present Value and Annualized Fixed O&M Social Costs (Millions, 2018$)

	Net Present Value		Annualized Cost	
Technology	**3%**	**7%**	**3%**	**7%**
0.5 mm Fine-Mesh Screens	$1.02	$0.70	$0.09	$0.07
Closed-Cycle Recirculating System	$4.54	$2.98	$0.38	$0.31

Note: All dollar values are in millions of real 2018 dollars. Present values are calculated as of January 1, 2022 for costs incurred from 2022 to 2036. Annualized costs are calculated based on the study period of January 1, 2022 to July 2, 2036.
Source: Table 5 and NERA calculations as explained in text.

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V. Energy Social Costs

This section provides estimates of the energy social costs of the two CWIS alternatives, which are the social costs due to reductions in energy output to the grid from BFN if either of the two CWIS alternatives were implemented.

A. Potential Categories of Energy Facility Costs

The construction and operation of a CWIS alternative at BFN could in principal affect BFN's electricity output in three ways, one during construction and two after the alternative is implemented.

1. *Loss in output during construction outages*. These costs include social costs if a CWIS alternative required BFN to incur an additional outage or downtime, i.e., an outage or downtime in addition to the regularly scheduled maintenance outages of BFN.

2. *Loss in output due to efficiency losses*. These costs include social costs if a CWIS alternative reduced the efficiency of electricity generation at BFN, resulting in less electricity being generated and thus less electricity being provided to the grid.

3. *Loss in output due to parasitic losses*. These costs include social costs if a CWIS alternative required electricity from BFN, also resulting in less electricity being provided by BFN to the grid.

ENERCON's analyses of the two CWIS alternatives conclude that the first potential source of energy costs is not relevant, as both the fine mesh screens and the CCRS could be installed during BFN's planned maintenance outages (ENERCON 2022, Section 5.6 and Section 13). As a result, neither CWIS technology would result in any construction outage and thus neither CWIS alternative would result in social costs related to outage or downtime. ENERCON also concluded that fine-mesh screens would not result in any efficiency loss but that both CWIS alternatives would result in parasitic losses. ENERCON thus developed estimates of the efficiency losses due to the CCRS alternative and estimates of the parasitic losses for both CWIS alternatives.

B. Changes in BFN Electricity Output to the Grid Due to CWIS Alternatives

This section summarizes the facility information developed by ENERCON on the efficiency losses and the parasitic losses (as measured by the reduction in electricity output provided to the grid) due to the two CWIS alternatives (ENERCON 2022, Section 5.9 and Section 12.1).

1. Annual Facility Efficiency Energy Losses

ENERCON estimates that the CCRS alternative would result in reduced operational efficiency at BFN. ENERCON has estimated that the CCRS would result in capacity losses of 17 mega-watts ("MW"). Based upon ENERCON's estimate that the annual capacity factor is 90 percent, the CCRS is estimated to lead to an annual efficiency loss of 134,000 mega-watt hours ("MWh")

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(ENERCON 2022, Section 4).As noted, ENERCON concludes that the fine-mesh screens CWIS alternative would not result in an efficiency loss at BFN. Table 7 summarizes ENERCON's estimates of the annual MWh losses in electricity output due to operational efficiency effects of the two CWIS alternatives.

Table 7: Annual Facility Efficiency Energy Losses (MWh)

Technology	Efficiency Loss (MWh)
0.5 mm Fine-Mesh Screens	0
Closed-Cycle Recirculating System	134,000

Source: ENERCON 2022, Section 4

2. Annual Facility Parasitic Energy Losses

ENERCON estimates that both the 0.5 mm fine-mesh screens and the CCRS would require electricity to operate and thus both would reduce the net electricity output at BFN through parasitic losses. ENERCON estimates that operation of the 0.5 mm fine-mesh screens alternative would result in a parasitic loss of 0.802 MW. Using the same estimate of a 90 percent capacity factor, ENERCON estimates the annual parasitic power loss from the 0.5 mm fine-mesh screens would be 6,330 MWh (ENERCON 2022, Section 12.1 and Section 14.1.3).

ENERCON estimates that operation of the CCRS alternative would result in a parasitic loss of 52 MW. Based upon ENERCON's same estimated plant capacity factor of 90 percent, the annual parasitic power loss from the CCRS alternative would be 410,000 MWh (ENERCON 2022, Section 4). Table 8 summarizes ENERCON's estimates of the parasitic losses at the facility due to the operation of the CWIS alternatives.

Table 8: Annual Facility Parasitic Energy Losses (MWh)

Technology	Parasitic Loss (MWh)
0.5 mm Fine-Mesh Screens	6,330
Closed-Cycle Recirculating System	410,000

Source: ENERCON 2022, Section 4 and Section 14.1.3.

C. Estimates of the Social Cost of BFN Energy Losses Based on Wholesale Electricity Prices

Both efficiency energy losses and parasitic energy losses would reduce the annual output from BFN. As EPA notes in its analyses of the social costs of these energy penalties, nuclear units facing such energy penalties would not be able to increase output at the units to compensate for the reduced output, and thus the social cost of the energy penalty would be equal to the additional resource costs of the replacement electricity (US EPA 2014a, p. I-4). Note that operating costs at BFN would not be reduced, and thus the additional resource costs of the replacement energy would be equal to the cost of the replacement output, without any offsetting decrease in costs at BFN.

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Because the dispatch of generating units within the relevant market area would be designed to minimize the cost of producing the electricity output needed to meet electricity demand—a feature referred to as "economic dispatch"—the cost of generating the replacement energy would tend to equal the cost of the unit with the highest production cost, i.e., the "marginal" unit. Moreover, based upon this electricity market setting, the wholesale market price would equal the production cost of this "marginal" unit. Note that the estimation of the social costs of these energy penalties could be more complicated if the energy penalty were large, because a large penalty might result in changes in the marginal unit and thus a potential change in wholesale price. Such a possibility could occur if one of the technologies resulted in a substantial construction outage period, since the loss of the substantial output at BFN could result in increases in electricity prices, which could affect consumer demand. Such complications would not be relevant for small energy penalties—relative to overall market supply—such as those related to the efficiency and parasitic losses at BFN under either of the two technology alternatives.

In summary, the social costs of reductions in the net BFN energy output to the grid would be measured by the resource costs of providing energy to replace the lost BFN output. These resource costs can be measured by the relevant future wholesale electricity prices, which reflect the cost of the relatively small increases in electricity supply needed to replace the losses at BFN due to the two alternatives. Projected future wholesale electricity prices are appropriate measures of the real-resource costs of relatively small changes in power output because they reflect the marginal costs of supplying an additional unit of electricity to the grid and because the relatively small changes in power output are unlikely to lead to changes in the marginal unit (and thus to changes in future electricity prices).

NERA uses annual wholesale electricity price projections from the U.S. Energy Information Administration's ("EIA") National Energy Modeling System[2] ("NEMS") to estimate the annual average wholesale prices for BFN output to the grid (EIA 2020) in each future year. The EIA uses NEMS to form baseline projections for national and regional energy prices and quantities, which are published in the *Annual Energy Outlook* each year. The annual wholesale electricity price forecast we use as the basis for our projections is the NEMS "Price to Generation" forecast, whose values include both wholesale power (i.e., costs of production) and wholesale capacity prices. [3] Note that since BFN is on the border between the SERC Central and the SERC Southeast subregions, the average forecast prices for these two SERC subregions are used to estimate the relevant wholesale prices.

Table 9 provides EIA's annual wholesale electricity price projections for the SERC Central and SERC Southeast subregions, as well as the average prices used to evaluate the social costs of

[2] NEMS is a detailed energy and economic model developed and maintained by the EIA Office of Energy Analysis to provide projections of domestic energy-economy markets in the long term and to perform policy analyses requested by decision-makers in the White House, Congress, Department of Energy, and other government agencies.

[3] The NEMS model documentation notes that the "price to generation" includes other potential costs to generators such as stranded costs, taxes, and other miscellaneous costs such as ancillary services, uplift costs, congestion costs, and price hedging costs. For purposes of our analysis, we presume that these costs are small in comparison to the energy and capacity components. (EIA 2020)

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reduced BFN output supplied to the grid. The prices are provided in 2018 dollars to be compatible with the other social cost categories and with the social benefits estimates.

Table 9: Annual Wholesale Electricity Price Projections (2018$/MWh)

Year	SERC Southeast	SERC Central	Browns Ferry
2022	$60.50	$48.49	$54.49
2023	$60.61	$47.25	$53.93
2024	$59.63	$46.96	$53.29
2025	$59.76	$46.33	$53.04
2026	$59.25	$46.35	$52.80
2027	$58.88	$46.15	$52.51
2028	$57.96	$45.77	$51.87
2029	$57.28	$45.26	$51.27
2030	$55.93	$44.21	$50.07
2031	$54.88	$43.23	$49.06
2032	$54.07	$42.40	$48.24
2033	$53.42	$41.97	$47.69
2034	$52.73	$41.39	$47.06
2035	$52.03	$40.47	$46.25
2036	$51.33	$39.55	$45.44

Note: Prices are in 2018 dollars per MWh.
Sources: Electric Power Projections by Electricity Market Module Region of Annual Energy Outlook Table Browser (EIA 2021a); BEA 2021; NERA calculations as explained in text.

D. Social Costs of Energy Losses

The ENERCON estimates of facility energy losses and the estimates of future wholesale electricity prices are used to estimate the social costs of the reductions in net electricity output to the grid due to the two CWIS alternatives. As with the other facility cost categories, no tax adjustments are needed to translate facility costs into social costs. Results for the two relevant categories of energy losses are provided below along with a final summary that includes both categories.

1. Discounted Efficiency Energy Social Costs

Table 10 summarizes the NPV and annualized social costs from reduced electricity output to the grid due to efficiency losses from the CWIS alternatives. As noted above, ENERCON estimates that the fine-mesh screens would not result in efficiency losses. The social costs calculations assume the annual costs are spread equally over the 12 months of each year. For 2036, the calculations assume that half of the annual costs are incurred and are spread evenly over the six full months of operation in that year. The NPV of efficiency loss social costs for the CCRS alternative ranges from about $19.8 million using a 7 percent discount rate to about $30.0 million using a 3 percent discount rate.

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Table 10: Net Present Values and Annualized Values of Efficiency Loss Social Costs (Millions, 2018$)

	Net Present Value		Annualized Cost	
Technology	**3%**	**7%**	**3%**	**7%**
0.5 mm Fine-Mesh Screens	$0.00	$0.00	$0.00	$0.00
Closed-Cycle Recirculating System	$30.02	$19.76	$2.51	$2.07

Note: All dollar values are in millions of real 2018 dollars. Present values are calculated as of January 1, 2022 for costs incurred from 2022 to 2036. Annualized costs are calculated based on the study period of January 1, 2022 to July 2, 2036.
Source: Table 7 and NERA calculations as explained in text.

2. Discounted Parasitic Energy Social Costs

Table 11 summarizes the NPV and annualized social costs from reduced electricity output to the grid due to parasitic losses from the CWIS alternatives. The social costs calculations assume the annual costs are spread equally over the 12 months of each year. For 2036, the calculations assume that half of the annual costs are incurred and are spread evenly over the six full months of operation in that year. For the fine-mesh screens, the NPV of parasitic loss social costs ranges from about $1.3 million using a 7 percent discount rate to about $2.0 million using a 3 percent discount rate. For the CCRS, the NPV of parasitic loss social costs ranges from about $60.5 million using a 7 percent discount rate to about $91.9 million using a 3 percent discount rate.

Table 11: Net Present Values and Annualized Values of Parasitic Loss Social Costs (Millions, 2018$)

	Net Present Value		Annualized Cost	
Technology	**3%**	**7%**	**3%**	**7%**
0.5 mm Fine-Mesh Screens	$1.95	$1.34	$0.16	$0.14
Closed-Cycle Recirculating System	$91.86	$60.45	$7.67	$6.33

Note: All dollar values are in millions of real 2018 dollars. Present values are calculated as of January 1, 2022 for costs incurred from 2022 to 2036. Annualized costs are calculated based on the study period of January 1, 2022 to July 2, 2036.
Source: Table 8 and NERA calculations as explained in text.

3. Discounted Total Energy Social Costs

Table 12 provides the NPV and annualized social costs for the total energy losses (i.e., the sum of efficiency and parasitic losses) due the CWIS alternatives. For the fine-mesh screens, the NPV of energy social costs ranges from about $1.3 million using a 7 percent discount rate to about $2.0 million using a 3 percent discount rate. For the CCRS, the NPV value of energy social costs ranges from about $80.2 million using a 7 percent discount rate to about $121.9 million using a 3 percent discount rate.

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Table 12: Net Present Values and Annualized Values of Total Energy Loss Social Costs (Millions, 2018$)

	Net Present Value		Annualized Cost	
Technology	**3%**	**7%**	**3%**	**7%**
0.5 mm Fine-Mesh Screens				
Parasitic Loss Costs	$1.95	$1.34	$0.16	$0.14
Efficiency Loss Costs	$0.00	$0.00	$0.00	$0.00
Total	**$1.95**	**$1.34**	**$0.16**	**$0.14**
Closed-Cycle Recirculating System				
Parasitic Loss Costs	$91.86	$60.45	$7.67	$6.33
Efficiency Loss Costs	$30.02	$19.76	$2.51	$2.07
Total	**$121.89**	**$80.21**	**$10.18**	**$8.39**

Note: All dollar values are in millions of real 2018 dollars. Present values are calculated as of January 1, 2022 for costs incurred from 2022 to 2036. Annualized costs are calculated based on the study period of January 1, 2022 to July 2, 2036.
Source: Table 10 and Table 11; NERA calculations as explained in text.

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VI. Administrative Costs

Administrative costs refer to the costs that would be incurred by the company (TVA) and by the regulatory agency (ADEM) to administer the CWIS alternatives (e.g., costs of permit applications). The (r)(10) Section (iii)(A) notes that administrative costs incurred by the facility and the administrative agency are to be included in social costs.

NERA understands that neither TVA nor ADEM were able to provide estimates of the additional administrative costs that would be incurred if TVA were required to implement either of the CWIS alternatives at BFN. Although as noted above, company and agency administrative costs are identified as components of social costs in the (r)(10) study, NERA's experience evaluating administrative costs at many other facilities indicates that these additional administrative costs are typically very small components of total social costs.

Thus, while the social costs estimates in this report do not include company and agency administrative costs, NERA concludes that excluding administrative costs is not likely to have any significant effect on the total social costs based on the facility costs or on comparisons between the social costs based on facility costs and the social benefits of the CWIS alternatives.

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VII. Social Costs Based on Adjusted Facility Costs

Table 13 summarizes our estimates of the NPVs and annualized values of the social costs for the two CWIS alternatives based upon adjustments of the facility costs and other facility information developed by ENERCON. The quantified social costs include the sum of capital costs, O&M costs, and energy costs as discussed in previous sections of this report. As noted, administrative costs are assessed qualitatively and judged not to be significant relative to the total of the other cost categories.

Table 13: Net Present Values and Annualized Total Social Costs Based on Adjusted Facility Costs (Millions, 2018$)

	Net Present Value		Annualized Cost	
Technology	**3%**	**7%**	**3%**	**7%**
0.5 mm Fine-Mesh Screens				
Capital	$76.03	$66.73	$6.35	$6.98
O&M	$1.02	$0.70	$0.09	$0.07
Electricity	$1.95	$1.34	$0.16	$0.14
Total	**$79.00**	**$68.78**	**$6.60**	**$7.20**
Closed-Cycle Recirculating System				
Capital	$272.31	$233.71	$22.75	$24.46
O&M	$4.54	$2.98	$0.38	$0.31
Electricity	$121.89	$80.21	$10.18	$8.39
Total	**$398.73**	**$316.90**	**$33.31**	**$33.16**

Note: All dollar values are in millions of real 2018 dollars. Present values are calculated as of January 1, 2022 for costs incurred from 2022 to 2036. Annualized costs are calculated based on the study period of January 1, 2022 to July 2, 2036.

Source: Table 4, Table 6, Table 12, and NERA calculations as explained in text.

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A. Net Present Value of Total Social Costs Based on Adjusted Facility Costs

For the 0.5 mm fine-mesh screens, the NPV of total social costs based upon the facility cost information developed by ENERCON ranges from about $68.8 million using a 7 percent discount rate to about $79.0 million using a 3 percent discount rate. For the CCRS, the NPV of total social costs based upon the facility information developed by ENERCON ranges from about $316.9 million using a 7 percent discount rate to about $398.7 million using a 3 percent discount rate.

B. Annualized Total Social Costs Based on Adjusted Facility Costs

For the 0.5 mm fine-mesh screens, the annualized total social costs based upon the facility cost information developed by ENERCON ranges from about $6.6 million using a 3 percent discount rate to about $7.2 using a 7 percent discount rate. For the CCRS, the annualized total social costs based upon the facility specific information developed by ENERCON ranges from about $33.2 million using a 7 percent discount rate to $33.3 million using a 7 percent discount rate.

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VIII. Compliance Costs Based on Adjusted Facility Costs

A. Overview of Methodology

As noted in the introduction, compliance with the requirement for the (r)(10) report includes estimates of "compliance costs," which are defined as costs borne by facility owners (EPA 2014b, p. 48428). Compliance costs differ from the social costs for several reasons. The following adjustments are evaluated for each category of social costs to develop compliance cost estimates.

- *Federal and state income taxes.* Compliance costs are after-tax payments that account for a private company's federal and state income taxes. Because TVA is not subject to federal or state income tax, however, this adjustment is not relevant in the case of BFN (TVA 2021).

- *Timing of costs.* Compliance costs are based upon costs as they are incurred by the company, which include accounting for the means in which they are assumed to be financed. (As noted above, social costs are incurred at the time of the expenditures, since that is when actual resources are expended and thus the opportunity costs are incurred.) We assume TVA's costs are financed through a loan whose terms are described below (section B).

- *Discount rate to calculate NPV and annualized costs*. The calculation of the net present value and annualized value is based upon a private discount rate, rather than the social discount rates used to discount social costs. Section B also discusses our assumption on the discount rate TVA would use.

B. Capital Costs

To calculate compliance costs related to the capital costs to install the technologies, we assume that TVA would finance costs through a 15-year long-term power bond using an interest rate equal to the average value identified in its most recent public filing, which is 4.56 percent (TVA 2021). We adjust this interest rate to account for inflation using the AEO 2021 estimated annual inflation rate for 2021-2036 of 2.20 percent (EIA 2021b) to calculate a real interest rate of 2.31 percent. Note that this interest rate is based upon an average maturity of TVA long-term power bonds of 15.3 years, which is very similar to the time period of the loan assumed in the calculations (14.5 years). We account for the full private costs associated with the assumed loan, including principal and interest payments and a final payment on June 1, 2036 that covers the remaining principal on the loan.

Table 14 shows the net present value and annualized compliance capital costs for each technology alternative based on these calculations. These calculations assume use of a private real discount rate of 2.31 percent, the same rate assumed in the loan, because TVA does not issue equity and thus there is no equivalent to the weighted average cost of capital ("WACC") used to calculate discount rates for private firms. The net present value of total capital compliance costs for the 0.5 mm fine-mesh screens is $84.3 million and is $307.9 million for the CCRS. The annualized cost for 0.05 mm fine-mesh screens is $6.8 million and for the CCRS is $24.7 million.

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Table 14: Net Present Value and Annualized Compliance Capital Costs (Millions, 2018$)

	Net Present Value	Annualized Cost
Technology	**2.3%**	**2.3%**
0.5 mm Fine-Mesh Screens	$84.30	$6.75
Closed-Cycle Recirculating System	$307.94	$24.67

Note: All dollar values are in millions of real 2018 dollars. Present values are calculated as of January 1, 2022 for costs incurred from 2022 to 2036. Annualized costs are calculated based on costs from 2022 to 2036. An annual discount rate of 2.31 percent is used. Costs are assumed to occur monthly, at the start of each month.
Source: NERA calculations as explained in text.

C. Operating and Maintenance Costs

Because operational costs are assumed to be paid by TVA as TVA incurs them and because TVA does not pay federal or state income taxes, the fixed O&M costs used to calculate compliance costs are the same as those used to calculate social costs. Table 15 provides the present value and annualized value estimates for compliance costs due to O&M costs, using the same 2.31 percent discount rate as used to calculate capital costs.

The net present value of total O&M compliance costs for the 0.5 mm fine-mesh screens is $1.1 million and is $4.9 million for the CCRS. The annualized cost for 0.05 mm fine-mesh screens is $0.1 million and for the CCRS is $0.4 million.

Table 15: Net Present Value and Annualized Compliance Fixed O&M Costs (Millions, 2018$)

	Net Present Value	Annualized Cost
Technology	**2.3%**	**2.3%**
0.5 mm Fine-Mesh Screens	$1.09	$0.09
Closed-Cycle Recirculating System	$4.89	$0.38

Note: All dollar values are in millions of real 2018 dollars. Present values are calculated as of January 1, 2022 for costs incurred from 2022 to 2036. Annualized costs are calculated based on costs from 2022 to 2036. Annual discount rate of 2.31 percent is used. Costs are assumed to occur monthly, at the start of each month.
Source: NERA calculations as explained in text.

D. Electricity Costs

a. Efficiency and Parasitic Power Loss Costs

TVA receives less revenue from its electricity sales due to efficiency and parasitic power losses, with the value of the losses based upon the sizes of the losses and the wholesale power prices over time (which measure the lost revenue to TVA). Because wholesale electricity prices also are used to calculate the social costs of the power losses—and because TVA does not pay federal or state income taxes and thus there is no difference between pre-tax and post-tax losses—the annual compliance costs of the power losses are the same as the annual social costs.

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Table 16 summarizes the present and annualized value estimates for compliance costs related to efficiency loss costs using the same discount rate of 2.31 percent. The net present value of efficiency loss compliance costs is zero for 0.5 mm fine-mesh Screens and $32.3 million for the CCRS. The annualized compliance cost is zero for 0.5 mm fine-mesh Screens and $2.5 for the CCRS.

Table 16: Net Present Value and Annualized Values of Efficiency Loss Compliance Costs (Millions, 2018$)

	Net Present Value	Annualized Cost
Technology	**2.3%**	**2.3%**
0.5 mm Fine-Mesh Screens	$0.00	$0.00
Closed-Cycle Recirculating System	$32.33	$2.52

Note: All dollar values are in millions of real 2018 dollars. Present values are calculated as of January 1, 2022 for costs incurred from 2022 to 2036. Annualized costs are calculated based on costs from 2022 to 2036. Annual discount rate of 2.31 percent is used. Costs are assumed to occur monthly, at the start of each month.
Source: NERA calculations as explained in text.

Table 17 summarizes the present and annualized value estimates for compliance costs related to parasitic loss costs. The net present value of parasitic loss compliance costs for 0.5 mm fine-mesh Screens is $2.1 million and is $98.9 million for the CCRS. The annualized cost of compliance is $0.2 million for 0.5 mm fine-mesh Screens and $7.7 million for the CCRS.

Table 17: Net Present Value and Annualized Values of Parasitic Loss Compliance Costs (Millions, 2018$)

	Net Present Value	Annualized Cost
Technology	**2.3%**	**2.3%**
0.5 mm Fine-Mesh Screens	$2.08	$0.16
Closed-Cycle Recirculating System	$98.92	$7.70

Note: All dollar values are in millions of real 2018 dollars. Present values are calculated as of January 1, 2022 for costs incurred from 2022 to 2036. Annualized costs are calculated based on costs from 2022 to 2036. Annual discount rate of 2.31 percent is used. Costs are assumed to occur monthly, at the start of each month.
Source: NERA calculations as explained in text.

E. Administrative Costs

The private (TVA) administrative costs are included in compliance costs, although public administrative costs are not included in compliance costs. Because no estimates were developed, these costs are not included in the monetized compliance costs. As with the social costs, based upon experience in cost evaluations at many other power plants, we conclude that this omission will not have a substantial effect on total compliance costs.

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F. Total Monetized Compliance Costs

Table 18 summarizes the total monetized compliance costs for each technology alternative in terms of net present values and annualized values. The net present values of total monetized compliance costs are $87.5 million for 0.5 mm fine-mesh Screens and $444.1 million for the CCRS. The annualized compliance cost for is $7.0 million for 0.5 mm fine-mesh Screens and $35.3 million for the CCRS.

Table 18: Net Present Value and Annualized Total Quantified Compliance Costs (Millions, 2018$)

	Net Present Value	Annualized Cost
Technology	**2.3%**	**2.3%**
0.5 mm Fine-Mesh Screens		
Capital	$84.30	$6.75
O&M	$1.09	$0.09
Electricity	$2.08	$0.16
Total	**$87.48**	**$7.00**
Closed-Cycle Recirculating System		
Capital	$307.94	$24.67
O&M	$4.89	$0.38
Electricity	$131.24	$10.22
Total	**$444.07**	**$35.27**

Note: All dollar values are in millions of real 2018 dollars. Present values are calculated as of January 1, 2022 for costs incurred from 2022 to 2036. Annualized costs are calculated based on costs from 2022 to 2036. Annual discount rate of 2.31 percent is used. Costs are assumed to occur monthly, at the start of each month.
Source: NERA calculations as explained in text.

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IX. Summary of Social Costs and Compliance Costs

Table 19 summarizes the estimates of social costs and compliance costs for the two technologies. As called for in the r(10) requirements, the estimates include net present values as well as annualized values. As noted in the table, the annual social cost estimates are discounted using the two social discount rates and the annual compliance cost estimates are discounted at the TVA private discount rate.

Table 19: Summary of Social Costs and Compliance Costs (Millions, 2018$)

	Net Present Value		Annualized Cost	
Social Costs	**3%**	**7%**	**3%**	**7%**
0.5 mm Fine-Mesh Screens	$79.00	$68.78	$6.60	$7.20
Closed-Cycle Recirculating System	$398.73	$316.90	$33.31	$33.16
	Net Present Value		**Annualized Cost**	
Compliance Costs		**2.3%**		**2.3%**
0.5 mm Fine-Mesh Screens		$87.48		$7.00
Closed-Cycle Recirculating System		$444.07		$35.27

Note: All dollar values are in millions of real 2018 dollars. Present values are calculated as of January 1, 2022 for costs incurred over the 15-year period from 2022 to 2036. Annualized costs are calculated based on costs from 2022 to 2036. Costs are assumed to occur monthly, at the start of each month.
Source: NERA calculations as explained in text.

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Browns Ferry Nuclear Power Plant

National Pollutant Discharge Elimination System (NPDES) Permit No. AL0022080

Updated Final §316(b) Rule Information

40 CFR 122.21(r)(11) Submittal

Biological and Economic Benefits Valuation Study



Prepared for:
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Appendix A: Biological Benefit Evaluation of Entrainment Reducing Technologies at Browns Ferry Nuclear Plant 135 Pages

Appendix B: Social Benefits Evaluation of Entrainment Reducing Technologies at Browns Ferry Nuclear Plant 34 Pages

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1 Introduction and Summary of Results

The U.S. Environmental Protection Agency's (EPA) Clean Water Act Section 316(b) cooling water intake structures (CWIS) final rule (Final §316(b) Rule), which requires existing facilities that withdraw greater than 125 million gallons per day (MGD) of actual intake flow (AIF) for which 25% or more of the AIF is used exclusively for cooling purposes to submit a Benefits Valuation Study. The study quantitatively compares alternative technologies and/or operations evaluated in (r)(10) report to reduce biological and social (monetary) effects of entrainment of aquatic life by the existing condenser cooling water (CCW) system. As stated in the (r)(6) report, Tennessee Valley Authority (TVA) is deferring the final decision of a chosen method of compliance with impingement mortality standard until after the Best Technology Available (BTA) determination for entrainment. The Benefits Valuation Study must be consistent with the following requirements of 40 CFR §122.21(r)(11):

i. *incremental changes in the numbers of individual fish and shellfish lost due to impingement mortality and entrainment as defined in 40 CFR 125.92, for all life stages of each exposed species;*

ii. *a description of basis for any estimates of changes in the stock sizes or harvest levels of commercial and recreational fish or shellfish species or forage fish species;*

iii. *A description of basis for any monetized values assigned to changes in the stock size or harvest levels of commercial and recreational fish or shellfish species, forage fish, and to any other ecosystem or non use benefits;*

iv. *discussion of mitigation efforts completed prior to October 14, 2014 including how long they have been in effect and how effective they have been;*

v. *discussion, with quantification and monetization, where possible, of any other benefits expected to accrue to the environment and local communities, including but not limited to improvements for mammals, birds, and other organisms and aquatic habitats; and*

vi. *discussion, with quantification and monetization, where possible, of any benefits expected to result from any reductions in thermal discharges from entrainment technologies.*

Pursuant to Section 122.21(r)(11) of the Rule, this summary report together with the detailed biological and economic analyses in Appendix A and Appendix B, respectively, evaluates the benefits for the following two candidate technologies considered in the Comprehensive Technical Feasibility and Cost Evaluation Study for Browns Ferry Nuclear Power Plant (BFN), which was submitted to the Alabama Department of Environmental Management (ADEM) pursuant to 40 CFR §122.21(r)(10):

1. closed cycle recirculating system (CCRS); and
2. 0.5-mm fine mesh traveling water screens (FMS).

The candidate technologies were evaluated relative to the existing CWIS assuming 100% through-plant entrainment mortality. A recent Entrainment Characterization Study [r(9)] quantified the concentration of species and numbers of organisms capable of being entrained in the CCW (mostly fish eggs and larvae). The biological benefits evaluation combined this concentration with volumes

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of cooling water typically withdrawn (existing CWIS) and each candidate technology to quantify the technology's reduction in numbers and species assumed killed by entrainment. The withdrawn species and numbers of early life stages were then converted to numbers of socially-used life stages (catchable stock sizes and harvest levels; Appendix A). For entrainable species not normally harvested but providing food (forage) for harvestable species, change in their availability as food (production foregone) was estimated.

As discussed in this report and Appendix A and Appendix B, there are no commercial fisheries in Wheeler Reservoir and, thus, there are no gains to commercial fishermen, which corresponds to the category of market use benefits. The estimated present value of recreational use benefits associated with FMS ranges from $460K to $651K (2018$), and the present value of recreational use benefits associated with CCRS ranges from $1.08M to $1.63M (2018$). The present value of benefits is calculated over a period from 2022 to 2036. The analysis start date reflects the assumed permit reissuance date for BFN, and the analysis end date reflects the end date of the Unit 3 operating permit, which has the latest end date of the three BFN units. The range of benefits is based on alternative discount rates (3 and 7 percent), as required by the Final §316(b) Rule.

The remainder of this summary report together with Appendix A and Appendix B addresses the requirements and provides the information required for submittal per §122.21(r)(11)(i)-(vi) of the Final §316(b) Rule. The information provided in Sections 2 through 7 is condensed and summarized. Detailed discussion and analysis of the information presented in Sections 2, 3, 6 and 7 is provided in Appendix A. Detailed discussion and analysis of the information presented in Section 4 is provided in Appendix B.

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2 Estimated Incremental Changes in Entrainment and Impingement Mortality

2.1 Baseline Entrainment Mortality Information

The biological benefit evaluation of the candidate technologies at BFN was based on the entrainment densities estimated from a two-year Entrainment Characterization Study (ECS). The study was conducted by Tennessee Valley Authority (TVA), from February 20, 2018 through December 19, 2019. Narrative and quantitative descriptions of the studies are provided in BFN's Final §316(b) Rule Section 122.21(r)(9) submittal. To assess the potential gains in recreational fishery benefits from entrainment reductions for each candidate technology, the entrainment abundance and mortality of the existing CWIS was used as the reference for quantifying these reductions. Descriptions of the entrainment mortality abundance calculation methodologies and estimates are provided in Section 3.2 of Appendix A. The biological benefits evaluation included 23 species of fish entrained at BFN. A narrative summary of the extensive data presented in Appendix A is provided below with references to the corresponding tables of Appendix A.

The total abundance of fish (by species) entrained through the existing CWIS at BFN is presented in Tables 3-14 (for year 2018) and 3-15 (for year 2019) of Appendix A. As stated in Section 1 above, 100% through-plant mortality is assumed for entrained species. For 2018, it was estimated that 3.01 billion individuals were entrained; for 2019, it was estimated that 3.22 billion individuals were entrained.

2.2 Entrainment Abundance Estimates from a CCRS

As discussed in Section 3.3 of Appendix A, operating a CCRS year-round for cooling purposes would reduce the entrainment abundance and mortality of fish for the existing CWIS by 92.4%. Annual entrainment abundance of fish for a CCRS was estimated to be 228.8 million individuals for year 2018, and 245.9 million individuals for year 2019 (Tables 3-16 and 3-17 of Appendix A, respectively). This reduction in entrainment abundance is directly proportional to flow reduction as discussed in Section 3.1.2 of Appendix A.

2.3 Entrainment Abundance Estimates from FMS

As discussed in Section 3.4.2 of Appendix A, the total abundance estimate (number of individuals) of fish entrained through a 0.5-mm FMS at BFN is 844.8 million for year 2018 (Table 3-20 of Appendix A), and 909.8 million for year 2019 (Table 3-21 of Appendix A). While entrainment mortality of fish entrained through the FMS was assumed as 100%, a portion of the fish excluded by FMS may be susceptible to mortality due to impingement (Section 3.4.3 of Appendix A). The estimated mortality of fish eggs and larvae entrained *or* impinged (i.e. "converts") if 0.5-mm FMS were installed at BFN is 2.68 billion for 2018 (Table 3-27) and 2.64 billion for 2019 (Table 3-28). Thus, entrainment mortality reductions from FMS are expected to be from 11% to 18% (Tables 3-32 through 3-34 of Appendix A).

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3 Estimated Changes in Stock Size and Harvest Levels

3.1 Identification of Fish Evaluated for Biological Benefits

As discussed in Section 4.1.1 of Appendix A, the biological benefits evaluation included 23 species of fish entrained at BFN. There are no commercial fisheries in Wheeler Reservoir, so the candidate technologies at BFN were not analyzed for commercial fisheries benefits. Entrained species at BFN were classified by species importance to the recreational fishery, game fish status in Alabama, and EPA's economic value categories, as shown in Table 4-1 of Appendix A (Section 4.1.2 of Appendix A).

3.2 Production Foregone

The incremental change in production foregone of forage species was estimated for each candidate technology. Production foregone is the reduction in prey biomass available to predators due to, in this case, entrainment at BFN, and includes the expected future growth prior to consumption by predators if the fish was not entrained. In this assessment, 100% of foregone production was assumed to be consumed by a single recreationally valuable predator species (Age-3 Blue Catfish). A description of the narrative benefits, modeling methodology, and estimation results is provided in Sections 4.2.2 and 4.3.2 of Appendix A. Both the CCRS and FMS scenarios were used to estimate the biomass for forage fish corresponding to the annual entrainment mortality reductions based on both years of entrainment data and two-year average. The production foregone estimates were an order of magnitude higher for the CCRS, and the taxa producing the greatest impacts were Mississippi Silverside (5,666 kg for CCRS and 1,749 kg for FMS) and Gizzard Shad (3,599 kg for CCRS and 111 kg for FMS; Appendix A, Table 4-7).

3.3 Unharvested Biomass

The incremental change in unharvested biomass was estimated for each evaluated candidate technology. The estimates of unharvested biomass represent the prey biomass or forage to scavengers or intermediary predators from natural mortalities that would have resulted if the early life stages had not been entrained. The Blue Catfish was used as the representative species that would benefit from biomass harvest. A description of the narrative benefits, modeling methodology, and estimation results is provided in Sections 4.2.5 of Appendix A.

3.4 Direct Recreational Fishery Benefits

The incremental change in harvest foregone was estimated for each evaluated candidate technology. The direct equivalent fishery yield model estimates the reduction in harvest due to removal of economically valuable species at early life stages. In this assessment, equivalent fishery yield is defined as the number of individuals that would have been expected to die from recreational fishing, either by harvest or post-release mortality, had the taxon not been entrained at an earlier life stage. A description of the narrative benefits, modeling methodology, and estimation results is provided in Sections 4.2.3 and 4.3.3 of Appendix A. Estimates of mean annual unharvested recreational fish biomass corresponding to the annual entrainment mortality reductions if a CCRS or 0.5-mm FMS were installed at the existing CWIS was 20,811 kg for CCRS and 5,195 kg for FMS. White Bass represented the majority of unharvested recreational fish biomass with an annual mean of 14,453 kg for CCRS and 3,506 kg for FMS; Appendix A, Table 4-8).

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3.5 Indirect Recreational Fishery Benefits

The indirect equivalent fishery yield of Blue Catfish estimates the reduction in the number of equivalent Age-3 Blue Catfish as a result of total production foregone and unharvested biomass. A description of the narrative benefits, modeling methodology, and estimation results is provided in Section 4.2.4 and 4.3.3. of Appendix A.

3.6 Total Estimated Change in Stock Size and Harvest Levels

The annual incremental gain in benefits for the two technologies are presented in tabular form in Tables 4-7 through 4-16 of Appendix A. Table 3-1 (reproduced from Table 4-4 of Appendix A) presents the estimated age-1 and adult equivalent loss from annual mortality at the existing CWIS. Table 3-2 (reproduced from Table 4-5 of Appendix A) and Table 3-3 (reproduced from Table 4-6 of Appendix A) summarize the estimated annual entrainment mortality reductions of age-1 equivalents and equivalent adults, respectively, for the two technologies (CCRS and FMS).

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Table 3-1: Estimated age-1 and adult equivalent loss from annual entrainment mortality at the existing CWIS of BFN Plant based on intake samples collected February 20, 2018, through December 19, 2019, and 2016-2020 daily average AIF

Taxon	Life Stage	Age-1 Equivalents			Equivalent Adults		
		2018	2019	Mean	2018	2019	Mean
Blue Catfish	Larvae	108		54	30		15
Buffalofish Ictiobus spp.	Larvae	137	236	187	75	130	102
Channel Catfish	Larvae	87,889	4,935	46,412	3,615	203	1,909
Common Carp	Larvae		13	7		8	4
Crappie Pomoxis spp.	Larvae	846	1,135	990	284	381	333
Darter Etheostoma spp.	Larvae	1,494	14,060	7,777	1,494	14,060	7,777
Emerald Shiner	Larvae	24,246	12,558	18,402	24,246	12,558	18,402
Freshwater Drum	Eggs	1,024	2,927	1,975	522	1,491	1,007
	Larvae	3,506	3,739	3,623	1,787	1,906	1,846
	All	4,530	6,666	5,598	2,309	3,397	2,853
Gizzard Shad	Eggs	61		30	61		30
	Larvae	39,524		19,762	39,524		19,762
	All	39,585		19,792	39,585		19,792
Grass Carp	Larvae	3		2	2		1
Logperch	Larvae	65,014	96,436	80,725	65,014	96,436	80,725
Mississippi Silverside	Eggs	208		104	208		104
	Larvae	865,391	141,246	503,318	865,391	141,246	503,318
	All	865,598	141,246	503,422	865,598	141,246	503,422
Sauger	Larvae	124	478	301	55	211	133
Shiner Pimephales spp.	Larvae	44,202	9,955	27,079	44,202	9,955	27,079
Skipjack Herring	Eggs		9	4		3	1
Spotted Sucker	Larvae	464	321	392	464	321	392
Sunfish Lepomis spp.	Larvae	91,559	52,803	72,181	91,559	52,803	72,181
Threadfin Shad	Eggs	1,561	63	812	1,561	63	812
	Larvae	943,827	1,586,750	1,265,288	943,827	1,586,750	1,265,288
	All	945,388	1,586,813	1,266,100	945,388	1,586,813	1,266,100
Topminnow Fundulus spp.	Larvae	37		18	37		18
Western Mosquitofish	Larvae	12,066		6,033	12,066		6,033
White Bass	Eggs	4		2	2		1
	Larvae	11,179	110,362	60,771	5,023	49,589	27,306
	All	11,183	110,362	60,773	5,025	49,589	27,307
Yellow Bass	Larvae	24		12	24		12
Yellow Perch	Larvae	1,010	6,863	3,936	303	2,060	1,182
Total	**All**	**2,195,507**	**2,044,890**	**2,120,198**	**2,101,374**	**1,970,175**	**2,035,775**

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Table 3-2: Estimated number of age-1 equivalents corresponding to the annual entrainment mortality reductions if a CCRS or 0.5-mm FMS were installed at the existing cooling water intake structure of BFN Plant based on intake samples collected February 20, 2018 through December 19, 2019 and 2016-2020 daily average AIF

Taxon	Life Stage	Age-1 Equivalents					
		2018		2019		Mean	
		CCRS	FMS	CCRS	FMS	CCRS	FMS
Blue Catfish	Larvae	100	63			50	32
Buffalofish Ictiobus spp.	Larvae	127	59	218	102	172	81
Channel Catfish	Larvae	81,209	51,432	4,560	2,888	42,884	27,160
Common Carp	Larvae			12	3	6	2
Crappie Pomoxis spp.	Larvae	782	15	1,049	20	915	18
Darter Etheostoma spp.[1]	Larvae	1,380	-7	12,992	-57	7,186	-32
Emerald Shiner	Larvae	22,403	8,717	11,604	4,517	17,004	6,617
Freshwater Drum	Eggs	946	766	2,704	2,190	1,825	1,478
	Larvae	3,240	429	3,455	457	3,347	443
	All	4,186	1,195	6,159	2,647	5,173	1,921
Gizzard Shad	Eggs	56	25			28	13
	Larvae	36,520	1,096			18,260	548
	All	36,576	1,121			18,288	560
Grass Carp	Larvae	3	1			1	<1
Logperch[1]	Larvae	60,073	-295	89,107	-432	74,590	-363
Mississippi Silverside	Eggs	192	149			96	75
	Larvae	799,621	246,713	130,512	40,271	465,066	143,492
	All	799,813	246,862	130,512	40,271	465,162	143,567
Sauger	Larvae	114	22	442	86	278	54
Shiner Pimephales spp.	Larvae	40,843	15,898	9,198	3,581	25,021	9,739
Skipjack Herring	Eggs			8	4	4	2
Spotted Sucker	Larvae	429	200	296	139	363	170
Sunfish Lepomis spp.	Larvae	84,601	292	48,790	168	66,695	230
Threadfin Shad	Eggs	1,442	647	58	26	750	337
	Larvae	872,096	124,592	1,466,157	209,425	1,169,127	167,009
	All	873,538	125,239	1,466,215	209,451	1,169,877	167,345
Topminnow Fundulus sp.	Larvae	34	3			17	1
Western Mosquitofish	Larvae	11,149	1,072			5,575	536
White Bass	Eggs	4	3			2	1
	Larvae	10,329	2,506	101,975	24,735	56,152	13,620
	All	10,333	2,509	101,975	24,735	56,154	13,622

[1] The 0.5-mm FMS requires additional spray wash equating to a 0.7% increase in water withdrawal (20.2 MGD), and therefore may result in higher entrainment mortality and negative benefits if impingement survival is less than 0.7%. This is the case for Darter and Logperch larvae which assume 0.3% impingement survival.

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Taxon	Life Stage	Age-1 Equivalents					
		2018		2019		Mean	
		CCRS	FMS	CCRS	FMS	CCRS	FMS
Yellow Bass	Larvae	22	5			11	3
Yellow Perch	Larvae	933	624	6,341	4,243	3,637	2,434
Total	**All**	**2,028,648**	**455,029**	**1,889,478**	**292,365**	**1,959,063**	**373,697**

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Table 3-3: Estimated number of equivalent adults corresponding to the annual entrainment mortality reductions if a CCRS or 0.5-mm FMS were installed at the existing cooling water intake structure of BFN Plant based on intake samples collected February 20, 2018 through December 19, 2019 and 2016-2020 daily average AIF

Taxon	Life Stage	Equivalent Adults					
		2018		2019		Mean	
		CCRS	FMS	CCRS	FMS	CCRS	FMS
Blue Catfish	Larvae	27	17			14	9
Buffalofish Ictiobus spp.	Larvae	70	33	120	56	95	44
Channel Catfish	Larvae	3,341	2,116	188	119	1,764	1,117
Common Carp	Larvae			8	2	4	1
Crappie Pomoxis spp.	Larvae	262	5	352	7	307	6
Darter Etheostoma spp.[2]	Larvae	1,380	-7	12,992	-57	7,186	-32
Emerald Shiner	Larvae	22,403	8,717	11,604	4,517	17,004	6,617
Freshwater Drum	Eggs	482	391	1,378	1,116	930	753
	Larvae	1,651	218	1,761	233	1,706	226
	All	2,133	609	3,139	1,349	2,636	979
Gizzard Shad	Eggs	56	25			28	13
	Larvae	36,520	1,096			18,260	548
	All	36,576	1,121			18,288	560
Grass Carp	Larvae	2	<1			1	<1
Logperch[2]	Larvae	60,073	-295	89,107	-432	74,590	-363
Mississippi Silverside	Eggs	192	149			96	75
	Larvae	799,621	246,713	130,512	40,271	465,066	143,492
	All	799,813	246,862	130,512	40,271	465,162	143,567
Sauger	Larvae	50	10	195	38	123	24
Shiner Pimephales spp.	Larvae	40,843	15,898	9,198	3,581	25,021	9,739
Skipjack Herring	Eggs			2	1	1	1
Spotted Sucker	Larvae	429	200	296	139	363	170
Sunfish Lepomis spp.	Larvae	84,601	292	48,790	168	66,695	230
Threadfin Shad	Eggs	1,442	647	58	26	750	337
	Larvae	872,096	124,592	1,466,157	209,425	1,169,127	167,009
	All	873,538	125,239	1,466,215	209,451	1,169,877	167,345
Topminnow Fundulus spp.	Larvae	34	3			17	1
Western Mosquitofish	Larvae	11,149	1,072			5,575	536
White Bass	Eggs	2	1			1	1
	Larvae	4,641	1,126	45,820	11,114	25,231	6,120
	All	4,643	1,127	45,820	11,114	25,232	6,121

[2] The 0.5-mm FMS requires additional spray wash equating to a 0.7% increase in water withdrawal (20.2 MGD), and therefore may result in higher entrainment mortality and negative benefits if impingement survival is less than 0.7%. This is the case for Darter and Logperch larvae which assume 0.3% impingement survival.

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Taxon	Life Stage	Equivalent Adults					
		2018		2019		Mean	
		CCRS	FMS	CCRS	FMS	CCRS	FMS
Yellow Bass	Larvae	22	5			11	3
Yellow Perch	Larvae	280	187	1,904	1,274	1,092	731
Total	**All**	**1,941,670**	**403,213**	**1,820,441**	**271,597**	**1,881,056**	**337,405**

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4 Entrainment Benefits Monetization Basis

4.1 Components of Social Benefits

As stated in Section 3.1 above, there are no commercial fisheries in Wheeler Reservoir and, as such there are no gains to commercial fishermen, which corresponds to the category of market use benefits. Therefore, three benefit categories are evaluated, including monetary valuations and qualitative assessment:

1. *Non-Market Direct Use Benefits.* These benefits consist of goods and services that have direct uses but are not traded in the marketplace. Dollar values of benefits of increased catch to recreational fishermen (i.e. Recreational Use Benefits) are based upon estimates of biological gains discussed in Section 3 above, and detailed in Appendix A.

2. *Indirect Use Benefits.* These benefits occur through indirect or secondary effects on non-marketed and marketed goods (in primary and secondary markets). Monetary benefit values are provided for estimates of the increases in recreational catch due to additional forage. Other potential indirect use benefits are assessed qualitatively.

3. *Non-Use Benefits.* These benefits occur when individuals value improved environmental quality without any past, present, or anticipated future use of the resources in question. Qualitative evaluations of this category are based upon quantitative biological information provided in Appendix A.

4.2 Recreational Use Benefits

Recreational fishing benefits are classified as non-market direct use benefits since the benefit in question – the value of catching an additional fish recreationally – is not purchased in a market. Therefore, there are no market prices that reflect the value of the recreational experience. Instead of a market price, the monetary value is measured by what can be inferred about anglers' "willingness-to-pay" for additional catch. The estimated annual benefits are about $85,900 per year for the FMS, and about $321,800 per year for CCRS (Section IV.D. of Appendix B). Table 4-1 (reproduced from Table 5 in Appendix B) presents the present values of recreational benefits for the two technologies over a period from 2022 to 2036, using real discount rates of both 3 percent and 7 percent.

Table 4-1 Present Values of Total Recreational Benefits, 2022-2036 (2018$)

Technology	Discount Rate	
	3%	7%
0.5-mm Fine Mesh Screens	$651,231	$460,414
Closed-Cycle Recirculating System	$1,630,354	$1,080,139

Note: Benefits are assumed to occur annually in each year in which the plant operates. Note that this assumption may overstate benefits in 2033-2036, years in which one or more units may cease operation following permit expiration. For the purposes of present value calculations, the benefits are assumed to occur at the start of each year.

Source: NERA calculations as explained in Appendix B, Section IV.

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Details of the recreational use benefits monetary analysis are presented in Section IV of Appendix B.

4.3 Indirect Use Benefits

Consistent with EPA's benefit assessment in the Final 316(b) Rule, monetary values for potential indirect benefits were not developed. Instead, for potential market indirect benefits (e.g. increases in fishing equipment sales) principles from the economic literature were used to conclude that secondary effects of changes in recreational fishing on the relevant markets would not lead to additional social benefits. Potential non-market indirect use benefits (e.g. increases in value of boating or bird-watching) due to the candidate technologies were evaluated using quantitative biological conclusions and are not expected to lead to significant indirect market or non-market benefits. Detailed evaluation of indirect use benefits is provided in Section V of Appendix B.

4.4 Non-Use Benefits

Evaluation of non-use benefits was based upon relevant biological information, the absence of an existing study of non-use values directly related to entrainment at BFN, the absence of a study that could be used appropriately as the basis for benefit transfer, and the overall cost and difficulty of developing an independent study of non-use benefits. It was concluded that a non-monetary evaluation of potential non-use benefits from the two candidate technologies was appropriate. Based on the economic criteria discussed in Section VI of Appendix B, and the biological information provided in Appendix A, it was determined that the non-use benefits are not likely to be significant for the two candidate technologies at BFN.

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5 Existing Mitigation Efforts

The Final 316(b) Rule, at 40 CFR 122.21(r)(11)(iv), requires a:

> *a discussion of mitigation efforts completed prior to October 14, 2014, including how long they have been in effect and how effective they have been;*

The BFN site did not put into place mitigation efforts prior to October 14, 2014.

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6 Non-Fishery Benefits

The Final 316(b) Rule, at 40 CFR 122.21(r)(11)(v), requires a:

> *discussion, with quantification and monetization, where possible, of any other benefits expected to accrue to the environment and local communities, including but not limited to improvements for mammals, birds, and other organisms and aquatic habitats.*

Available information was reviewed, but a complete analysis of the complex food web dynamics at BFN is not available. The estimated entrainment reductions from CCRS and FMS at BFN would not be expected to lead to significant indirect benefits due to improvements for mammals, birds, and other organisms and aquatic habitats. This assumption is likely to be valid at the regional scale of the river near BFN but localized on-site impacts on mammals and birds associated with the construction and operation of the CCRS and FMS are unknown.

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7 Thermal Discharge Reduction Benefits

The Final 316(b) Rule, at 40 CFR 122.21(r)(11)(vi), requires a:

> *discussion, with quantification and monetization, where possible, of any benefits expected to result from any reductions in thermal discharges from entrainment technologies.*

The installation and operation of FMS do not significantly increase cooling water volume, reduce once-through cooling or ultimately reduce the expected spatial extent or magnitude of the thermal discharge at BFN. As such, no thermal discharge reduction benefits are expected from FMS at BFN. However, operation of a CCRS would expect to lead to a substantial reduction in spatial extent and magnitude of the thermal discharge. Based on the results from §316(a) thermal discharge studies (Baxter and Simmons 2008), the thermal discharge from the existing CWIS operations at BFN do not cause appreciable harm or adverse environment impacts; thus, reduction of the thermal discharge from operating a CCRS and FMS is not expected to lead to meaningful biological benefits. The finding that BFN's thermal discharge under existing CWIS operations is not causing appreciable harm was substantiated by BFN being granted a §316(a) variance in their NPDES Permit. Potential benefit to fishing near the thermal discharge, especially during winter months, has not been quantified or studied. Based on the thermal discharge size and available habitat, the increase in fishing activity near the thermal discharge if a CCRS was installed was assumed to be negligible.

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Appendix A. Biological Benefit Evaluation of Entrainment Reducing Technologies at Browns Ferry Nuclear Plant

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Biological Benefit Evaluation of Entrainment Reducing Technologies at Browns Ferry Nuclear Plant

In Support of 40 CFR §122(r)(11) Submittal for
NPDES Permit No. AL0022080



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Acronyms and Abbreviations

ADEM	Alabama Department of Environmental Management
AIF	actual intake flow
BFN	Browns Ferry Nuclear Plant
BTA	Best Technology Available
CCRS	closed cycle recirculating system
CWIS	cooling water intake structure
ECS	entrainment characterization study
EPA	Environmental Protection Agency
fps	feet per second
kg	kilograms
m^3	cubic meters
MGD	million gallons per day
mm	millimeters
MW	megawatt
Normandeau	Normandeau Associates, Inc.
NPDES	National Pollutant Discharge Elimination System
PYSL	post yolk-sac larvae
TL	total length
TVA	Tennessee Valley Authority
TW	total weight
YOY	young of the year
YSL	yolk-sac larvae

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1 §122.21(r)(11) Requirements

The U.S. Environmental Protection Agency's ("EPA") Clean Water Act Section 316(b) cooling water intake structures ("CWIS") final rule ("Final §316(b) Rule"), which requires existing facilities that withdraw greater than 125 million gallons per day ("MGD") for actual intake flow ("AIF") for which 25% or more of the AIF is used exclusively for cooling purposes to submit a Benefits Valuation Study consistent with the following requirements of 40 CFR §122.21 (r)(11):

> *The owner or operator of an existing facility that withdraws greater than 125 mgd AIF must develop for submission to the Director an evaluation of the benefits of the candidate entrainment reduction technologies and operational measures evaluated in paragraph (r)(10) of this section including using the Entrainment Characterization Study completed in paragraph (r)(9) of this section. Each category of benefits must be described narratively, and when possible, benefits should be quantified in physical or biological units and monetized using appropriate economic valuation methods. The benefits valuation study must include, but is not limited to, the following elements:*
>
> *(i) incremental changes in the numbers of individual fish and shellfish lost due to impingement mortality and entrainment as defined in 40 CFR 125.92, for all life stages of each exposed species;*
>
> *(ii) description of basis for any estimates of changes in the stock sizes or harvest levels of commercial and recreational fish or shellfish species or forage fish species;*
>
> *(iii) description of basis for any monetized values assigned to changes in the stock size or harvest levels of commercial and recreational fish or shellfish species, forage fish, and to any other ecosystem or nonuse benefits;*
>
> *(iv) a discussion of mitigation efforts completed prior to October 14, 2014, including how long they have been in effect and how effective they have been;*
>
> *(v) discussion, with quantification and monetization, where possible, of any other benefits expected to accrue to the environment and local communities, including but not limited to improvements for mammals, birds, and other organisms and aquatic habitats; and,*
>
> (vi) *discussion, with quantification and monetization, where possible, of any benefits expected to result from any reductions in thermal discharges from entrainment technologies.*

2 Background

Tennessee Valley Authority ("TVA") owns and operates the Browns Ferry Nuclear Plant ("Browns Ferry", "BFN", or "the Plant") on the eastern shore of the Tennessee River on Wheeler Reservoir in Athens, Limestone County, Alabama. Browns Ferry has three nuclear generating units with a total design electrical rating of 3,300 megawatts ("MW"); Unit 1 has been in operation since 1973, Unit 2 since 1974, and Unit 3 since 1976. Non-contact cooling water for the Plant is withdrawn from the Wheeler Reservoir of the Tennessee River through an intake forebay that is separated from the Tennessee River by a gated structure with three intake bays, each with a 6-m high gate that is adjustable to control the intake flow velocity into the CWIS. Browns Ferry is subject to compliance with the Final §316(b) Rule. Entrainment compliance requirements of the Final §316(b) Rule under the §316(b) Regulations are specified in National Pollutant Discharge Elimination System Permit No. AL-0022080 ("NPDES Permit") issued by

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the Alabama Department of Environmental Management ("ADEM") effective September 1, 2016. The NPDES Permit requires BFN's CWIS to reflect the Best Technology Available ("BTA") for minimizing adverse environmental impacts from entrainment and impingement. Since the AIF for BFN during 2016 through 2020 is greater than 125 MGD, a Benefits Valuation Study for the plant is required as specified by §122.21 (r)(11).

To satisfy Section 122.21(r)(11), this report evaluates the biological benefits of implementing a closed cycle recirculating system ("CCRS") and 0.5-mm fine mesh traveling water screens ("FMS") as BTA alternatives at BFN. These alternatives were evaluated relative to the existing CWIS assuming 100% through-plant entrainment mortality. This report addresses §122.21(r)(11)(i and ii) by estimating the biological benefits of the BTA alternatives as the incremental gains from entrainment mortality reductions and their equivalent recreational and commercial harvest, which were then used as input data for monetizing the benefits in the economic assessment. The selection criteria, features, and cooling water withdrawal rates for CCRS and FMS as candidate entrainment reduction technologies were discussed in the Comprehensive Technical Feasibility and Cost Evaluation Study submitted to ADEM pursuant to 40 CFR §122.21 (r)(10).

3 Entrainment Information Pursuant to §122.21(r)(11)(i)

3.1 Entrainment Abundance Data

3.1.1 Entrainment Monitoring Data

The biological benefit evaluation of entrainment reduction technologies at Browns Ferry is based on the entrainment densities estimated from a two-year Entrainment Characterization Study ("ECS") performed to address Final §316 Rule §122.21(r)(9)(TVA 2021a). The study was conducted by TVA from February 20, 2018, through December 19, 2019, and sampled ichthyoplankton density at the entrance of the intake channel within the hydraulic zone of influence weekly during the peak entrainment season from February through August and approximately monthly from September through January (TVA 2021a). Ichthyoplankton could not be collected inside the intake channel for security reasons, but TVA believed the sample design led to representative collections. Previous entrainment data were collected by TVA through stationary sampling behind the skimmer wall in the intake channel with a 0.5-m square, 790-micron mesh beam net during 1971–1979 and 2008–2009 (TVA 1978; TVA 1980; TVA 2012). Ambient ichthyoplankton densities were also sampled at three sites approximately 0.2 river miles upstream of the skimmer wall and used in the ECS in conjunction with historical intake samples to demonstrate that the samples collected near the skimmer wall during 2018 and 2019 were representative of entrainment by BFN's intake and the source waterbody. Herein, density data collected from ichthyoplankton tows in front of the skimmer wall will be referred as "entrainment data" or "intake samples."

In the ECS, samples were taken with a beam net (0.75 m circular, 3.75 m long, with 363-micron "Nitex" mesh netting) towed into the current at a speed of 1.0 m/s to filter approximately 150 m^3 of water per sample. Water volume filtered was measured with a large-vaned General Oceanics Inc.® flowmeter suspended in the mouth of the net. Flowmeter counts of approximately 12,500 were used to achieve the target volume of 150 m^3. The sampling design included six net samples

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(three taken during the day, three at night) taken from the full water column at the skimmer wall each sampling period (Table 3-1). Sampling events alternated between four six-hour periods to remove diel period bias.

Not all eggs and larvae were identified to species in the 2018–2019 study (Table 3-2). If specimens were too damaged or there was a lack of taxonomic knowledge in the laboratory, the designations "unidentifiable fish larvae" or "unspecified X" (where X = the family or other grouping to which the specimen can be identified) were used. The entrainment density data represented 38 taxonomic categories of entrainable fish (5 egg taxa and 30 larval taxa in 2018; 3 egg taxa and 24 larval taxa in 2019). Sixteen taxa were identified to species and four taxa were identified to genus. For purposes of the Benefits Valuation Study, apparent differences or inconsistencies in the original taxonomic nomenclature were reconciled by re-classification. Other higher-level taxa were apportioned to species or genus to appropriate model life history and monetized, which is described in more detail in Section 3.2.2.

3.1.2 Actual Intake Flow Data

The assessment of potential benefits for each technology used expected daily water withdrawal volumes to scale up entrainment densities to abundance estimates that would be considered representative of current and future operations. Daily water withdrawal volumes were based on the January 2016–December 2020 daily average AIF at BFN provided by TVA that corresponds to the dates sampled in 2018 and 2019, and extrapolated by the number of days represented in each sample period (Table 3-3). The water withdrawal volumes based on the 2016–2020 daily average AIF were used to estimate the fish entrainment abundance at BFN for each technology alternative. Specifically, these water withdrawal volumes would be reduced by 92.4% with installation of a CCRS (Table 3-4) and increased by an additional 20.2 MGD that would be withdrawn if 0.5-mm FMS were installed to accommodate the greater amount of spray wash required for the screens (Table 3-5).

3.2 Entrainment Abundance Estimates for the Existing CWIS

To assess the potential gains in recreational fishery benefits from entrainment reductions for each technology alternative, the entrainment abundance and mortality of the existing CWIS was used as the reference for quantifying these reductions. In this section, the estimation of entrainment abundance and mortality at BFN's existing CWIS is described.

3.2.1 Calculation Methods of Entrainment Density

The mean entrainment density ($D_{t,\,i,\,p}$) for taxon t and life stage i in each period p at BFN was calculated as an arithmetic mean of the sample densities of fish. The sample densities were based on egg and larval specimens with a limiting body dimension less than 14.2 mm (0.56 inches) used to define entrainment under the Final §316(b) Rule.

The mean density of entrainable ichthyoplankton used in these calculations by taxon and life stage collected at the intake at BFN were obtained for each sample period during 2018 (Table 3-6). Entrainment density fluctuated over the study duration but peaked during Sample Period 13 on May 14, 2018 (13,171.1 N/1000 m^3) and Sample Period 15 on 28 May 28, 2018 (14,025.5 N/1000 m^3; Table 3-6). The most abundant taxa and life stages collected in 2018 were Herring Family larvae (84.7%), Mississippi Silverside larvae (4.2%), Threadfin Shad larvae (2.3%),

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Sunfish *Lepomis* spp. larvae (2.2%), Temperate Basses Family larvae (1.8%), and Freshwater Drum eggs (1.9%; Table 3-6). All other taxa and life stages collected at BFN intake during 2018 comprised less than 5% of the overall mean entrainment density.

Mean entrainment density by taxon and life stage collected at the intake at BFN were obtained for each sample period during 2019 (Table 3-7). In 2019, mean entrainment density was relatively low (≤ 304.0 N/1000 m^3) from the first sample period (Sample Period 32) on 28 January 2019 to Sample Period 38 on 1 April 2019 and again from Sample Period 48 on 10 June 2019 to last period on 16 December 2019 (Table 3-7). As in 2018, entrainment density fluctuated between sample periods but from 8 April 2019 to 3 June 2019 two peaks occurred, 6 May 2019 (7,553.8 N/1000 m^3), and 27 May 2019 (10,068.3 N/1000 m^3; Table 3-7). The most abundant taxa and life stages collected in 2019 were Herring Family larvae (73.2 %), Temperate Basses Family larvae (17.9%), Freshwater Drum eggs (5.2%), and Sunfish *Lepomis* spp. larvae (1.2%, Table 3-7). All other taxa and life stages collected at BFN intake during 2019 comprised less than 3% of the overall mean entrainment density.

3.2.2 Taxon Apportionment

The monetization of the benefits of implementing entrainment reduction technologies at BFN requires applying monetary values to equivalent fishery yield estimates of recreational catch and commercial harvest of species with fishery importance that arise from reductions directly and indirectly (via trophic transfer) relative to the existing CWIS. Annual entrainment data of all taxa identified from sampling were used to quantify the fish protection benefits (i.e., incremental gains) from each technology alternative. However, to do so, unidentifiable fish taxa and several fish taxa identified to family or species complexes were apportioned to genus or species level for modelling the life histories at the appropriate taxonomic resolution appropriate for monetizing the fishery benefits of each technology alternative.

The taxa identified to higher-than-species level were apportioned to genus or species proportional to the mean densities of the member genus/species and life stages identified for that respective sample period (or adjacent sample period when no other related species were identified). The first step to taxon apportionment was allocating the densities of unidentified fish taxa among the remaining taxa. The densities of unidentified eggs (Table 3-8) and larvae (Table 3-9) were apportioned to genus or species that were also entrained in that sample period. Eggs identified in the Herring Family (but not Skipjack Herring) that could not be identified to genus or species were apportioned to Gizzard Shad and Threadfin Shad based on species composition of their larvae (Table 3-10). Larvae identified as Herring Family were apportioned to Gizzard Shad and Threadfin Shad (Table 3-11).

Other taxa were classified to genus/species because there was only one representative genus or species within the identified higher-level taxa for that year or sample period. Eggs identified as Temperate Basses were classified as White Bass because that was only family member identified to genus or species in 2018. Similarly, larvae identified as Temperate Basses family were classified as White Bass since it was the only member species identified in those respective sample periods. Shiner *Pimephales* spp. was the only identified cyprinid in the sample periods with unspecified cyprinids (Carps and Minnows) or unidentified shiner.

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3.2.3 Calculation Methods of Entrainment Abundance

After mean entrainment densities for each taxon and stage ($D_{,t,i,p}$) were apportioned and consolidated to genus or species, the entrainment abundance ($E_{t,i,p}$) for species t and life stage i in each sample period p at BFN was calculated as:

$$E_{t,i,p} = \frac{D_{t,i,p}}{1000} V_p \qquad \text{Equation 1}$$

where, $D_{t,i,p}$ = intake sample density (number per 1000 m^3) for species t and life stage i in sample period p, and

V_p = total volume (m^3) at AIF for combined units at sample period p (Table 3-3).

Annual entrainment abundance of species t and life stage i ($E_{t,i}$) at BFN (for all units combined) was estimated by summation of $E_{t,i,p}$ as:

$$E_{t,i} = \sum_{p=1}^{n} E_{t,i,p} \qquad \text{Equation 2}$$

where, n = number of sample periods within the annual period.

To characterize inter-annual variability, entrainment abundance was estimated separately for each year of density data.

3.2.4 Entrainment Abundance and Mortality Estimates for the Existing CWIS

After taxon apportionment, mean entrainment density by taxon and life stage collected at BFN were obtained for each sample period during 2018 (Table 3-12) and 2019 (Table 3-13). The most abundant taxa and life stages collected in 2018 were Threadfin Shad larvae (46.7%), Gizzard Shad larvae (40.7%), Mississippi Silverside larvae (4.2%), Sunfish *Lepomis* spp. larvae (2.2%), Freshwater Drum eggs (1.9%), and White Bass larvae (1.9%; Table 3-12). The most abundant taxa and life stages collected in 2018 after species apportionment were Threadfin Shad larvae (73.2%), White Bass larvae (17.9%), Freshwater Drum eggs (5.2%), and Sunfish *Lepomis* spp. larvae (1.2%; Table 3-13). All other taxa and life stages collected at BFN after taxon apportionment each comprised less than 1% of the annual mean entrainment density during 2018 and 2019.

When the 2016–2020 daily-average AIF was used to scale up mean densities to entrainment abundance for each sample period, the annual entrainment abundance was estimated to be 3.01 billion individuals based on 2018 data (Table 3-14) and 3.22 billion individuals based on 2019 data (Table 3-15). Similar to species composition based on the density data, the taxa and life stages with the highest estimated annual entrainment abundance were in Threadfin Shad larvae (1.41 billion; 47%), Gizzard Shad eggs (1.22 billion; 41%), and Mississippi Silverside larvae (128 million; 4%) based on 2018 data. Annual entrainment abundance estimated from

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2019 data was highest for Threadfin Shad larvae (2.36 billion; 73%), White Bass larvae (577 million; 18%), and Freshwater Drum (165 million; 5%).

3.3 Entrainment Abundance Estimates from a Closed-Cycle Recirculating System

If BFN operated their mechanical draft cooling towers year-round to provide a CCRS for cooling purposes, then the entrainment abundance of fish estimated for the existing CWIS would be reduced by 92.4% assuming entrainment reduction is directly proportional to flow reduction. Specifically, entrainment abundance estimates for species *t* and life stage *i* with a CCRS were estimated by sample period and year using Equation 1 and Equation 2, respectively, with substitution of the reduced cooling water withdrawal volumes as presented in Table 3-4.

Annual entrainment abundance of fish for a CCRS retrofitted at BFN was estimated to be 228.8 million individuals based on Year-1 densities (Table 3-16) and 245.9 million based on Year-2 densities (Table 3-17).

3.4 Entrainment Abundance Estimates from 0.5-mm Fine Mesh Screens

3.4.1 Calculation Methods of Entrainment Abundance for Fine Mesh Screens

Assuming BFN installed and operated FMS with continuous rotation, entrainment abundance was estimated following similar calculations described by Equation 1 and Equation 2 in Section 3.2.1, except entrainment density for individual species and life stages was adjusted to account for physical size exclusion by the 0.5-mm FMS and slightly greater withdrawal volumes. The physical size exclusion factor ($F_{e,\,t,\,i}$) used to exclude individual species *t* and life stage *i* from passing through a 0.5-mm FMS was estimated as the proportion of measured individuals for species *t* and life stage *i* that were greater than or equal to 0.5 mm in the limiting dimension. The entrainment abundance for 0.5-mm FMS in each sample period ($E_{FMS,t,i,p}$) was estimated as

$$E_{FMS,t,i,p} = \frac{D_{t,i,p}}{1000}\left(1 - F_{e,t,i}\right)V_p \qquad \text{Equation 3}$$

where,

$D_{t\,i,\,p}$ = entrainment density (N/1000 m^3) for species *t* and life stage *i* in sample period *p* (Table 3-12 and Table 3-13);

V_p = total volume (m^3) at AIF for combined units at sample period *p* with the additional 20.2 MGD for spray wash (Table 3-5); and

$F_{e,\,t,\,i}$ = physical size exclusion factor for a 0.5-mm FMS estimated as a proportion of measured individuals with limiting dimension greater than 0.5 mm (Table 3-18 and Table 3-19).

No site-specific or local egg diameter data were available, so ranges in egg diameters obtained from the literature were used to estimate F_e for each taxon *t* of fish eggs collected in the intake samples at BFN:

$$F_{e,t,eggs} = 1 - \left(CDF((m - \phi)/\sigma)\right) \qquad \text{Equation 4}$$

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where CDF = Normal cumulative distribution function,
m = Mesh size (i.e., 0.5 mm),
ϕ = Mean diameter estimated as the mid-point for literature-derived range in egg diameter (Table 3-18), and
σ = Standard deviation estimated as the egg diameter range divided by 4, which assumes approximately 95% of the possible values are within two standard deviations (i.e., the range spans four standard deviations).

Individual measurement data of larvae were not available from BFN, so data collected near Sequoyah Nuclear Plant on the Tennessee River northeast of BFN was used as surrogate data. Head capsule depth and width of measured larvae were used to estimate the fraction of larvae that would be excluded by a 0.5-mm FMS at BFN. Maximum head capsule depths ranged from 0.6 mm (Common Carp) to 5.7 mm (Gizzard Shad), and maximum head capsule width ranged from 0.8 mm (Common Carp, Emerald Shiner, and *Pimephales* spp.) to 3.6 mm (Channel Catfish; Table 3-19). Based on these dimensions, the proportion of larvae that would be excluded by the 0.5-mm FMS was 0.675 or greater for all taxa, and all larvae would be excluded from a majority (15 of 22) of taxa examined (Table 3-19).

Equation 3 is modified to estimate the abundance of entrainable organisms impinged ("converts") on FMS ($E_{converts,t,i,p}$) as

$$E_{converts,t,i,p} = \frac{D_{t,i,p}}{1000}\left(F_{e,t,i}\right)V_p \qquad \text{Equation 5}$$

Estimation of entrainment abundance and reduction if a 0.5-mm FMS was installed at BFN did not account for fish entrained through the existing traveling screens if the FMS were bypassed for safety-related reasons as described in the Comprehensive Technical Feasibility and Cost Evaluation Study. Rather than assuming the frequency, timing and duration of a safety-related bypass over the period of 2022–2036, the biological benefits of a 0.5-mm FMS were estimated assuming safety-related bypasses would not be required. However, the effectiveness of the 0.5-mm FMS at reducing entrainment would be less if a safety-related bypass was required during the entrainment season.

3.4.2 Entrainment Abundance Estimates for Fine Mesh Screens

The total estimated abundance (number of individuals) of fish entrained through a 0.5-mm FMS at BFN was 844.8 million based on entrainment sample densities from 2018 (Table 3-20) and 909.8 million based on entrainment sample densities from 2019 (Table 3-21). Threadfin Shad (51.9%), Gizzard Shad (45.3%), and White Bass (2.0%) larvae represented the dominant taxa and life stage for 2018. Threadfin Shad (81.1%), White Bass (18.2%), and Freshwater Drum (0.7%) larvae were the dominant taxa and life stage for 2019. The majority of estimated entrainment through a 0.5-mm FMS occurred during May for both 2018 and 2019.

The estimated abundance of entrainable fish eggs and larvae excluded by a 0.5-mm FMS at BFN was 2.19 billion in 2018 (Table 3-22) and 2.34 billion in 2019 (Table 3-23). Threadfin Shad

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(44.7%), Gizzard Shad (38.8%), and Mississippi Silverside (5.9%) larvae represented the dominant taxa and life stage for 2018. Threadfin Shad (70.3%) and White Bass (17.8%) larvae and Freshwater Drum eggs (7.1%) were the dominant taxa and life stages for 2019. The majority of estimated entrainment exclusion by a 0.5-mm FMS occurred during May for both 2018 and 2019.

3.4.3 Calculation Methods of Entrainment Mortality for Fine Mesh Screens

While entrainment mortality of fish entrained through the FMS was assumed 100%, a portion of the fish excluded by FMS may be susceptible to mortality (i.e., converting entrainment to impingement mortality). Survival of entrainable eggs and larvae impinged on the FMS ("impingement or FMS survival") for selected species and life stages (or available surrogates) were gathered from the literature to estimate entrainment mortality of fish pass through or excluded by 0.5-mm (Table 3-24).

The entrainment mortality adjusted for a 0.5-mm FMS (EM_{FMS}) for species t and life stage i during sample period p was estimated as

$$EM_{FMS,t,i,p} = E_{\text{FMS},t,i,p} + \left[E_{converts,t,i,p}(1 - S_{FMS,t,i})\right] \quad \text{Equation 6}$$

where, $E_{FMS,\ t,i,p}$ = entrainment abundance of taxon t and life stage i that pass through FMS during sample period p as defined by Equation 4,

$E_{converts,t,i,m}$ = monthly abundance of species t and life stage i that are entrainment size (per §125.92(h)) but are impinged on FMS (converts) as defined by Equation 5, and

$S_{FMS,\ t,i}$ = fine mesh screen survival of species t and life stage i (Table 3-24).

3.4.4 Entrainment Mortality Estimates for Fine Mesh Screens

The estimated mortality of entrainable fish eggs and larvae from impingement if 0.5-mm FMS were installed at BFN was 1.83 billion for 2018 (Table 3-25) and 1.73 billion for 2019 (Table 3-26). Gizzard Shad (43.9%), Threadfin Shad (42.6%), and Mississippi Silverside (5.0%) larvae represented the majority of mortality for 2018. Threadfin Shad (75.8%) and White Bass (16.3%) larvae and Freshwater Drum eggs (2.4%) represented the majority of mortality for 2019. The majority of estimated mortality occurred during May for both 2018 and 2019.

The estimated mortality of fish eggs and larvae entrained or impinged (converts) if 0.5-mm FMS were installed at BFN was 2.68 billion for 2018 (Table 3-27) and 2.64 billion for 2019 (Table 3-28). Threadfin Shad (45.5%), Gizzard Shad (44.3%), and Mississippi Silverside (3.4%) larvae represented the dominant taxa and life stage for 2018. Threadfin Shad (77.6%) and White Bass (16.9%) larvae and Freshwater Drum eggs (1.6%) were the dominant taxa and life stage for 2019. The majority of estimated mortality occurred during May for both 2018 and 2019.

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3.5 Entrainment Abundance and Mortality Reductions from the Existing CWIS with CCRS and FMS

The estimated entrainment reductions for both the CCRS and FMS relative to the existing CWIS are shown in Table 3-29 through Table 3-34. The CCRS is expected to reduce entrainment abundance and mortality by 92.4%, while entrainment abundance reductions from the FMS are expected to be about 72% (Table 3-29 to Table 3-31) and entrainment mortality reductions from the FMS are expected to range from 11 to 18% (Table 3-32 to Table 3-34). The entrainment mortality reductions from the FMS were substantially lower than the expected 72% reduction in entrainment abundance because some ichthyoplankton excluded by the FMS do not survive impingement on the screens or the interaction with the screens. The 0.5-mm FMS requires additional spray wash equating to a 0.7% increase in water withdrawal (20.2 MGD), and therefore may result in higher entrainment mortality and negative benefits if impingement survival is less than 0.7%. This is the case for Darter and Logperch larvae which assume 0.3% impingement survival. Of the entrainable ichthyoplankton expected to be excluded by the FMS (converts), the estimated survival of these fish was 16 to 26% based on the survival rates in Table 3-24.

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Table 3-1. Number of samples by sample period (SP) and diel period (Day, Night, Total) collected by tows with a 363-micron mesh, 0.75-m diameter beam net in the hydraulic zone of influence of Browns Ferry Nuclear Power Plant during 2018 and 2019.

2018 (Year 1)								2019 (Year 2)							
					N Samples								N Samples		
SP	Sample Date	Start Date	End Date	N Days	Day	Night	Total	SP*	Sample Date	Start Date	End Date	N Days	Day	Night	Total
1	19-Feb	1-Jan	25-Feb	56	3	3	6	32	28-Jan	1-Jan	15-Feb	46	3	3	6
2	26-Feb	26-Feb	4-Mar	7	-	3	3	34	4-Mar	16-Feb	10-Mar	23	3	3	6
3	5-Mar	5-Mar	11-Mar	7	3	3	6	35	11-Mar	11-Mar	17-Mar	7	3	3	6
4	12-Mar	12-Mar	18-Mar	7	3	3	6	36	18-Mar	18-Mar	24-Mar	7	3	3	6
5	19-Mar	19-Mar	25-Mar	7	3	3	6	37	25-Mar	25-Mar	31-Mar	7	3	3	6
6	26-Mar	26-Mar	1-Apr	7	3	3	6	38	1-Apr	1-Apr	7-Apr	7	3	3	6
7	2-Apr	2-Apr	8-Apr	7	3	3	6	39	8-Apr	8-Apr	14-Apr	7	3	3	6
8	9-Apr	9-Apr	15-Apr	7	3	3	6	40	15-Apr	15-Apr	21-Apr	7	3	3	6
9	16-Apr	16-Apr	22-Apr	7	3	3	6	41	22-Apr	22-Apr	28-Apr	7	3	3	6
10	23-Apr	23-Apr	29-Apr	7	3	3	6	42	29-Apr	29-Apr	5-May	7	3	3	6
11	30-Apr	30-Apr	6-May	7	3	3	6	43	6-May	6-May	12-May	7	3	3	6
12	7-May	7-May	13-May	7	3	3	6	44	13-May	13-May	19-May	7	3	3	6
13	14-May	14-May	20-May	7	3	3	6	45	20-May	20-May	26-May	7	3	3	6
14	21-May	21-May	27-May	7	3	3	6	46	27-May	27-May	2-Jun	7	3	3	6
15	28-May	28-May	3-Jun	7	3	3	6	47	3-Jun	3-Jun	9-Jun	7	3	3	6
16	4-Jun	4-Jun	10-Jun	7	3	3	6	48	10-Jun	10-Jun	16-Jun	7	3	3	6
17	11-Jun	11-Jun	17-Jun	7	3	3	6	49	17-Jun	17-Jun	23-Jun	7	3	3	6
18	18-Jun	18-Jun	24-Jun	7	3	3	6	50	24-Jun	24-Jun	30-Jun	7	3	3	6
19	25-Jun	25-Jun	1-Jul	7	3	3	6	51	1-Jul	1-Jul	7-Jul	7	3	3	6
20	2-Jul	2-Jul	8-Jul	7	3	3	6	52	8-Jul	8-Jul	14-Jul	7	3	3	6
21	9-Jul	9-Jul	15-Jul	7	3	3	6	53	15-Jul	15-Jul	21-Jul	7	3	3	6
22	16-Jul	16-Jul	22-Jul	7	3	3	6	54	22-Jul	22-Jul	28-Jul	7	3	3	6
23	23-Jul	23-Jul	29-Jul	7	3	3	6	55	29-Jul	29-Jul	4-Aug	7	3	3	6
24	30-Jul	30-Jul	5-Aug	7	3	3	6	56	5-Aug	5-Aug	11-Aug	7	3	3	6
25	6-Aug	6-Aug	12-Aug	7	3	3	6	57	12-Aug	12-Aug	18-Aug	7	3	3	6
26	13-Aug	13-Aug	19-Aug	7	3	3	6	58	19-Aug	19-Aug	25-Aug	7	3	3	6
27	20-Aug	20-Aug	26-Aug	7	3	3	6	59	26-Aug	26-Aug	1-Sep	7	3	3	6
28	24-Sep	27-Aug	30-Sep	35	3	3	6	60	16-Sep	2-Sep	30-Sep	29	3	3	6
29	22-Oct	1-Oct	31-Oct	31	3	3	6	61	28-Oct	1-Oct	31-Oct	31	3	3	6
30	19-Nov	1-Nov	30-Nov	30	3	3	6	62	25-Nov	1-Nov	30-Nov	30	3	3	6
31	24-Dec	1-Dec	31-Dec	31	3	3	6	63	16-Dec	1-Dec	31-Dec	31	3	3	6
Total				**365**	**90**	**93**	**183**	**Total**				**365**	**93**	**93**	**186**

*Intake samples were not collected during Sample Period 33; the duration of Sample Periods 32 and 34 were extended to represent this unsampled period.

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Table 3-2. List of unique taxa and life stages identified at Browns Ferry Nuclear Power Plant based on 2018–2019 intake density data with taxonomic re-classification and taxon apportionment of higher-level taxa (X = Present).

Family	Taxon Identification[1]	Taxon Classification	2018	2019	Taxon Apportionment
Eggs					
	UNIDENTIFIABLE	Unidentified Osteichthyes	X		All lowest taxa
Atherinopsidae	UNSPECIFIED ATHERINOPSIDS (SILVERSIDES)	Mississippi Silverside	X		
Clupeidae	SKIPJACK HERRING	Skipjack Herring		X	
	UNSPECIFIED CLUPEIDS (NOT SKIPJACK)	Herring Family	X	X	Gizzard Shad, Threadfin Shad
Moronidae	UNSPECIFIED MORONIDS (NOT *M. SAXATILIS*)	Temperate Basses Family	X		White Bass[2]
Sciaenidae	FRESHWATER DRUM	Freshwater Drum	X	X	
Larvae					
	UNIDENTIFIABLE FISH	Unidentified Osteichthyes	X	X	
Atherinopsidae	MISSISSIPPI SILVERSIDE	Mississippi Silverside	X	X	
	UNSPECIFIED ATHERINOPSIDS (SILVERSIDE)	Mississippi Silverside	X	X	
Catostomidae	SPOTTED SUCKER	Spotted Sucker	X	X	
	UNSPECIFIED CATOSTOMID (ICTIOBINAE-BUFFALO OR CARPSUCKER)	Buffalofish *Ictiobus* spp.	X	X	
Centrarchidae	UNSPECIFIED CENTRARCHID (*LEPOMIS* SP)	Sunfish *Lepomis* spp.	X	X	
	UNSPECIFIED CENTRARCHID (*POMOXIS* SP)	Crappie *Pomoxis* spp.	X	X	
Clupeidae	GIZZARD SHAD	Gizzard Shad	X		
	THREADFIN SHAD	Threadfin Shad	X	X	
	UNSPECIFIED CLUPEIDS	Herring Family	X	X	Gizzard Shad, Threadfin Shad
Cyprinidae	COMMON CARP	Common Carp		X	
	GRASS CARP	Grass Carp	X		
	UNSPECIFIED CYPRINID (*PIMEPHALES* SP)	Shiner *Pimephales* spp.	X		
	UNSPECIFIED CYPRINIDS	Carps and Minnows Family	X	X	Shiner *Pimephales* spp.[3]
	UNSPECIFIED CYPRINIDS (*N. ATHERINIODES* GROUP)	Emerald Shiner	X	X	
	UNSPECIFIED CYPRINIDS (*PIMEPHALES* GROUP)	Shiner *Pimephales* spp.	X	X	
	UNSPECIFIED CYPRINIDS (UNSPECIFIED SHINER)	Shiner species		X	Shiner *Pimephales* spp.[3]
Fundulidae	UNSPECIFIED FUNDULIDAE (TOPMINNOW)	Topminnow *Fundulus* spp.	X		

(continued)

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Table 3-2. (continued)

Family	Taxon Identification	Taxon Classification	2018	2019	Taxon Apportionment
Ictaluridae	BLUE CATFISH	Blue Catfish	X		
	CHANNEL CATFISH	Channel Catfish	X	X	
Moronidae	UNSPECIFIED MORONID	Temperate Basses Family	X	X	White Bass[2]
	UNSPECIFIED MORONID (NOT *M. SAXATILIS*)	Temperate Basses Family	X	X	White Bass[2]
	WHITE BASS	White Bass	X	X	
	YELLOW BASS	Yellow Bass	X		
Percidae	LOGPERCH	Logperch	X	X	
	SAUGER	Sauger	X	X	
	UNSPECIFIED PERCID (DARTER NUT NOT LOGPERCH)	Darter *Etheostoma* spp.	X	X	
	UNSPECIFIED PERCID (LOGPERCH TYPE)	Logperch	X	X	
	UNSPECIFIED PERCIDS (*ETHEOSTOMA* SP)	Darter *Etheostoma* spp.	X		
	YELLOW PERCH	Yellow Perch	X	X	
Poeciliidae	WESTERN MOSQUITOFISH	Western Mosquitofish	X		
Sciaenidae	FRESHWATER DRUM	Freshwater Drum	X	X	

1 Taxonomic names as identified in the entrainment data

2 Unspecified moronids were classified as White Bass based on lack of identification of Yellow Bass or Striped Bass eggs or larvae during those periods or year.

3 Unspecified cyprinids were classified as shiner *Pimephales* species because they were the only identified cyprinids when these unspecified cyprinids occurred.

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Table 3-3. Actual intake flow (AIF) in million gallons per day (MGD) and total cooling water withdrawal volume (m^3) by sampling year and sample period for the existing cooling water intake structure at Browns Ferry Nuclear Plant based on daily average AIF from January 2016 through December 2020.

Sampling Year 1 (2018)				Sampling Year 2 (2019)			
Sample Period	Number of Days	Mean AIF (MGD)	Total Volume (m^3)	Sample Period	Number of Days	Mean AIF (MGD)	Total Volume (m^3)
1	56	2,760.1	585,101,191	32	46	2,782.2	484,465,881
2	7	2,376.8	62,981,341	34	23	2,437.2	212,196,457
3	7	2,138.9	56,676,441	35	7	2,138.9	56,677,351
4	7	2,138.9	56,677,351	36	7	2,269.1	60,125,971
5	7	2,320.2	61,481,453	37	7	2,585.4	68,507,475
6	7	2,607.5	69,093,217	38	7	2,786.6	73,840,284
7	7	2,815.7	74,609,720	39	7	2,910.5	77,121,213
8	7	2,931.3	77,672,522	40	7	2,945.1	78,039,606
9	7	2,924.3	77,488,297	41	7	2,875.8	76,202,365
10	7	2,882.7	76,386,135	42	7	2,878.2	76,267,366
11	7	2,870.5	76,062,582	43	7	2,802.1	74,249,931
12	7	2,801.2	74,225,955	44	7	2,861.0	75,809,144
13	7	2,850.7	75,537,148	45	7	2,845.8	75,406,416
14	7	2,865.7	75,934,599	46	7	2,952.9	78,244,730
15	7	2,958.8	78,401,071	47	7	2,916.1	77,269,867
16	7	2,909.1	77,086,022	48	7	2,910.5	77,121,061
17	7	2,910.5	77,121,137	49	7	2,903.5	76,937,444
18	7	2,903.5	76,937,444	50	7	2,903.5	76,937,444
19	7	2,910.5	77,121,668	51	7	2,980.0	78,964,674
20	7	2,987.0	79,148,899	52	7	3,000.9	79,516,590
21	7	3,000.9	79,516,590	53	7	2,975.4	78,843,020
22	7	2,938.5	77,863,573	54	7	2,812.1	74,513,550
23	7	2,849.0	75,492,997	55	7	2,973.1	78,779,691
24	7	2,966.1	78,595,466	56	7	2,952.2	78,227,017
25	7	2,952.2	78,227,017	57	7	2,952.2	78,227,017
26	7	2,952.2	78,227,017	58	7	2,952.2	78,227,017
27	7	2,952.2	78,227,017	59	7	2,959.2	78,411,241
28	35	2,919.3	386,769,814	60	29	2,910.8	319,533,861
29	31	2,641.5	309,978,142	61	31	2,641.5	309,978,142
30	30	2,831.3	321,527,947	62	30	2,831.3	321,527,947
31	31	2,919.2	342,559,220	63	31	2,919.2	342,559,220
Year[a]	**365**	**2,802.9**	**3,872,728,992**	**Year**	**365**	**2,802.9**	**3,872,728,992**

[a] The mean AIF for the year is the 2016–2020 daily average (n=365) and the total volume for the year is the sum of the volumes withdrawn for the sample periods corresponding to the dates sampled in 2018 and 2019.

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Table 3-4. Actual intake flow (AIF) in million gallons per day (MGD) and total cooling water withdrawal volume (m^3), by sampling year and sample period, expected for a closed-cycle cooling recirculating system retrofitted at Browns Ferry Nuclear Plant based on daily average AIF from January 2016 through December 2020.

Sampling Year 1 (2018)				Sampling Year 2 (2019)			
Sample Period	Number of Days	Mean AIF (MGD)	Total Volume (m^3)	Sample Period	Number of Days	Mean AIF (MGD)	Total Volume (m^3)
1	56	209.8	44,467,690	32	46	211.4	36,819,407
2	7	180.6	4,786,582	34	23	185.2	16,126,931
3	7	162.6	4,307,410	35	7	162.6	4,307,479
4	7	162.6	4,307,479	36	7	172.5	4,569,574
5	7	176.3	4,672,590	37	7	196.5	5,206,568
6	7	198.2	5,251,085	38	7	211.8	5,611,862
7	7	214.0	5,670,339	39	7	221.2	5,861,212
8	7	222.8	5,903,112	40	7	223.8	5,931,010
9	7	222.2	5,889,111	41	7	218.6	5,791,380
10	7	219.1	5,805,346	42	7	218.7	5,796,320
11	7	218.2	5,780,756	43	7	213.0	5,642,995
12	7	212.9	5,641,173	44	7	217.4	5,761,495
13	7	216.7	5,740,823	45	7	216.3	5,730,888
14	7	217.8	5,771,030	46	7	224.4	5,946,599
15	7	224.9	5,958,481	47	7	221.6	5,872,510
16	7	221.1	5,858,538	48	7	221.2	5,861,201
17	7	221.2	5,861,206	49	7	220.7	5,847,246
18	7	220.7	5,847,246	50	7	220.7	5,847,246
19	7	221.2	5,861,247	51	7	226.5	6,001,315
20	7	227.0	6,015,316	52	7	228.1	6,043,261
21	7	228.1	6,043,261	53	7	226.1	5,992,070
22	7	223.3	5,917,632	54	7	213.7	5,663,030
23	7	216.5	5,737,468	55	7	226.0	5,987,256
24	7	225.4	5,973,255	56	7	224.4	5,945,253
25	7	224.4	5,945,253	57	7	224.4	5,945,253
26	7	224.4	5,945,253	58	7	224.4	5,945,253
27	7	224.4	5,945,253	59	7	224.9	5,959,254
28	35	221.9	29,394,506	60	29	221.2	24,284,573
29	31	200.8	23,558,339	61	31	200.8	23,558,339
30	30	215.2	24,436,124	62	30	215.2	24,436,124
31	31	221.9	26,034,501	63	31	221.9	26,034,501
Year[a]	**365**	**213.0**	**294,327,403**	**Year**	**365**	**213.0**	**294,327,403**

[a] The mean AIF for the year is the 2016–2020 daily average (n=365) and the total volume for the year is the sum of the volumes withdrawn for the sample periods corresponding to the dates sampled in 2018 and 2019.

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Table 3-5. Actual intake flow (AIF) in million gallons per day (MGD) and total cooling water withdrawal volume (m^3) by sampling year and sample period if 0.5-mm fine mesh screens were installed in the existing cooling water intake structure at Browns Ferry Nuclear Plant based on daily average AIF from January 2016 through December 2020.

Sampling Year 1 (2018)				Sampling Year 2 (2019)			
Sample Period	Number of Days	Mean AIF (MGD)	Total Volume (m^3)	Sample Period	Number of Days	Mean AIF (MGD)	Total Volume (m^3)
1	56	2,780.3	589,374,769	32	46	2,802.6	488,014,477
2	7	2,397.0	63,515,538	34	23	2,457.0	213,913,520
3	7	2,159.1	57,210,639	35	7	2,159.1	57,211,549
4	7	2,159.1	57,211,549	36	7	2,289.2	60,660,169
5	7	2,340.4	62,015,650	37	7	2,605.6	69,041,673
6	7	2,627.7	69,627,415	38	7	2,806.8	74,374,481
7	7	2,835.8	75,143,917	39	7	2,930.6	77,655,410
8	7	2,951.4	78,206,719	40	7	2,965.3	78,573,804
9	7	2,944.5	78,022,495	41	7	2,896.0	76,736,562
10	7	2,902.9	76,920,332	42	7	2,898.4	76,801,563
11	7	2,890.7	76,596,780	43	7	2,822.3	74,784,129
12	7	2,821.4	74,760,152	44	7	2,881.1	76,343,341
13	7	2,870.8	76,071,346	45	7	2,865.9	75,940,613
14	7	2,885.8	76,468,797	46	7	2,973.0	78,778,927
15	7	2,978.9	78,935,268	47	7	2,936.2	77,804,064
16	7	2,929.3	77,620,219	48	7	2,930.6	77,655,259
17	7	2,930.6	77,655,335	49	7	2,923.7	77,471,641
18	7	2,923.7	77,471,641	50	7	2,923.7	77,471,641
19	7	2,930.6	77,655,866	51	7	3,000.2	79,498,871
20	7	3,007.1	79,683,096	52	7	3,021.0	80,050,787
21	7	3,021.0	80,050,787	53	7	2,995.6	79,377,218
22	7	2,958.6	78,397,770	54	7	2,832.2	75,047,747
23	7	2,869.2	76,027,195	55	7	2,993.2	79,313,888
24	7	2,986.3	79,129,663	56	7	2,972.4	78,761,214
25	7	2,972.4	78,761,214	57	7	2,972.4	78,761,214
26	7	2,972.4	78,761,214	58	7	2,972.4	78,761,214
27	7	2,972.4	78,761,214	59	7	2,979.3	78,945,439
28	35	2,939.4	389,440,801	60	29	2,930.9	321,746,964
29	31	2,661.7	312,343,873	61	31	2,661.7	312,343,873
30	30	2,851.4	323,817,364	62	30	2,851.4	323,817,364
31	31	2,939.3	344,924,951	63	31	2,939.3	344,924,951
Year[a]	**365**	**2,823.1**	**3,900,583,566**	**Year**	**365**	**2,823.1**	**3,900,583,566**

[a] The mean AIF for the year is the 2016–2020 daily average (n=365) and the total volume for the year is the sum of the volumes withdrawn for the sample periods corresponding to the dates sampled in 2018 and 2019.

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Table 3-6. Mean entrainment density (N/1000 m^3) by taxon and sample period at Browns Ferry Nuclear Plant during 2018.

		Sample Period															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Taxon	Life Stage	19-Feb	26-Feb	5-Mar	12-Mar	19-Mar	26-Mar	2-Apr	9-Apr	16-Apr	23-Apr	30-Apr	7-May	14-May	21-May	28-May	4-Jun
Blue Catfish	Larvae															1.2	
Buffalofish *Ictiobus* spp.	Larvae			2.3		5.6	15.7	17.3	16.9	26.9	5.0	7.0	1.3				
Carps and Minnows Family	Larvae																
Channel Catfish	Larvae																
Common Carp	Larvae																
Crappie *Pomoxis* spp.	Larvae				2.5				7.9	4.6	1.1		1.1				
Darter *Etheostoma* spp.	Larvae			1.3										1.1		1.2	
Emerald Shiner	Larvae														2.2		
Freshwater Drum	Eggs												18.1	14.2	124.1	552.8	
	Larvae												1.1	1.2	22.1	59.6	74.0
Gizzard Shad	Larvae															33.2	1.1
Grass Carp	Larvae																1.1
Herring Family	Eggs									3.4		4.8	142.6	17.7	6.9		
	Larvae									4.9	55.3	138.4	1,171.3	13,044.5	4,366.4	12,415.2	708.9
Logperch	Larvae		2.4	8.6	1.3	31.8	10.7	33.0	11.6	25.8	11.4	1.2		1.2			
Mississippi Silverside	Eggs								1.0			2.3					
	Larvae										3.8	2.5	22.1	63.3	510.6	679.5	274.9
Sauger	Larvae										1.2						
Shiner *Pimephales* spp.	Larvae														2.3	40.8	1.1
Shiner species	Larvae																
Skipjack Herring	Eggs																
Spotted Sucker	Larvae									3.6							
Sunfish Lepomis spp.	Larvae										1.3			9.4	73.1	63.4	3.3
Temperate Basses Family	Eggs								2.2	1.2							
	Larvae		2.4					1.4	217.4	284.0	103.3	3.8	7.2	13.8	8.5	75.0	
Threadfin Shad	Larvae															35.0	
Topminnow *Fundulus* spp.	Larvae													2.3			
Unidentified Osteichthyes	Eggs											2.5		1.2		1.2	
	Larvae													1.2	2.4	33.6	1.1
Western Mosquitofish	Larvae																
White Bass	Larvae															33.9	4.4
Yellow Bass	Larvae																
Yellow Perch	Larvae			1.1				2.5									
Total	All		4.9	13.2	3.8	37.5	26.4	54.1	257.0	354.5	182.5	162.6	1,364.8	13,171.1	5,118.5	14,025.5	1,069.9

(extended)

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Table 3-6. (extended)

Taxon	Life Stage	Sample Period															Total	%
		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
		11-Jun	18-Jun	25-Jun	2-Jul	9-Jul	16-Jul	23-Jul	30-Jul	6-Aug	13-Aug	20-Aug	24-Sep	22-Oct	19-Nov	24-Dec		
Blue Catfish	Larvae																<0.1	<0.1
Buffalofish *Ictiobus* spp.	Larvae																3.2	0.3
Carps and Minnows Family	Larvae	1.3			7.3		9.7		9.1		1.2	1.2					1.0	0.1
Channel Catfish	Larvae				6.0		9.8		2.3		2.4						0.7	0.1
Common Carp	Larvae																	-
Crappie *Pomoxis* spp.	Larvae																0.6	<0.1
Darter *Etheostoma* spp.	Larvae																0.1	<0.1
Emerald Shiner	Larvae																0.1	<0.1
Freshwater Drum	Eggs	1.1			14.5				2.3		1.2	13.2					23.9	1.9
	Larvae	81.8															7.7	0.6
Gizzard Shad	Larvae																1.1	0.1
Grass Carp	Larvae																<0.1	<0.1
Herring Family	Eggs																5.7	0.4
	Larvae	375.6	461.3	196.9	45.6	18.1	25.3	53.7	55.6	20.4	25.2	20.2	1.2				1,071.1	84.7
Logperch	Larvae																4.5	0.4
Mississippi Silverside	Eggs																0.1	<0.1
	Larvae	10.8	12.1	15.7	9.6	8.6	3.6		3.2	2.4	36.2						53.5	4.2
Sauger	Larvae																<0.1	<0.1
Shiner *Pimephales* spp.	Larvae	3.9	1.2		42.0		18.3		39.6		14.2	10.7					5.6	0.4
Shiner species	Larvae																	-
Skipjack Herring	Eggs																	-
Spotted Sucker	Larvae																0.1	<0.1
Sunfish *Lepomis* spp.	Larvae	87.4	144.1	69.6	66.4	51.3	47.3	34.4	173.5	9.5	16.7	3.6					27.5	2.2
Temperate Basses Family	Eggs																0.1	<0.1
	Larvae																23.1	1.8
Threadfin Shad	Larvae	1.3	2.4		688.6	2.4	50.7		68.3		55.9	1.2	1.2				29.3	2.3
Topminnow *Fundulus* spp.	Larvae																0.1	<0.1
Unidentified Osteichthyes	Eggs																0.2	<0.1
	Larvae	2.2	12.3	3.5	2.4	3.6	6.1	16.9	14.8		2.4						3.3	0.3
Western Mosquitofish	Larvae								1.2								<0.1	<0.1
White Bass	Larvae																1.2	0.1
Yellow Bass	Larvae				1.2												<0.1	<0.1
Yellow Perch	Larvae																0.1	<0.1
Total	All	565.4	633.5	285.8	883.5	83.9	170.9	105.0	370.0	32.3	155.4	50.0	2.4				1,264.0	100.0

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Table 3-7. Mean entrainment (N/1000 m^3) density by taxon and sample period at Browns Ferry Nuclear Plant during 2019.

Taxon	Life Stage	Sample Period															
		32	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
		28-Jan	4-Mar	11-Mar	18-Mar	25-Mar	1-Apr	8-Apr	15-Apr	22-Apr	29-Apr	6-May	13-May	20-May	27-May	3-Jun	10-Jun
Blue Catfish	Larvae																
Buffalofish *Ictiobus* spp.	Larvae					6.1	19.9	50.6	52.4	29.8		1.2	1.1	1.2			
Carps and Minnows Family	Larvae														2.3		
Channel Catfish	Larvae																
Common Carp	Larvae									2.4				2.4			
Crappie *Pomoxis* spp.	Larvae					6.3		3.8	4.6	1.2	2.4	1.2	3.4				
Darter *Etheostoma* spp.	Larvae						1.1			10.7	13.0	6.2					
Emerald Shiner	Larvae								1.1								
Freshwater Drum	Eggs										35.3	1,523.6		122.5	496.2	14.7	3.6
	Larvae											40.4	57.1	43.4	86.2	28.4	2.4
Gizzard Shad	Larvae																
Grass Carp	Larvae																
Herring Family	Eggs									2.4		1.3					
	Larvae					9.7	8.2	205.7	1,183.8	3,655.4	1,427.1	5,030.4	6,963.7	853.7	9,246.3	1,985.7	279.0
Logperch	Larvae			17.9	29.1	30.1	9.3	49.3	14.9	29.8	16.5	3.7	2.3				
Mississippi Silverside	Eggs																
	Larvae								1.1	1.2	3.5		13.5	7.3	128.2	107.1	7.1
Sauger	Larvae						1.2	3.5									
Shiner *Pimephales* spp.	Larvae											1.2		1.2	4.5		
Shiner species	Larvae											1.2					
Skipjack Herring	Eggs					1.2											
Spotted Sucker	Larvae							2.5									
Sunfish *Lepomis* spp.	Larvae												3.4	3.7	94.7	352.0	9.5
Temperate Basses Family	Eggs																
	Larvae					16.8	247.7	2,917.9	413.8	1,963.8	919.6	934.4	107.2	6.2	3.4		
Threadfin Shad	Larvae																2.4
Topminnow *Fundulus* spp.	Larvae																
Unidentified Osteichthyes	Eggs																
	Larvae					2.4	4.6	11.1	3.4	13.2		3.9	1.1				
Western Mosquitofish	Larvae																
White Bass	Larvae												2.2	1.2	5.6		
Yellow Bass	Larvae																
Yellow Perch	Larvae					2.4	1.2	1.3			1.2	5.1	7.8	2.5	1.1		
Total	All			17.9	29.1	75.0	293.2	3,245.6	1,675.2	5,709.8	2,418.7	7,553.8	7,162.8	1,045.5	10,068.3	2,487.9	304.0

(extended)

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Table 3-7. (extended)

Taxon	Life Stage	Sample Period																
		49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	Total	%
		17-Jun	24-Jun	1-Jul	8-Jul	15-Jul	22-Jul	29-Jul	5-Aug	12-Aug	19-Aug	26-Aug	16-Sep	28-Oct	25-Nov	16-Dec		
Blue Catfish	Larvae																	-
Buffalofish *Ictiobus* spp.	Larvae																5.2	0.4
Carps and Minnows Family	Larvae				7.1												0.3	<0.1
Channel Catfish	Larvae				1.2												<0.1	<0.1
Common Carp	Larvae																0.2	<0.1
Crappie *Pomoxis* spp.	Larvae																0.7	0.1
Darter *Etheostoma* spp.	Larvae																1.0	0.1
Emerald Shiner	Larvae																<0.1	<0.1
Freshwater Drum	Eggs																70.8	5.2
	Larvae	1.2															8.4	0.6
Gizzard Shad	Larvae																	-
Grass Carp	Larvae																	-
Herring Family	Eggs																0.1	<0.1
	Larvae	2.3	2.3		1.2												995.3	73.2
Logperch	Larvae																6.5	0.5
Mississippi Silverside	Eggs																	-
	Larvae	1.2															8.7	0.6
Sauger	Larvae																0.2	<0.1
Shiner *Pimephales* spp.	Larvae				29.0												1.2	0.1
Shiner species	Larvae																<0.1	<0.1
Skipjack Herring	Eggs																<0.1	<0.1
Spotted Sucker	Larvae																0.1	<0.1
Sunfish *Lepomis* spp.	Larvae	2.4	4.6	6.0	11.6	3.5	4.7	3.5	2.4	4.7							16.3	1.2
Temperate Basses Family	Eggs																	-
	Larvae																242.9	17.9
Threadfin Shad	Larvae				1.2												0.1	<0.1
Topminnow *Fundulus* spp.	Larvae																	-
Unidentified Osteichthyes	Eggs																	-
	Larvae																1.3	0.1
Western Mosquitofish	Larvae																	-
White Bass	Larvae																0.3	<0.1
Yellow Bass	Larvae																	-
Yellow Perch	Larvae																0.7	0.1
Total	All	7.1	6.9	6.0	51.2	3.5	4.7	3.5	2.4	4.7							1,360.5	100.0

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Table 3-8. Taxon apportionment of unidentified fish eggs to entrainment densities (N/1000 m^3) based on proportion (P) of other identified taxa entrained at Browns Ferry Nuclear Plant during February 2018 through January 2019.

Year	Sample Period	Taxon	Identified Taxon Density	P	Unidentified Density	Apportioned Density
2018	Apr30	Herring Family	4.8	0.7	2.5	1.7
		Mississippi Silverside	2.3	0.3	2.5	0.8
	May14	Freshwater Drum	14.2	0.4	1.2	0.5
		Herring Family	17.7	0.6	1.2	0.7
	May28	Freshwater Drum	552.8	1.0	1.2	1.2

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Table 3-9. Taxon apportionment of unidentified fish larvae to entrainment densities (N/1000 m^3) based on proportion (P) of other identified taxa entrained at Browns Ferry Nuclear Plant during February 2018 through January 2019.

Year	Sample Period	Taxon	Identified Taxon Density	P	Unidentified Density	Apportioned Density
2018	May14	Darter *Etheostoma* spp.	1.1	<0.01	1.2	<0.1
		Freshwater Drum	1.2	<0.01	1.2	<0.1
		Herring Family	13,044.5	0.99	1.2	1.2
		Logperch	1.2	<0.01	1.2	<0.1
		Mississippi Silverside	63.3	<0.01	1.2	<0.1
		Sunfish *Lepomis* spp.	9.4	<0.01	1.2	<0.1
		Topminnow *Fundulus* spp.	2.3	<0.01	1.2	<0.1
		White Bass	13.8	<0.01	1.2	<0.1
	May21	Emerald Shiner	2.2	<0.01	2.4	<0.1
		Freshwater Drum	22.1	<0.01	2.4	<0.1
		Herring Family	4,366.4	0.88	2.4	2.1
		Mississippi Silverside	510.6	0.10	2.4	0.2
		Shiner *Pimephales* spp.	2.3	<0.01	2.4	<0.1
		Sunfish *Lepomis* spp.	73.1	0.01	2.4	<0.1
		White Bass	8.5	<0.01	2.4	<0.1
	May28	Blue Catfish	1.2	<0.01	33.6	<0.1
		Darter *Etheostoma* spp.	1.2	<0.01	33.6	<0.1
		Freshwater Drum	59.6	<0.01	33.6	0.1
		Gizzard Shad	33.2	<0.01	33.6	0.1
		Herring Family	12,415.2	0.92	33.6	31.0
		Mississippi Silverside	679.5	0.05	33.6	1.7
		Shiner *Pimephales* spp.	40.8	<0.01	33.6	0.1
		Sunfish *Lepomis* spp.	63.4	<0.01	33.6	0.2
		Threadfin Shad	35.0	<0.01	33.6	0.1
		White Bass	108.9	0.01	33.6	0.3
	Jun4	Freshwater Drum	74.0	0.07	1.1	0.1
		Gizzard Shad	1.1	<0.01	1.1	<0.1
		Grass Carp	1.1	<0.01	1.1	<0.1
		Herring Family	708.9	0.66	1.1	0.7
		Mississippi Silverside	274.9	0.26	1.1	0.3
		Shiner *Pimephales* spp.	1.1	<0.01	1.1	<0.1
		Sunfish *Lepomis* spp.	3.3	<0.01	1.1	<0.1
		White Bass	4.4	<0.01	1.1	<0.1
	Jun11	Freshwater Drum	81.8	0.15	2.2	0.3
		Herring Family	375.6	0.67	2.2	1.5
		Mississippi Silverside	10.8	0.02	2.2	<0.1
		Shiner *Pimephales* spp.	5.2	0.01	2.2	<0.1
		Sunfish *Lepomis* spp.	87.4	0.16	2.2	0.3
		Threadfin Shad	1.3	<0.01	2.2	<0.1

(continued)

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Table 3-9. (continued)

Year	Sample Period	Taxon	Identified Taxon Density	P	Unidentified Density	Apportioned Density
2018 (cont.)	Jun18	Herring Family	461.3	0.74	12.3	9.1
		Mississippi Silverside	12.1	0.02	12.3	0.2
		Shiner *Pimephales* spp.	1.2	<0.01	12.3	<0.1
		Sunfish *Lepomis* spp.	144.1	0.23	12.3	2.8
		Threadfin Shad	2.4	<0.01	12.3	<0.1
	Jun25	Herring Family	196.9	0.70	3.5	2.5
		Mississippi Silverside	15.7	0.06	3.5	0.2
		Sunfish *Lepomis* spp.	69.6	0.25	3.5	0.9
	Jul2	Channel Catfish	6.0	0.01	2.4	<0.1
		Herring Family	45.6	0.05	2.4	0.1
		Mississippi Silverside	9.6	0.01	2.4	<0.1
		Shiner *Pimephales* spp.	49.3	0.06	2.4	0.1
		Sunfish *Lepomis* spp.	66.4	0.08	2.4	0.2
		Threadfin Shad	688.6	0.79	2.4	1.9
		Yellow Bass	1.2	<0.01	2.4	<0.1
	Jul9	Herring Family	18.1	0.23	3.6	0.8
		Mississippi Silverside	8.6	0.11	3.6	0.4
		Sunfish *Lepomis* spp.	51.3	0.64	3.6	2.3
		Threadfin Shad	2.4	0.03	3.6	0.1
	Jul16	Channel Catfish	9.8	0.06	6.1	0.4
		Herring Family	25.3	0.15	6.1	0.9
		Mississippi Silverside	3.6	0.02	6.1	0.1
		Shiner *Pimephales* spp.	28.0	0.17	6.1	1.0
		Sunfish *Lepomis* spp.	47.3	0.29	6.1	1.8
		Threadfin Shad	50.7	0.31	6.1	1.9
	Jul23	Herring Family	53.7	0.61	16.9	10.3
		Sunfish *Lepomis* spp.	34.4	0.39	16.9	6.6
	Jul30	Channel Catfish	2.3	0.01	14.8	0.1
		Herring Family	55.6	0.16	14.8	2.3
		Mississippi Silverside	3.2	0.01	14.8	0.1
		Shiner *Pimephales* spp.	48.7	0.14	14.8	2.0
		Sunfish *Lepomis* spp.	173.5	0.49	14.8	7.3
		Threadfin Shad	68.3	0.19	14.8	2.9
		Western Mosquitofish	1.2	<0.01	14.8	<0.1
	Aug13	Channel Catfish	2.4	0.02	2.4	<0.1
		Herring Family	25.2	0.17	2.4	0.4
		Mississippi Silverside	36.2	0.24	2.4	0.6
		Shiner *Pimephales* spp.	15.4	0.10	2.4	0.2
		Sunfish *Lepomis* spp.	16.7	0.11	2.4	0.3
		Threadfin Shad	55.9	0.37	2.4	0.9

(continued)

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Table 3-9. (continued)

Year	Sample Period	Taxon	Identified Taxon Density	P	Unidentified Density	Apportioned Density
2019	Mar25	Buffalofish *Ictiobus* spp.	6.1	0.09	2.4	0.2
		Crappie *Pomoxis* spp.	6.3	0.09	2.4	0.2
		Herring Family	9.7	0.14	2.4	0.3
		Logperch	30.1	0.42	2.4	1.0
		White Bass	16.8	0.24	2.4	0.6
		Yellow Perch	2.4	0.03	2.4	0.1
	Apr1	Buffalofish *Ictiobus* spp.	19.9	0.07	4.6	0.3
		Darter *Etheostoma* spp.	1.1	<0.01	4.6	<0.1
		Herring Family	8.2	0.03	4.6	0.1
		Logperch	9.3	0.03	4.6	0.1
		Sauger	1.2	<0.01	4.6	<0.1
		White Bass	247.7	0.86	4.6	3.9
		Yellow Perch	1.2	<0.01	4.6	<0.1
	Apr8	Buffalofish *Ictiobus* spp.	50.6	0.02	11.1	0.2
		Crappie *Pomoxis* spp.	3.8	<0.01	11.1	<0.1
		Herring Family	205.7	0.06	11.1	0.7
		Logperch	49.3	0.02	11.1	0.2
		Sauger	3.5	<0.01	11.1	<0.1
		Spotted Sucker	2.5	<0.01	11.1	<0.1
		White Bass	2,917.9	0.90	11.1	10.0
		Yellow Perch	1.3	<0.01	11.1	<0.1
	Apr15	Buffalofish *Ictiobus* spp.	52.4	0.03	3.4	0.1
		Crappie *Pomoxis* spp.	4.6	<0.01	3.4	<0.1
		Emerald Shiner	1.1	<0.01	3.4	<0.1
		Herring Family	1,183.8	0.71	3.4	2.4
		Logperch	14.9	0.01	3.4	<0.1
		Mississippi Silverside	1.1	<0.01	3.4	<0.1
		White Bass	413.8	0.25	3.4	0.8
	Apr22	Buffalofish *Ictiobus* spp.	29.8	0.01	13.2	0.1
		Common Carp	2.4	<0.01	13.2	<0.1
		Crappie *Pomoxis* spp.	1.2	<0.01	13.2	<0.1
		Darter *Etheostoma* spp.	10.7	<0.01	13.2	<0.1
		Herring Family	3,655.4	0.64	13.2	8.4
		Logperch	29.8	0.01	13.2	0.1
		Mississippi Silverside	1.2	<0.01	13.2	<0.1
		White Bass	1,963.8	0.34	13.2	4.5
	May6	Buffalofish *Ictiobus* spp.	1.2	<0.01	3.9	<0.1
		Crappie *Pomoxis* spp.	1.2	<0.01	3.9	<0.1
		Darter *Etheostoma* spp.	6.2	<0.01	3.9	<0.1
		Freshwater Drum	40.4	0.01	3.9	<0.1
		Herring Family	5,030.4	0.83	3.9	3.2
		Logperch	3.7	<0.01	3.9	<0.1

(continued)

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Table 3-9. (continued)

Year	Sample Period	Taxon	Identified Taxon Density	P	Unidentified Density	Apportioned Density
2019 (cont.)	May6 (cont.)	Shiner *Pimephales* spp.	2.4	<0.01	3.9	<0.1
		White Bass	934.4	0.16	3.9	0.6
		Yellow Perch	5.1	<0.01	3.9	<0.1
	May13	Buffalofish *Ictiobus* spp.	1.1	<0.01	1.1	<0.1
		Crappie *Pomoxis* spp.	3.4	<0.01	1.1	<0.1
		Freshwater Drum	57.1	0.01	1.1	<0.1
		Herring Family	6,963.7	0.97	1.1	1.1
		Logperch	2.3	<0.01	1.1	<0.1
		Mississippi Silverside	13.5	<0.01	1.1	<0.1
		Sunfish *Lepomis* spp.	3.4	<0.01	1.1	<0.1
		White Bass	109.4	0.02	1.1	<0.1
		Yellow Perch	7.8	<0.01	1.1	<0.1

Table 3-10. Taxon apportionment of fish eggs identified as Herring Family (but not Skipjack Herring) to entrainment densities (N/1000 m^3) based on proportion (P) of identified member taxa of larvae entrained in the first periods following egg entrainment at Browns Ferry Nuclear Plant during February 2018 through January 2019.

Year	Sample Period	Taxon	Species Density[1]	P	Herring Family Density	Apportioned Density
2018	Apr16	Gizzard Shad	33.2	0.49	3.4	1.7
		Threadfin Shad	35.0	0.51	3.4	1.8
	Apr30	Gizzard Shad	33.2	0.49	6.5	3.2
		Threadfin Shad	35.0	0.51	6.5	3.3
	May7	Gizzard Shad	33.2	0.49	142.6	69.3
		Threadfin Shad	35.0	0.51	142.6	73.2
	May14	Gizzard Shad	33.2	0.49	18.4	8.9
		Threadfin Shad	35.0	0.51	18.4	9.4
	May21	Gizzard Shad	33.2	0.49	6.9	3.4
		Threadfin Shad	35.0	0.51	6.9	3.6
2019	Apr22	Threadfin Shad	2.4	1.00	2.4	2.4
	May6	Threadfin Shad	2.4	1.00	1.3	1.3

[1] With exception of Skipjack Herring eggs, no clupeid eggs were identified to genus or species. Larval densities of Gizzard Shad and Threadfin Shad from sample periods 15 in 2018 and only Threadfin Shad larvae were identified in 2019.

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Table 3-11. Taxon apportionment of entrained fish larvae identified as Herring Family to species-specific entrainment densities (N/1000 m^3) based on proportion (P) of identified member taxa of larvae entrained in the same or proximal periods of entrainment at Browns Ferry Nuclear Plant during February 2018 through January 2019.

Year	Sampling Period	Taxon	Species Density	P	Herring Family Density	Apportioned Density
2018	Apr16	Gizzard Shad		0.49	4.9	2.4
		Threadfin Shad		0.51	4.9	2.5
	Apr23	Gizzard Shad		0.49	55.3	26.9
		Threadfin Shad		0.51	55.3	28.4
	Apr30	Gizzard Shad		0.49	138.4	67.3
		Threadfin Shad		0.51	138.4	71.1
	May7	Gizzard Shad		0.49	1,171.3	569.7
		Threadfin Shad		0.51	1,171.3	601.6
	May14	Gizzard Shad		0.49	13,045.7	6,344.8
		Threadfin Shad		0.51	13,045.7	6,700.9
	May21	Gizzard Shad		0.49	4,368.4	2,124.6
		Threadfin Shad		0.51	4,368.4	2,243.8
	May28	Gizzard Shad	33.2	0.49	12,446.2	6,053.3
		Threadfin Shad	35.1	0.51	12,446.2	6,393.0
	Jun4	Gizzard Shad	1.1	1.00	709.6	709.6
	Jun11	Threadfin Shad	1.3	1.00	377.1	377.1
	Jun18	Threadfin Shad	2.5	1.00	470.4	470.4
	Jun25	Threadfin Shad		1.00	199.4	199.4
	Jul2	Threadfin Shad	690.5	1.00	45.7	45.7
	Jul9	Threadfin Shad	2.5	1.00	18.9	18.9
	Jul16	Threadfin Shad	52.6	1.00	26.2	26.2
	Jul23	Threadfin Shad		1.00	64.0	64.0
	Jul30	Threadfin Shad	71.2	1.00	57.9	57.9
	Aug6	Threadfin Shad		1.00	20.4	20.4
	Aug13	Threadfin Shad	56.8	1.00	25.6	25.6
	Aug20	Threadfin Shad	1.2	1.00	20.2	20.2
	Sep24	Threadfin Shad	1.2	1.00	1.2	1.2
2019	Mar25	Threadfin Shad		1.00	10.0	10.0
	Apr1	Threadfin Shad		1.00	8.3	8.3
	Apr8	Threadfin Shad		1.00	206.4	206.4
	Apr15	Threadfin Shad		1.00	1,186.2	1,186.2
	Apr22	Threadfin Shad		1.00	3,663.8	3,663.8
	Apr29	Threadfin Shad		1.00	1,427.1	1,427.1
	May6	Threadfin Shad		1.00	5,033.6	5,033.6
	May13	Threadfin Shad		1.00	6,964.8	6,964.8
	May20	Threadfin Shad		1.00	853.7	853.7
	May27	Threadfin Shad		1.00	9,246.3	9,246.3
	Jun3	Threadfin Shad		1.00	1,985.7	1,985.7
	Jun10	Threadfin Shad	2.4	1.00	279.0	279.0
	Jun17	Threadfin Shad		1.00	2.3	2.3
	Jun24	Threadfin Shad		1.00	2.3	2.3
	Jul8	Threadfin Shad	1.2	1.00	1.2	1.2

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Table 3-12. Mean entrainment density (N/1000 m^3) and annual percent of ichthyoplankton apportioned to species/genus and life stage from intake samples collected in each sample period at Browns Ferry Nuclear Power Plant during 2018.

Taxon	Life Stage	Sample Period															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		19-Feb	26-Feb	5-Mar	12-Mar	19-Mar	26-Mar	2-Apr	9-Apr	16-Apr	23-Apr	30-Apr	7-May	14-May	21-May	28-May	4-Jun
Blue Catfish	Larvae															1.2	
Buffalofish *Ictiobus* spp.	Larvae			2.3		5.6	15.7	17.3	16.9	26.9	5.0	7.0	1.3				
Channel Catfish	Larvae																
Common Carp	Larvae																
Crappie *Pomoxis* spp.	Larvae				2.5				7.9	4.6	1.1		1.1				
Darter *Etheostoma* spp.	Larvae			1.3										1.1		1.2	
Emerald Shiner	Larvae														2.2		
Freshwater Drum	Eggs												18.1	14.7	124.1	554.0	
	Larvae												1.1	1.2	22.1	59.8	74.1
Gizzard Shad	Eggs									1.7		3.2	69.3	8.9	3.4		
	Larvae									2.4	26.9	67.3	569.7	6,344.8	2,124.6	6,086.5	710.7
Grass Carp	Larvae																1.1
Logperch	Larvae		2.4	8.6	1.3	31.8	10.7	33.0	11.6	25.8	11.4	1.2		1.2			
Mississippi Silverside	Eggs								1.0			3.2					
	Larvae										3.8	2.5	22.1	63.3	510.8	681.2	275.2
Sauger	Larvae										1.2						
Shiner *Pimephales* spp.	Larvae														2.3	40.9	1.1
Skipjack Herring	Eggs																
Spotted Sucker	Larvae									3.6							
Sunfish *Lepomis* spp.	Larvae										1.3			9.4	73.1	63.5	3.3
Threadfin Shad	Eggs									1.8		3.3	73.2	9.4	3.6		
	Larvae									2.5	28.4	71.1	601.6	6,700.9	2,243.8	6,428.1	
Topminnow *Fundulus* spp.	Larvae													2.3			
Western Mosquitofish	Larvae																
White Bass	Eggs								2.2	1.2							
	Larvae		2.4					1.4	217.4	284.0	103.3	3.8	7.2	13.8	8.5	109.2	4.4
Yellow Bass	Larvae																
Yellow Perch	Larvae			1.1				2.5									
Total	All	0.0	4.9	13.2	3.8	37.5	26.4	54.1	257.0	354.5	182.5	162.6	1,364.8	13,171.1	5,118.5	14,025.5	1,069.9

(extended)

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Table 3-12. (extended)

Taxon	Life Stage	Sample Period																
		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
		11-Jun	18-Jun	25-Jun	2-Jul	9-Jul	16-Jul	23-Jul	30-Jul	6-Aug	13-Aug	20-Aug	24-Sep	22-Oct	19-Nov	24-Dec	Total	%
Blue Catfish	Larvae																<0.1	<0.1
Buffalofish *Ictiobus* spp.	Larvae																3.2	0.3
Channel Catfish	Larvae				6.0		10.2		2.4		2.4						0.7	0.1
Common Carp	Larvae																	-
Crappie *Pomoxis* spp.	Larvae																0.6	<0.1
Darter *Etheostoma* spp.	Larvae																0.1	<0.1
Emerald Shiner	Larvae																0.1	<0.1
Freshwater Drum	Eggs	1.1			14.5				2.3		1.2	13.2					24.0	1.9
	Larvae	82.1															7.8	0.6
Gizzard Shad	Eggs																2.8	0.2
	Larvae																514.0	40.7
Grass Carp	Larvae																<0.1	<0.1
Logperch	Larvae																4.5	0.4
Mississippi Silverside	Eggs																0.1	<0.1
	Larvae	10.9	12.4	15.9	9.7	9.0	3.8		3.4	2.4	36.7						53.6	4.2
Sauger	Larvae																<0.1	<0.1
Shiner *Pimephales* spp.	Larvae	5.2	1.2		49.4		29.1		50.8		15.7	11.9					6.7	0.5
Skipjack Herring	Eggs																	-
Spotted Sucker	Larvae																0.1	<0.1
Sunfish *Lepomis* spp.	Larvae	87.7	147.0	70.5	66.5	53.6	49.0	41.0	180.8	9.5	17.0	3.6					28.3	2.2
Threadfin Shad	Eggs																2.9	0.2
	Larvae	378.4	472.9	199.4	736.2	21.4	78.8	64.0	129.1	20.4	82.4	21.3	2.4				589.8	46.7
Topminnow *Fundulus* spp.	Larvae																0.1	<0.1
Western Mosquitofish	Larvae								1.2								<0.1	<0.1
White Bass	Eggs																0.1	<0.1
	Larvae																24.4	1.9
Yellow Bass	Larvae				1.2												<0.1	<0.1
Yellow Perch	Larvae																0.1	<0.1
Total	All	565.4	633.5	285.8	883.5	83.9	170.9	105.0	370.0	32.3	155.4	50.0	2.4	0.0	0.0	0.0	1,264.0	100.0

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Table 3-13. Mean entrainment density (N/1000 m^3) and annual percent of ichthyoplankton apportioned to species/genus and life stage from intake samples collected in each sample period at Browns Ferry Nuclear Power Plant during 2019.

Taxon	Life Stage	Sample Period														
		32	34	35	36	37	38	39	40	41	42	43	44	45	46	47
		28-Jan	4-Mar	11-Mar	18-Mar	25-Mar	1-Apr	8-Apr	15-Apr	22-Apr	29-Apr	6-May	13-May	20-May	27-May	3-Jun
Blue Catfish	Larvae															
Buffalofish *Ictiobus* spp.	Larvae					6.3	20.2	50.7	52.5	29.9		1.2	1.1	1.2		
Channel Catfish	Larvae															
Common Carp	Larvae									2.4				2.4		
Crappie *Pomoxis* spp.	Larvae					6.5		3.8	4.6	1.2	2.4	1.2	3.4			
Darter *Etheostoma* spp.	Larvae						1.2			10.7	13.0	6.2				
Emerald Shiner	Larvae								1.1							
Freshwater Drum	Eggs										35.3	1,523.6		122.5	496.2	14.7
	Larvae											40.5	57.1	43.4	86.2	28.4
Gizzard Shad	Eggs															
	Larvae															
Grass Carp	Larvae															
Logperch	Larvae			17.9	29.1	31.1	9.4	49.4	14.9	29.9	16.5	3.7	2.3			
Mississippi Silverside	Eggs															
	Larvae								1.1	1.2	3.5		13.5	7.3	128.2	107.1
Sauger	Larvae						1.2	3.6								
Shiner *Pimephales* spp.	Larvae											2.4		1.2	6.7	
Skipjack Herring	Eggs					1.2										
Spotted Sucker	Larvae							2.5								
Sunfish *Lepomis* spp.	Larvae												3.4	3.7	94.7	352.0
Threadfin Shad	Eggs									2.4		1.3				
	Larvae					10.0	8.3	206.4	1,186.2	3,663.8	1,427.1	5,033.6	6,964.8	853.7	9,246.3	1,985.7
Topminnow *Fundulus* spp.	Larvae															
Western Mosquitofish	Larvae															
White Bass	Eggs															
	Larvae					17.3	251.7	2,927.9	414.6	1,968.3	919.6	935.0	109.4	7.4	9.0	
Yellow Bass	Larvae															
Yellow Perch	Larvae					2.4	1.2	1.3			1.2	5.1	7.8	2.5	1.1	
Total	All	0.0	0.0	17.9	29.1	75.0	293.2	3,245.6	1,675.2	5,709.8	2,418.7	7,553.8	7,162.8	1,045.5	10,068.3	2,487.9

(extended)

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Table 3-13. (extended)

Taxon	Life Stage	Sample Period																Total	%
		48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63		
		10-Jun	17-Jun	24-Jun	1-Jul	8-Jul	15-Jul	22-Jul	29-Jul	5-Aug	12-Aug	19-Aug	26-Aug	16-Sep	28-Oct	25-Nov	16-Dec		
Blue Catfish	Larvae																		0.0
Buffalofish *Ictiobus* spp.	Larvae																	5.3	0.4
Channel Catfish	Larvae					1.2												<0.1	<0.1
Common Carp	Larvae																	0.2	<0.1
Crappie *Pomoxis* spp.	Larvae																	0.7	0.1
Darter *Etheostoma* spp.	Larvae																	1.0	0.1
Emerald Shiner	Larvae																	<0.1	<0.1
Freshwater Drum	Eggs	3.6																70.8	5.2
	Larvae	2.4	1.2															8.4	0.6
Gizzard Shad	Eggs																		0.0
	Larvae																		0.0
Grass Carp	Larvae																		0.0
Logperch	Larvae																	6.6	0.5
Mississippi Silverside	Eggs																		0.0
	Larvae	7.1	1.2															8.7	0.6
Sauger	Larvae																	0.2	<0.1
Shiner *Pimephales* spp.	Larvae					36.1												1.5	0.1
Skipjack Herring	Eggs																	<0.1	<0.1
Spotted Sucker	Larvae																	0.1	<0.1
Sunfish *Lepomis* spp.	Larvae	9.5	2.4	4.6	6.0	11.6	3.5	4.7	3.5	2.4	4.7							16.3	1.2
Threadfin Shad	Eggs																	0.1	<0.1
	Larvae	281.4	2.3	2.3		2.4												995.9	73.2
Topminnow *Fundulus* spp.	Larvae																		0.0
Western Mosquitofish	Larvae																		0.0
White Bass	Eggs																		0.0
	Larvae																	243.9	17.9
Yellow Bass	Larvae																		0.0
Yellow Perch	Larvae																	0.7	0.1
Total	All	304.0	7.1	6.9	6.0	51.2	3.5	4.7	3.5	2.4	4.7	0.0	0.0	0.0	0.0	0.0	0.0	1,360.5	100.0

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Table 3-14. Entrainment abundance (thousands of individuals) and annual percent of ichthyoplankton apportioned to species/genus and life stage from intake samples collected in each sample period at Browns Ferry Nuclear Power Plant during 2018.

Taxon	Life Stage	Sample Period															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		19-Feb	26-Feb	5-Mar	12-Mar	19-Mar	26-Mar	2-Apr	9-Apr	16-Apr	23-Apr	30-Apr	7-May	14-May	21-May	28-May	4-Jun
Blue Catfish	Larvae															92	
Buffalofish *Ictiobus* spp.	Larvae			128		346	1,088	1,288	1,313	2,083	386	536	94				
Channel Catfish	Larvae																
Common Carp	Larvae																
Crappie *Pomoxis* spp.	Larvae				142				611	357	86		83				
Darter *Etheostoma* spp.	Larvae			73										85		92	
Emerald Shiner	Larvae														169		
Freshwater Drum	Eggs												1,345	1,114	9,421	43,435	
	Larvae												83	93	1,676	4,687	5,711
Gizzard Shad	Eggs									129		241	5,147	675	256		
	Larvae									185	2,054	5,120	42,285	479,270	161,331	477,189	54,786
Grass Carp	Larvae																87
Logperch	Larvae		154	485	71	1,957	737	2,459	899	1,999	874	89		88			
Mississippi Silverside	Eggs								81			240					
	Larvae										289	188	1,644	4,780	38,789	53,408	21,213
Sauger	Larvae										93						
Shiner *Pimephales* spp.	Larvae														175	3,205	84
Skipjack Herring	Eggs																
Spotted Sucker	Larvae									282							
Sunfish *Lepomis* spp.	Larvae										99			709	5,551	4,981	255
Threadfin Shad	Eggs									136		254	5,435	712	271		
	Larvae									195	2,170	5,408	44,658	506,166	170,385	503,968	
Topminnow *Fundulus* spp.	Larvae													171			
Western Mosquitofish	Larvae																
White Bass	Eggs								169	97							
	Larvae		154					102	16,886	22,006	7,891	289	532	1,046	645	8,560	340
Yellow Bass	Larvae																
Yellow Perch	Larvae			64				185									
Total	All	0	308	750	213	2,303	1,826	4,034	19,959	27,471	13,942	12,366	101,306	994,908	388,668	1,099,617	82,476

(extended)

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Table 3-14. (extended)

Taxon	Life Stage	Sample Period																
		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
		11-Jun	18-Jun	25-Jun	2-Jul	9-Jul	16-Jul	23-Jul	30-Jul	6-Aug	13-Aug	20-Aug	24-Sep	22-Oct	19-Nov	24-Dec	Total	%
Blue Catfish	Larvae																92	<0.1
Buffalofish *Ictiobus* spp.	Larvae																7,263	0
Channel Catfish	Larvae				473		792		189		189						1,644	0
Common Carp	Larvae																	0
Crappie *Pomoxis* spp.	Larvae																1,279	<0.1
Darter *Etheostoma* spp.	Larvae																250	<0.1
Emerald Shiner	Larvae																169	<0.1
Freshwater Drum	Eggs	86			1,149				182		93	1,030					57,854	2
	Larvae	6,333															18,583	1
Gizzard Shad	Eggs																6,448	0
	Larvae																1,222,221	41
Grass Carp	Larvae																87	<0.1
Logperch	Larvae																9,813	0
Mississippi Silverside	Eggs																321	<0.1
	Larvae	838	953	1,228	765	712	294		265	191	2,874						128,433	4
Sauger	Larvae																93	<0.1
Shiner *Pimephales* spp.	Larvae	403	93		3,909		2,264		3,992		1,226	930					16,279	1
Skipjack Herring	Eggs																	0
Spotted Sucker	Larvae																282	<0.1
Sunfish *Lepomis* spp.	Larvae	6,765	11,307	5,434	5,267	4,261	3,819	3,095	14,206	741	1,329	278					68,095	2
Threadfin Shad	Eggs																6,810	0
	Larvae	29,181	36,384	15,376	58,272	1,699	6,136	4,834	10,146	1,595	6,444	1,670	921				1,405,608	47
Topminnow *Fundulus* spp.	Larvae																171	<0.1
Western Mosquitofish	Larvae								96								96	<0.1
White Bass	Eggs																266	<0.1
	Larvae																58,450	2
Yellow Bass	Larvae				94												94	<0.1
Yellow Perch	Larvae																249	<0.1
Total	All	43,606	48,737	22,038	69,930	6,671	13,304	7,928	29,077	2,527	12,155	3,908	921	0	0	0	3,010,949	100

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Table 3-15. Estimated abundance (thousands of individuals) and annual percent of ichthyoplankton apportioned to species/genus and life stage from intake samples collected in each sample period at Browns Ferry Nuclear Power Plant during 2019.

Taxon	Life Stage	Sample Period														
		32	34	35	36	37	38	39	40	41	42	43	44	45	46	47
		28-Jan	4-Mar	11-Mar	18-Mar	25-Mar	1-Apr	8-Apr	15-Apr	22-Apr	29-Apr	6-May	13-May	20-May	27-May	3-Jun
Blue Catfish	Larvae															
Buffalofish *Ictiobus* spp.	Larvae					435	1,493	3,913	4,099	2,279		87	85	92		
Channel Catfish	Larvae															
Common Carp	Larvae									182				183		
Crappie *Pomoxis* spp.	Larvae					443		291	358	91	182	91	261			
Darter *Etheostoma* spp.	Larvae						86			819	989	462				
Emerald Shiner	Larvae								88							
Freshwater Drum	Eggs										2,692	113,128		9,240	38,824	1,139
	Larvae											3,005	4,326	3,273	6,742	2,195
Gizzard Shad	Eggs															
	Larvae															
Grass Carp	Larvae															
Logperch	Larvae			1,013	1,749	2,133	697	3,813	1,165	2,275	1,260	277	172			
Mississippi Silverside	Eggs															
	Larvae								89	91	266		1,021	552	10,032	8,273
Sauger	Larvae						87	274								
Shiner *Pimephales* spp.	Larvae											178		92	526	
Skipjack Herring	Eggs					84										
Spotted Sucker	Larvae							195								
Sunfish *Lepomis* spp.	Larvae												257	280	7,408	27,201
Threadfin Shad	Eggs									182		94				
	Larvae					687	615	15,916	92,572	279,190	108,845	373,746	527,996	64,371	723,473	153,435
Topminnow *Fundulus* spp.	Larvae															
Western Mosquitofish	Larvae															
White Bass	Eggs															
	Larvae					1,188	18,584	225,800	32,357	149,992	70,139	69,424	8,296	560	706	
Yellow Bass	Larvae															
Yellow Perch	Larvae					167	86	99			91	380	595	192	84	
Total	All	0	0	1,013	1,749	5,136	21,649	250,302	130,728	435,101	184,464	560,872	543,009	78,835	787,795	192,242

(extended)

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Table 3-15. (extended)

Taxon	Life Stage	Sample Period																	%
		48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	Total	
		10-Jun	17-Jun	24-Jun	1-Jul	8-Jul	15-Jul	22-Jul	29-Jul	5-Aug	12-Aug	19-Aug	26-Aug	16-Sep	28-Oct	25-Nov	16-Dec		
Blue Catfish	Larvae																		0
Buffalofish *Ictiobus* spp.	Larvae																	12,484	0
Channel Catfish	Larvae					92												92	<0.1
Common Carp	Larvae																	365	<0.1
Crappie *Pomoxis* spp.	Larvae																	1,717	0
Darter *Etheostoma* spp.	Larvae																	2,356	0
Emerald Shiner	Larvae																	88	<0.1
Freshwater Drum	Eggs	277																165,300	5
	Larvae	186	93															19,820	1
Gizzard Shad	Eggs																		0
	Larvae																		0
Grass Carp	Larvae																		0
Logperch	Larvae																	14,555	1
Mississippi Silverside	Eggs																		0
	Larvae	549	90															20,962	1
Sauger	Larvae																	361	<0.1
Shiner *Pimephales* spp.	Larvae					2,870												3,666	0
Skipjack Herring	Eggs																	84	<0.1
Spotted Sucker	Larvae																	195	<0.1
Sunfish *Lepomis* spp.	Larvae	730	182	357	477	923	274	352	273	185	372							39,271	1
Threadfin Shad	Eggs																	276	<0.1
	Larvae	21,700	179	175		189												2,363,089	73
Topminnow *Fundulus* spp.	Larvae																		0
Western Mosquitofish	Larvae																		0
White Bass	Eggs																		0
	Larvae																	577,046	18
Yellow Bass	Larvae																		0
Yellow Perch	Larvae																	1,694	0
Total	All	23,443	544	532	477	4,074	274	352	273	185	372	0	0	0	0	0	0	3,223,420	100

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Table 3-16. Estimated abundance (thousands of individuals) of fish eggs and larvae entrained by a closed-cycle recirculating system installed at Browns Ferry Nuclear Power Plant based on intake samples collected in each sample period during 2018 and 92.4% flow reduction in the 2016–2020 actual intake flow.

Taxon	Life Stage	Sample Period																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		19-Feb	26-Feb	5-Mar	12-Mar	19-Mar	26-Mar	2-Apr	9-Apr	16-Apr	23-Apr	30-Apr	7-May	14-May	21-May	28-May	4-Jun	11-Jun
Blue Catfish	Larvae															7		
Buffalofish *Ictiobus* spp.	Larvae			10		26	83	98	100	158	29	41	7					
Channel Catfish	Larvae																	
Common Carp	Larvae																	
Crappie *Pomoxis* spp.	Larvae				11				46	27	7		6					
Darter *Etheostoma* spp.	Larvae			6										6		7		
Emerald Shiner	Larvae														13			
Freshwater Drum	Eggs												102	85	716	3,301		7
	Larvae												6	7	127	356	434	481
Gizzard Shad	Eggs									10		18	391	51	19			
	Larvae									14	156	389	3,214	36,425	12,261	36,266	4,164	
Grass Carp	Larvae																7	
Logperch	Larvae		12	37	5	149	56	187	68	152	66	7		7				
Mississippi Silverside	Eggs								6			18						
	Larvae										22	14	125	363	2,948	4,059	1,612	64
Sauger	Larvae										7							
Shiner *Pimephales* spp.	Larvae														13	244	6	31
Skipjack Herring	Eggs																	
Spotted Sucker	Larvae									21								
Sunfish *Lepomis* spp.	Larvae										8			54	422	379	19	514
Threadfin Shad	Eggs									10		19	413	54	21			
	Larvae									15	165	411	3,394	38,469	12,949	38,302		2,218
Topminnow *Fundulus* spp.	Larvae													13				
Western Mosquitofish	Larvae																	
White Bass	Eggs								13	7								
	Larvae		12					8	1,283	1,672	600	22	40	79	49	651	26	
Yellow Bass	Larvae																	
Yellow Perch	Larvae			5				14										
Total	All	0	23	57	16	175	139	307	1,517	2,088	1,060	940	7,699	75,613	29,539	83,571	6,268	3,314

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(extended)

Table 3-16. (extended)

Taxon	Life Stage	Sample Period															
		18	19	20	21	22	23	24	25	26	27	28	29	30	31		
		18-Jun	25-Jun	2-Jul	9-Jul	16-Jul	23-Jul	30-Jul	6-Aug	13-Aug	20-Aug	24-Sep	22-Oct	19-Nov	24-Dec	Total	%
Blue Catfish	Larvae															7	<0.1
Buffalofish *Ictiobus* spp.	Larvae															552	0.2
Channel Catfish	Larvae			36		60		14		14						125	0.1
Common Carp	Larvae																0
Crappie *Pomoxis* spp.	Larvae															97	<0.1
Darter *Etheostoma* spp.	Larvae															19	<0.1
Emerald Shiner	Larvae															13	<0.1
Freshwater Drum	Eggs			87				14		7	78					4,397	1.9
	Larvae															1,412	0.6
Gizzard Shad	Eggs															490	0.2
	Larvae															92,889	40.6
Grass Carp	Larvae															7	<0.1
Logperch	Larvae															746	0.3
Mississippi Silverside	Eggs															24	<0.1
	Larvae	72	93	58	54	22		20	15	218						9,761	4.3
Sauger	Larvae															7	<0.1
Shiner *Pimephales* spp.	Larvae	7		297		172		303		93	71					1,237	0.5
Skipjack Herring	Eggs																0
Spotted Sucker	Larvae															21	<0.1
Sunfish *Lepomis* spp.	Larvae	859	413	400	324	290	235	1,080	56	101	21					5,175	2.3
Threadfin Shad	Eggs															518	0.2
	Larvae	2,765	1,169	4,429	129	466	367	771	121	490	127	70				106,826	46.7
Topminnow *Fundulus* spp.	Larvae															13	<0.1
Western Mosquitofish	Larvae							7								7	<0.1
White Bass	Eggs															20	<0.1
	Larvae															4,442	1.9
Yellow Bass	Larvae			7												7	<0.1
Yellow Perch	Larvae															19	<0.1
Total	All	3,704	1,675	5,315	507	1,011	603	2,210	192	924	297	70	0	0	0	228,832	100

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Table 3-17. Estimated abundance (thousands of individuals) of fish eggs and larvae entrained by a closed-cycle recirculating system installed at Browns Ferry Nuclear Power Plant based on intake samples collected in each sample period during 2019 and 92.4% flow reduction in the 2016–2020 actual intake flow.

Taxon	Life Stage	Sample Period															
		32	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
		28-Jan	4-Mar	11-Mar	18-Mar	25-Mar	1-Apr	8-Apr	15-Apr	22-Apr	29-Apr	6-May	13-May	20-May	27-May	3-Jun	10-Jun
Blue Catfish	Larvae																
Buffalofish *Ictiobus* spp.	Larvae					33	113	297	312	173		7	6	7			
Channel Catfish	Larvae																
Common Carp	Larvae									14				14			
Crappie *Pomoxis* spp.	Larvae					34		22	27	7	14	7	20				
Darter *Etheostoma* spp.	Larvae						7			62	75	35					
Emerald Shiner	Larvae								7								
Freshwater Drum	Eggs										205	8,598		702	2,951	87	21
	Larvae											228	329	249	512	167	14
Gizzard Shad	Eggs																
	Larvae																
Grass Carp	Larvae																
Logperch	Larvae			77	133	162	53	290	89	173	96	21	13				
Mississippi Silverside	Eggs																
	Larvae								7	7	20		78	42	762	629	42
Sauger	Larvae						7	21									
Shiner *Pimephales* spp.	Larvae											14		7	40		
Skipjack Herring	Eggs					6											
Spotted Sucker	Larvae							15									
Sunfish *Lepomis* spp.	Larvae												20	21	563	2,067	55
Threadfin Shad	Eggs									14		7					
	Larvae					52	47	1,210	7,036	21,218	8,272	28,405	40,128	4,892	54,984	11,661	1,649
Topminnow *Fundulus* spp.	Larvae																
Western Mosquitofish	Larvae																
White Bass	Eggs																
	Larvae					90	1,412	17,161	2,459	11,399	5,331	5,276	630	43	54		
Yellow Bass	Larvae																
Yellow Perch	Larvae					13	7	8			7	29	45	15	6		
Total	All	0	0	77	133	390	1,645	19,023	9,935	33,068	14,019	42,626	41,269	5,991	59,872	14,610	1,782

(extended)

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Table 3-17. (extended)

Taxon	Life Stage	Sample Period																
		49	50	51	52	53	54	55	56	57	58	59	60	61	62	63		
		17-Jun	24-Jun	1-Jul	8-Jul	15-Jul	22-Jul	29-Jul	5-Aug	12-Aug	19-Aug	26-Aug	16-Sep	28-Oct	25-Nov	16-Dec	Total	%
Blue Catfish	Larvae																	0
Buffalofish *Ictiobus* spp.	Larvae																949	0.4
Channel Catfish	Larvae				7												7	<0.1
Common Carp	Larvae																28	<0.1
Crappie *Pomoxis* spp.	Larvae																130	0.1
Darter *Etheostoma* spp.	Larvae																179	0.1
Emerald Shiner	Larvae																7	<0.1
Freshwater Drum	Eggs																12,563	5.1
	Larvae	7															1,506	0.6
Gizzard Shad	Eggs																	0
	Larvae																	0
Grass Carp	Larvae																	0
Logperch	Larvae																1,106	0.5
Mississippi Silverside	Eggs																	0
	Larvae	7															1,593	0.7
Sauger	Larvae																27	<0.1
Shiner *Pimephales* spp.	Larvae				218												279	0.1
Skipjack Herring	Eggs																6	<0.1
Spotted Sucker	Larvae																15	<0.1
Sunfish *Lepomis* spp.	Larvae	14	27	36	70	21	27	21	14	28							2,985	1.2
Threadfin Shad	Eggs																21	<0.1
	Larvae	14	13		14												179,595	73.3
Topminnow *Fundulus* spp.	Larvae																	0
Western Mosquitofish	Larvae																	0
White Bass	Eggs																	0
	Larvae																43,856	17.9
Yellow Bass	Larvae																	0
Yellow Perch	Larvae																129	0.1
Total	All	41	40	36	310	21	27	21	14	28	0	0	0	0	0	0	244,980	100

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Table 3-18. Egg diameter metrics of taxa were apportioned to species used to estimate fraction excluded by 0.5-mm fine mesh screens.

Family	Species	Egg Diameter				0.5-mm F_e	Source
		Mean[b]	Min	Max	Standard Deviation[c]		
Atherinopsidae	Mississippi Silverside	1.25	1.10	1.40	0.08	1.000	Auer 1982
Clupeidae	Gizzard Shad	0.85	0.50	1.20	0.18	0.974	EPRI 2019
Clupeidae	Skipjack Herring	2.65	2.50	2.80	0.08	1.000	EPRI 2019
Clupeidae	Threadfin Shad	0.85	0.50	1.20	0.18	0.974	EPRI 2019
Moronidae	White Bass	0.85	0.75	0.95	0.05	1.000	McEntire and Fuller 2009
Sciaenidae	Freshwater Drum	1.35	1.00	1.70	0.18	1.000	EPRI 2019

[a] Values for these eggs are provided using the full range of values for identified eggs collected (all other values in table).

[b] Means were estimated as the mid-point of the range assuming normal distribution.

[c] Standard deviation was estimated based on the range divided by four, corresponding to 95% of the expected true values falling within two standard deviations of the mean, or spanning four standard deviations in the range.

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Table 3-19. Descriptive statistics of head capsule depth and width measurements of fish larvae collected near Sequoyah Nuclear Plant used to estimate fraction (F_e) of larvae that would be excluded by a 0.5-mm fine mesh screen at Browns Ferry Nuclear Plant.

Species or Genus	F_e	N	Head Capsule Depth (mm)			Head Capsule Width (mm)		
			Min	Mean	Max	Min	Mean	Max
Blue Catfish[1]	1.000	5	2.5	2.7	3.3	2.8	3.0	3.2
Buffalofish *Ictiobus* spp.[2]	1.000	17	0.9	1.0	1.0	1.0	1.1	1.3
Channel Catfish[3]	1.000	5	2.5	2.7	3.1	2.8	3.1	3.6
Common Carp[4]	1.000	2	0.4	0.5	0.6	0.7	0.8	0.8
Crappie *Pomoxis* spp.	1.000	68	0.6	0.8	1.2	0.6	0.8	1.1
Darter *Etheostoma* spp.[5]	1.000	3	0.9	1.0	1.2	1.0	1.0	1.1
Freshwater Drum	0.675	191	0.3	0.7	1.5	0.3	0.6	1.3
Emerald Shiner	1.000	2	0.4	0.5	0.6	0.7	0.8	0.8
Gizzard Shad[6]	0.689	257	0.3	0.8	5.7	0.3	0.8	3.0
Grass Carp[7]	1.000	3	0.4	0.6	0.8	0.7	0.8	0.9
Logperch[5]	1.000	3	0.9	1.0	1.2	1.0	1.0	1.1
Mississippi Silverside[8]	1.000	2	0.7	1.0	1.2	0.7	0.9	1.1
Sauger	1.000	1	1.2	1.2	1.2	1.2	1.2	1.2
Shiner *Pimephales* spp.[4]	1.000	2	0.4	0.5	0.6	0.7	0.8	0.8
Spotted Sucker[2]	1.000	17	0.9	1.0	1.0	1.0	1.1	1.3
Sunfish *Lepomis* spp.	1.000	76	0.5	1.0	3.2	0.6	0.9	2.3
Threadfin Shad[6]	0.676	247	0.3	0.7	2.0	0.3	0.8	1.8
Topminnow *Fundulus* spp.[9]	0.686	582	0.3	0.7	1.5	0.3	0.6	1.3
Western Mosquitofish[9]	0.766	781	0.3	0.8	3.2	0.3	0.8	3.4
White Bass[10]	0.715	144	0.4	0.9	2.8	0.4	0.8	2.1
Yellow Bass[11]	0.715	144	0.4	0.9	2.8	0.4	0.8	2.1
Yellow Perch	1.000	6	0.7	1.1	1.6	0.7	1.0	1.4

1 Includes river samples and Channel Catfish specimens from intake and river samples to improve sample size

2 Identified and measured as Ictiobinae (Buffalo or Carpsucker)

3 Includes intake and river samples to improve sample size

4 Measurements of Cyprinid (*Pimephales* group)

5 Measurements of Unidentifiable Darter (*P. caprodes* type) from river samples and Unidentifiable Darter (not *P. caprodes*) from intake and river samples

6 Includes measurements identified as clupeids

7 Measurements of Cyprinid (*Pimephales* group) and 3 specimens identified as Grass Carp in river samples

8 Identified and measured as Atherinids (Silverside)

9 All measurements of specimens from intake samples excluding those exceeding the maximum total length observed at BFN for larval topminnows (8 mm TL) and larval Western Mosquitofish (18 mm TL)

10 Includes specimen identified as Morone and Morone (not saxatilis)

11 Used data for White Bass but adjusted to the maximum total length of Yellow Bass larvae observed at BFN (45 mm TL)

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Table 3-20. Estimated abundance (thousands of individuals) of fish eggs and larvae entrained if 0.5-mm fine mesh screens were installed at Browns Ferry Nuclear Plant based on intake samples collected in each sample period during 2018 and physical size exclusion.

		Sample Period															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Taxon	Life Stage	19-Feb	26-Feb	5-Mar	12-Mar	19-Mar	26-Mar	2-Apr	9-Apr	16-Apr	23-Apr	30-Apr	7-May	14-May	21-May	28-May	4-Jun
Blue Catfish	Larvae																
Buffalofish *Ictiobus* spp.	Larvae																
Channel Catfish	Larvae																
Common Carp	Larvae																
Crappie *Pomoxis* spp.	Larvae																
Darter *Etheostoma* spp.	Larvae																
Emerald Shiner	Larvae																
Freshwater Drum	Eggs																
	Larvae												27	30	548	1,534	1,869
Gizzard Shad	Eggs									3		6	135	18	7		
	Larvae									58	643	1,604	13,245	150,107	50,527	149,417	17,157
Grass Carp	Larvae																
Logperch	Larvae																
Mississippi Silverside	Eggs																
	Larvae																
Sauger	Larvae																
Shiner *Pimephales* spp.	Larvae																
Skipjack Herring	Eggs																
Spotted Sucker	Larvae																
Sunfish *Lepomis* spp.	Larvae																
Threadfin Shad	Eggs									4		7	142	19	7		
	Larvae									61	677	1,688	13,944	158,021	53,191	157,295	
Topminnow *Fundulus* spp.	Larvae													54			
Western Mosquitofish	Larvae																
White Bass	Eggs																
	Larvae		44					29	4,846	6,315	2,265	83	153	300	185	2,456	98
Yellow Bass	Larvae																
Yellow Perch	Larvae																
Total	All	0	44	0	0	0	0	29	4,846	6,441	3,585	3,388	27,646	308,549	104,465	310,702	19,123

(extended)

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Table 3-20. (extended)

Taxon	Life Stage	Sample Period																
		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
		11-Jun	18-Jun	25-Jun	2-Jul	9-Jul	16-Jul	23-Jul	30-Jul	6-Aug	13-Aug	20-Aug	24-Sep	22-Oct	19-Nov	24-Dec	Total	%
Blue Catfish	Larvae																	0
Buffalofish *Ictiobus* spp.	Larvae																	0
Channel Catfish	Larvae																	0
Common Carp	Larvae																	0
Crappie *Pomoxis* spp.	Larvae																	0
Darter *Etheostoma* spp.	Larvae																	0
Emerald Shiner	Larvae																	0
Freshwater Drum	Eggs																	0
	Larvae	2,073															6,081	0.7
Gizzard Shad	Eggs																169	<0.1
	Larvae																382,758	45.3
Grass Carp	Larvae																	0
Logperch	Larvae																	0
Mississippi Silverside	Eggs																	0
	Larvae																	0
Sauger	Larvae																	0
Shiner *Pimephales* spp.	Larvae																	0
Skipjack Herring	Eggs																	0
Spotted Sucker	Larvae																	0
Sunfish *Lepomis* spp.	Larvae																	0
Threadfin Shad	Eggs																178	<0.1
	Larvae	9,109	11,357	4,799	18,186	530	1,915	1,509	3,167	498	2,011	521	288				438,768	51.9
Topminnow *Fundulus* spp.	Larvae																54	<0.1
Western Mosquitofish	Larvae								23								23	<0.1
White Bass	Eggs																	0
	Larvae																16,773	2.0
Yellow Bass	Larvae				27												27	<0.1
Yellow Perch	Larvae																	0
Total	All	11,181	11,357	4,799	18,213	530	1,915	1,509	3,189	498	2,011	521	288	0	0	0	844,831	100.0

ADEM Watermark

Table 3-21. Estimated abundance (thousands of individuals) of fish eggs and larvae entrained if 0.5-mm fine mesh screens were installed at Browns Ferry Nuclear Plant based on intake samples collected in each sample period during 2019 and physical size exclusion.

Taxon	Life Stage	Sample Period															
		32	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
		28-Jan	4-Mar	11-Mar	18-Mar	25-Mar	1-Apr	8-Apr	15-Apr	22-Apr	29-Apr	6-May	13-May	20-May	27-May	3-Jun	10-Jun
Blue Catfish	Larvae																
Buffalofish *Ictiobus* spp.	Larvae																
Channel Catfish	Larvae																
Common Carp	Larvae																
Crappie *Pomoxis* spp.	Larvae																
Darter *Etheostoma* spp.	Larvae																
Emerald Shiner	Larvae																
Freshwater Drum	Eggs																
	Larvae											984	1,416	1,071	2,206	718	61
Gizzard Shad	Eggs																
	Larvae																
Grass Carp	Larvae																
Logperch	Larvae																
Mississippi Silverside	Eggs																
	Larvae																
Sauger	Larvae																
Shiner *Pimephales* spp.	Larvae																
Skipjack Herring	Eggs																
Spotted Sucker	Larvae																
Sunfish *Lepomis* spp.	Larvae																
Threadfin Shad	Eggs									5		2					
	Larvae					215	192	4,968	28,894	87,156	33,978	116,695	164,832	20,096	225,808	47,894	6,774
Topminnow *Fundulus* spp.	Larvae																
Western Mosquitofish	Larvae																
White Bass	Eggs																
	Larvae					341	5,335	64,799	9,285	43,048	20,130	19,928	2,381	161	202		
Yellow Bass	Larvae																
Yellow Perch	Larvae																
Total	All	0	0	0	0	556	5,527	69,767	38,179	130,208	54,108	137,609	168,629	21,329	228,216	48,612	6,834

(extended)

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Table 3-21. (extended)

Taxon	Life Stage	Sample Period																
		49	50	51	52	53	54	55	56	57	58	59	60	61	62	63		
		17-Jun	24-Jun	1-Jul	8-Jul	15-Jul	22-Jul	29-Jul	5-Aug	12-Aug	19-Aug	26-Aug	16-Sep	28-Oct	25-Nov	16-Dec	Total	%
Blue Catfish	Larvae																	0
Buffalofish *Ictiobus* spp.	Larvae																	0
Channel Catfish	Larvae																	0
Common Carp	Larvae																	0
Crappie *Pomoxis* spp.	Larvae																	0
Darter *Etheostoma* spp.	Larvae																	0
Emerald Shiner	Larvae																	0
Freshwater Drum	Eggs																	0
	Larvae	31															6,486	0.7
Gizzard Shad	Eggs																	0
	Larvae																	0
Grass Carp	Larvae																	0
Logperch	Larvae																	0
Mississippi Silverside	Eggs																	0
	Larvae																	0
Sauger	Larvae																	0
Shiner *Pimephales* spp.	Larvae																	0
Skipjack Herring	Eggs																	0
Spotted Sucker	Larvae																	0
Sunfish *Lepomis* spp.	Larvae																	0
Threadfin Shad	Eggs																7	<0.1
	Larvae	56	55		59												737,670	81.1
Topminnow *Fundulus* spp.	Larvae																	0
Western Mosquitofish	Larvae																	0
White Bass	Eggs																	0
	Larvae																165,609	18.2
Yellow Bass	Larvae																	0
Yellow Perch	Larvae																	0
Total	All	86	55	0	59	0	0	0	0	0	0	0	0	0	0	0	909,773	100.0

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Table 3-22. Estimated abundance (thousands of individuals) of entrainable fish eggs and larvae excluded and impinged (converts) if 0.5-mm fine mesh screens were installed at Browns Ferry Nuclear Plant based on intake samples collected in each sample period during 2018 and physical size exclusion.

		Sample Period															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Taxon	Life State	19-Feb	26-Feb	5-Mar	12-Mar	19-Mar	26-Mar	2-Apr	9-Apr	16-Apr	23-Apr	30-Apr	7-May	14-May	21-May	28-May	4-Jun
Blue Catfish	Larvae															93	
Buffalofish *Ictiobus* spp.	Larvae			129		349	1,097	1,297	1,322	2,098	388	540	95				
Channel Catfish	Larvae																
Common Carp	Larvae																
Crappie *Pomoxis* spp.	Larvae				143				616	360	87		84				
Darter *Etheostoma* spp.	Larvae			73										86		93	
Emerald Shiner	Larvae														170		
Freshwater Drum	Eggs												1,354	1,121	9,488	43,731	
	Larvae												56	63	1,139	3,185	3,882
Gizzard Shad	Eggs									127		236	5,049	662	252		
	Larvae									128	1,425	3,553	29,344	332,552	111,939	331,023	38,009
Grass Carp	Larvae																87
Logperch	Larvae		155	490	72	1,974	743	2,477	905	2,013	880	90		88			
Mississippi Silverside	Eggs								81			242					
	Larvae										291	190	1,656	4,814	39,061	53,772	21,360
Sauger	Larvae										94						
Shiner *Pimephales* spp.	Larvae														176	3,226	85
Skipjack Herring	Eggs																
Spotted Sucker	Larvae									284							
Sunfish *Lepomis* spp.	Larvae										100			714	5,590	5,014	257
Threadfin Shad	Eggs									134		250	5,332	699	266		
	Larvae									136	1,507	3,758	31,036	351,724	118,393	350,107	
Topminnow *Fundulus* spp.	Larvae													118			
Western Mosquitofish	Larvae																
White Bass	Eggs								170	97							
	Larvae		111					73	12,156	15,843	5,681	208	383	753	464	6,162	245
Yellow Bass	Larvae																
Yellow Perch	Larvae			65				187									
Total	All	0	266	757	215	2,323	1,840	4,034	15,250	21,219	10,454	9,065	74,389	693,395	286,937	796,408	63,924

(extended)

ADEM Watermark

Table 3-22. (extended)

Taxon	Life State	Sample Period																
		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
		11-Jun	18-Jun	25-Jun	2-Jul	9-Jul	16-Jul	23-Jul	30-Jul	6-Aug	13-Aug	20-Aug	24-Sep	22-Oct	19-Nov	24-Dec	Total	%
Blue Catfish	Larvae																93	<0.1
Buffalofish *Ictiobus* spp.	Larvae																7,315	0.3
Channel Catfish	Larvae				477		797		191		191						1,655	0.1
Common Carp	Larvae																	0
Crappie *Pomoxis* spp.	Larvae																1,289	0.1
Darter *Etheostoma* spp.	Larvae																252	<0.1
Emerald Shiner	Larvae																170	<0.1
Freshwater Drum	Eggs	86			1,157				183		93	1,037					58,251	2.7
	Larvae	4,305															12,630	0.6
Gizzard Shad	Eggs																6,325	0.3
	Larvae																847,975	38.8
Grass Carp	Larvae																87	<0.1
Logperch	Larvae																9,887	0.5
Mississippi Silverside	Eggs																323	<0.1
	Larvae	844	959	1,237	771	716	296		267	192	2,894						129,321	5.9
Sauger	Larvae																94	<0.1
Shiner *Pimephales* spp.	Larvae	406	93		3,936		2,280		4,019		1,234	936					16,390	0.7
Skipjack Herring	Eggs																	0
Spotted Sucker	Larvae																284	<0.1
Sunfish *Lepomis* spp.	Larvae	6,812	11,386	5,471	5,302	4,289	3,845	3,117	14,303	746	1,338	280					68,563	3.1
Threadfin Shad	Eggs																6,680	0.3
	Larvae	20,274	25,280	10,683	40,479	1,180	4,263	3,359	7,049	1,108	4,477	1,160	640				976,612	44.7
Topminnow *Fundulus* spp.	Larvae																118	<0.1
Western Mosquitofish	Larvae								74								74	<0.1
White Bass	Eggs																268	<0.1
	Larvae																42,080	1.9
Yellow Bass	Larvae				68												68	<0.1
Yellow Perch	Larvae																251	<0.1
Total	All	32,727	37,718	17,391	52,189	6,186	11,480	6,476	26,085	2,046	10,227	3,413	640	0	0	0	2,187,055	100.0

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Table 3-23. Estimated abundance (thousands of individuals) of entrainable fish eggs and larvae excluded and impinged (converts) if 0.5-mm fine mesh screens were installed at Browns Ferry Nuclear Plant based on intake samples collected in each sample period during 2019 and physical size exclusion.

Taxon	Life State	Sample Period														
		32	34	35	36	37	38	39	40	41	42	43	44	45	46	47
		28-Jan	4-Mar	11-Mar	18-Mar	25-Mar	1-Apr	8-Apr	15-Apr	22-Apr	29-Apr	6-May	13-May	20-May	27-May	3-Jun
Blue Catfish	Larvae															
Buffalofish *Ictiobus* spp.	Larvae					438	1,504	3,940	4,127	2,295		88	86	92		
Channel Catfish	Larvae															
Common Carp	Larvae									183				185		
Crappie *Pomoxis* spp.	Larvae					447		293	360	91	183	92	263			
Darter *Etheostoma* spp.	Larvae						87			825	995	465				
Emerald Shiner	Larvae								88							
Freshwater Drum	Eggs										2,711	113,942		9,305	39,089	1,147
	Larvae											2,043	2,941	2,225	4,582	1,492
Gizzard Shad	Eggs															
	Larvae															
Grass Carp	Larvae															
Logperch	Larvae			1,022	1,764	2,149	702	3,840	1,173	2,291	1,269	279	174			
Mississippi Silverside	Eggs															
	Larvae								89	91	268		1,028	556	10,101	8,330
Sauger	Larvae						88	276								
Shiner *Pimephales* spp.	Larvae											179		92	530	
Skipjack Herring	Eggs					84										
Spotted Sucker	Larvae							196								
Sunfish *Lepomis* spp.	Larvae												259	282	7,459	27,389
Threadfin Shad	Eggs									178		92				
	Larvae					478	427	11,058	64,312	193,992	75,629	259,740	366,884	44,731	502,604	106,602
Topminnow *Fundulus* spp.	Larvae															
Western Mosquitofish	Larvae															
White Bass	Eggs															
	Larvae					856	13,384	162,565	23,294	107,996	50,501	49,995	5,973	404	508	
Yellow Bass	Larvae															
Yellow Perch	Larvae					169	87	100			92	383	599	193	84	
Total	All	0	0	1,022	1,764	4,621	16,279	182,269	93,444	307,943	131,648	427,299	378,206	58,065	564,957	144,959

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(extended)

Table 3-23. (extended)

Taxon	Life State	Sample Period																	
		48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63		
		10-Jun	17-Jun	24-Jun	1-Jul	8-Jul	15-Jul	22-Jul	29-Jul	5-Aug	12-Aug	19-Aug	26-Aug	16-Sep	28-Oct	25-Nov	16-Dec	Total	%
Blue Catfish	Larvae																		0
Buffalofish *Ictiobus* spp.	Larvae																	12,571	0.5
Channel Catfish	Larvae					93												93	<0.1
Common Carp	Larvae																	368	<0.1
Crappie *Pomoxis* spp.	Larvae																	1,729	0.1
Darter *Etheostoma* spp.	Larvae																	2,372	0.1
Emerald Shiner	Larvae																	88	<0.1
Freshwater Drum	Eggs	279																166,473	7.1
	Larvae	126	64															13,472	0.6
Gizzard Shad	Eggs																		0
	Larvae																		0
Grass Carp	Larvae																		0
Logperch	Larvae																	14,664	0.6
Mississippi Silverside	Eggs																		0
	Larvae	553	91															21,107	0.9
Sauger	Larvae																	364	<0.1
Shiner *Pimephales* spp.	Larvae					2,890												3,691	0.2
Skipjack Herring	Eggs																	84	<0.1
Spotted Sucker	Larvae																	196	<0.1
Sunfish *Lepomis* spp.	Larvae	735	183	359	480	929	276	354	275	187	374							39,541	1.7
Threadfin Shad	Eggs																	271	<0.1
	Larvae	15,077	124	122		131												1,641,912	70.3
Topminnow *Fundulus* spp.	Larvae																		0
Western Mosquitofish	Larvae																		0
White Bass	Eggs																		0
	Larvae																	415,476	17.8
Yellow Bass	Larvae																		0
Yellow Perch	Larvae																	1,706	0.1
Total	All	16,771	462	481	480	4,043	276	354	275	187	374	0	0	0	0	0	0	2,336,178	100.0

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Table 3-24. Fine mesh screen survival (S_{FMS}) for selected species and life stages (or their surrogates) encountered at Browns Ferry Nuclear Plant.

Taxon[1]	Family	Life Stage	S_{FMS}	Sample Size	Surrogate	Reference	Location	Comments
Blue Catfish	Ictaluridae	Larvae	0.588	305	Channel Catfish	Kuhl and Mueller 1988 as cited in EPRI 2003	Prairie Island Nuclear Generating Plant, MN	0.5-mm fine mesh; range 0-10% survival for larvae (4.1mm-22.5mm) and juveniles (12.5-75.0mm)
Buffalofish *Ictiobus* spp.	Catostomidae	Larvae	0.436	2,023	Catostomidae Family	Kuhl and Mueller 1988 as cited in EPRI 2003	Prairie Island Nuclear Generating Plant, MN	0.5-mm fine mesh; range 0-10% survival for larvae (4.1mm-22.5mm) and juveniles (12.5-75.0mm)
Channel Catfish	Ictaluridae	Larvae	0.588	305		Kuhl and Mueller 1988 as cited in EPRI 2003	Prairie Island Nuclear Generating Plant, MN	0.5-mm fine mesh; range 0-10% survival for larvae (4.1mm-22.5mm) and juveniles (12.5-75.0mm)
Common Carp	Cyprinidae	Larvae	0.237	2,659		Kuhl and Mueller 1988 as cited in EPRI 2003	Prairie Island Nuclear Generating Plant, MN	0.5-mm fine mesh; range 0-10% survival for larvae (4.1mm-22.5mm) and juveniles (12.5-75.0mm)
Crappie *Pomoxis* spp.	Centrarchidae	Larvae	0.025	186		Kuhl and Mueller 1988 as cited in EPRI 2003	Prairie Island Nuclear Generating Plant, MN	0.5-mm fine mesh; range 0-10% survival for larvae (4.1mm-22.5mm) and juveniles (12.5-75.0mm)
Darter *Etheostoma* spp.	Percidae	Larvae	0.003	311	Percidae Family	Kuhl and Mueller 1988 as cited in EPRI 2003	Prairie Island Nuclear Generating Plant, MN	0.5-mm fine mesh; range 0-10% survival for larvae (4.1mm-22.5mm) and juveniles (12.5-75.0mm)
Emerald Shiner	Cyprinidae	Larvae	0.364	55		Beak 1988 as cited in EPRI 2013	Dunkirk Steam Station, NY	Dual-flow screens with 3.2 mm mesh. Maximum velocity to the screens was 0.9 fps
Freshwater Drum	Sciaenidae	Egg	0.750	NA[2]	Sciaenidae	Taft et al. 1981 as cited in EPRI 2013	Big Bend Station, FL	0.5 mm screen mesh, 0.5-1.0 fps intake velocity
Freshwater Drum	Sciaenidae	Larvae	0.190	108	Sciaenidae	Taft et al. 1981 as cited in EPRI 2013	Big Bend Station, FL	0.5 mm screen mesh, 0.5-1.0 fps intake velocity
Gizzard Shad	Clupeidae	Larvae	0.050	NA[2]		Kuhl and Mueller 1988 as cited in EPRI 2003	Prairie Island Nuclear Generating Plant, MN	0.5-mm fine mesh; range 0-10% survival for larvae (4.1mm-22.5mm) and juveniles (12.5-75.0mm)
Gizzard Shad	Clupeidae	Egg	0.432	NA[2]	*Alosa* spp.	Taft et al. 1981 as cited in EPRI 2013	Big Bend Station, FL	0.5 mm screen mesh, 0.5-1.0 fps intake velocity, Table A-6 (EPRI 2013)
Grass Carp	Cyprinidae	Larvae	0.237	2,659	Common Carp	Kuhl and Mueller 1988 as cited in EPRI 2003	Prairie Island Nuclear Generating Plant, MN	0.5-mm fine mesh; range 0-10% survival for larvae (4.1mm-22.5mm) and juveniles (12.5-75.0mm)
Logperch	Percidae	Larvae	0.003	311	Percidae Family	Kuhl and Mueller 1988 as cited in EPRI 2003	Prairie Island Nuclear Generating Plant, MN	0.5-mm fine mesh; range 0-10% survival for larvae (4.1mm-22.5mm) and juveniles (12.5-75.0mm)
Mississippi Silverside	Atherinopsidae	Egg	0.720	NA[2]	7 species average	Taft et al. 1981 as cited in EPRI 2013	Big Bend Station, FL	0.5 mm screen mesh, 0.5-1.0 fps intake velocity, Table A-6 (EPRI 2013)
Mississippi Silverside	Atherinopsidae	Larvae	0.290	38	Atlantic Silverside	LMS 1987 as cited in EPRI 2013	Brayton Point, MA	Unit 4, 1.0 mm mesh, 25 ° angled screens, approximated 1.0 fps intake velocity
Sauger	Percidae	Larvae	0.185	68		Kuhl and Mueller 1988 as cited in EPRI 2003	Prairie Island Nuclear Generating Plant, MN	0.5-mm fine mesh; range 0-10% survival for larvae (4.1mm-22.5mm) and juveniles (12.5-75.0mm)

(continued)

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Table 3-24. (continued)

Taxon[1]	Family	Life Stage	S_{FMS}	Sample Size	Surrogate	Reference	Location	Comments
Shiner *Notropis* spp.	Cyprinidae	Larvae	0.364	55	Emerald Shiner	Beak 1988 as cited in EPRI 2013	Dunkirk Steam Station, NY	Dual-flow screens with 3.2 mm mesh. Maximum velocity to the screens was 0.9 fps
Shiner *Pimephales* spp.	Cyprinidae	Larvae	0.364	55	Emerald Shiner	Beak 1988 as cited in EPRI 2013	Dunkirk Steam Station, NY	Dual-flow screens with 3.2 mm mesh. Maximum velocity to the screens was 0.9 fps
Skipjack Herring	Clupeidae	Egg	0.432	NA[2]	*Alosa* spp.	Taft et al. 1981 as cited in EPRI 2013	Big Bend Station, FL	0.5 mm screen mesh, 0.5-1.0 fps intake velocity, Table A-6 (EPRI 2013)
Spotted Sucker	Catostomidae	Larvae	0.436	2,023	Catostomidae Family	Kuhl and Mueller 1988 as cited in EPRI 2003	Prairie Island Nuclear Generating Plant, MN	0.5-mm fine mesh; range 0-10% survival for larvae (4.1mm-22.5mm) and juveniles (12.5-75.0mm)
Sunfish *Lepomis* spp.	Centrarchidae	Larvae	0.010	225	Common Sunfishes, Eared Sunfishes	Kuhl and Mueller 1988 as cited in EPRI 2003	Prairie Island Nuclear Generating Plant, MN	0.5-mm fine mesh; range 0-10% survival for larvae (4.1mm-22.5mm) and juveniles (12.5-75.0mm)
Threadfin Shad	Clupeidae	Larvae	0.200	499		LMS 1987 as cited in EPRI 2013	Brayton Point, MA	Unit 4, 1.0 mm mesh, 25 ° angled screens, approximated 1.0 fps intake velocity
Threadfin Shad	Clupeidae	Egg	0.432	NA[2]	*Alosa* spp.	Taft et al. 1981 as cited in EPRI 2013	Big Bend Station, FL	0.5 mm screen mesh, 0.5-1.0 fps intake velocity, Table A-6 (EPRI 2013)
Topminnow *Fundulus* spp.	Fundulidae	Larvae	0.124	787	8 species average	Taft et al. 1981 as cited in EPRI 2013	Big Bend Station, FL	0.5 mm screen mesh, 0.5-1.0 fps intake velocity, Table A-9 (EPRI 2013)
Western Mosquitofish	Poeciliidae	Larvae	0.124	787	8 species average	Taft et al. 1981 as cited in EPRI 2013	Big Bend Station, FL	0.5 mm screen mesh, 0.5-1.0 fps intake velocity, Table A-9 (EPRI 2013)
White Bass	Moronidae	Larvae	0.321	187		Beak 1988 as cited in EPRI 2013	Dunkirk Steam Station, NY	Dual-flow screens with 3.2 mm mesh. Maximum velocity to the screens was 0.9 fps
White Bass	Moronidae	Egg	0.720	NA[2]	7 species average	Taft et al. 1981 as cited in EPRI 2013	Big Bend Station, FL	0.5 mm screen mesh, 0.5-1.0 fps intake velocity, Table A-6 (EPRI 2013)
Yellow Bass	Moronidae	Larvae	0.321	187	White Bass	Beak 1988 as cited in EPRI 2013	Dunkirk Steam Station, NY	Dual-flow screens with 3.2 mm mesh. Maximum velocity to the screens was 0.9 fps
Yellow Perch	Percidae	Larvae	0.621	95		Beak 1988 as cited in EPRI 2013	Dunkirk Steam Station, NY	Dual-flow screens with 3.2 mm mesh. Maximum velocity to the screens was 0.9 fps

[1] Several changes were made in the 2018–2019 entrainment data (TVA 2021a) to adjust for standard taxonomic nomenclature. High level taxon identifications were apportioned to species or genus based on proportions in densities (see Section 4.2.2):
Unspecified Catostomid (Ictiobinae-Buffalo or Carpsucker) → Buffalofish Ictiobus spp.
Unspecified Centrarchid (Pomoxis spp.) → Crappie Pomoxis spp.
Unspecified Percids (Etheostoma spp.), Unspecified Percid (Darter but not Logperch) → Darter Etheostoma spp.
Unspecified Cyprinids (N. atherinoides group) → Emerald Shiner
Unspecified Percid (Logperch type) → Logperch
Unspecified Atherinopsid (Silverside), Unspecified Atherinopsid (Silversides) → Mississippi Silverside
Unspecified Cyprinids (Pimephales group), Unspecified Cyprinids (Pimephales spp.) → Shiner Pimephales spp.
Unspecified Centrarchid (Lepomis spp.) → Sunfish Lepomis spp.
Unspecified Funulidae (Topminnow) → Topminnow Fundulus spp.

[2] Sample size was not available in the respective reference material.

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Table 3-25. Estimated mortality (thousands of individuals) of entrainable fish eggs and larvae from impingement ("converts") if 0.5-mm fine mesh screens were installed at Browns Ferry Nuclear Plant based on intake samples collected in each sample period during 2018 and physical size exclusion.

		Sample Period															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Taxon	Life Stage	19-Feb	26-Feb	5-Mar	12-Mar	19-Mar	26-Mar	2-Apr	9-Apr	16-Apr	23-Apr	30-Apr	7-May	14-May	21-May	28-May	4-Jun
Blue Catfish	Larvae															38	
Buffalofish *Ictiobus* spp.	Larvae			73		197	618	732	746	1,183	219	305	54				
Channel Catfish	Larvae																
Common Carp	Larvae																
Crappie *Pomoxis* spp.	Larvae				140				600	351	84		81				
Darter *Etheostoma* spp.	Larvae			73										86		93	
Emerald Shiner	Larvae														108		
Freshwater Drum	Eggs												339	280	2,372	10,933	
	Larvae												46	51	923	2,580	3,144
Gizzard Shad	Eggs									72		135	2,878	377	143		
	Larvae									122	1,354	3,375	27,877	315,925	106,342	314,472	36,109
Grass Carp	Larvae																67
Logperch	Larvae		155	488	72	1,969	741	2,470	902	2,007	877	89		88			
Mississippi Silverside	Eggs								23			68					
	Larvae										207	135	1,176	3,418	27,734	38,178	15,166
Sauger	Larvae										77						
Shiner *Pimephales* spp.	Larvae														112	2,052	54
Skipjack Herring	Eggs																
Spotted Sucker	Larvae									160							
Sunfish *Lepomis* spp.	Larvae										99			707	5,534	4,964	254
Threadfin Shad	Eggs									76		142	3,039	398	151		
	Larvae									109	1,206	3,006	24,829	281,380	94,714	280,086	
Topminnow *Fundulus* spp.	Larvae													103			
Western Mosquitofish	Larvae																
White Bass	Eggs								48	27							
	Larvae		75					50	8,254	10,757	3,858	141	260	511	315	4,184	166
Yellow Bass	Larvae																
Yellow Perch	Larvae			25				71									
Total	All	0	230	659	211	2,165	1,359	3,321	10,572	14,864	7,981	7,395	60,578	603,324	238,448	657,580	54,959

(extended)

ADEM Watermark

Table 3-25. (extended)

Taxon	Life Stage	Sample Period																
		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
		11-Jun	18-Jun	25-Jun	2-Jul	9-Jul	16-Jul	23-Jul	30-Jul	6-Aug	13-Aug	20-Aug	24-Sep	22-Oct	19-Nov	24-Dec	Total	%
Blue Catfish	Larvae																38	<0.1
Buffalofish *Ictiobus* spp.	Larvae																4,126	0.2
Channel Catfish	Larvae				196		328		79		79						682	<0.1
Common Carp	Larvae																	0
Crappie *Pomoxis* spp.	Larvae																1,256	0.1
Darter *Etheostoma* spp.	Larvae																251	<0.1
Emerald Shiner	Larvae																108	<0.1
Freshwater Drum	Eggs	22			289				46		23	259					14,563	0.8
	Larvae	3,487															10,230	0.6
Gizzard Shad	Eggs																3,605	0.2
	Larvae																805,576	43.9
Grass Carp	Larvae																67	<0.1
Logperch	Larvae																9,857	0.5
Mississippi Silverside	Eggs																90	<0.1
	Larvae	599	681	878	547	509	210		190	136	2,054						91,818	5.0
Sauger	Larvae																77	<0.1
Shiner *Pimephales* spp.	Larvae	258	59		2,503		1,450		2,556		785	595					10,424	0.6
Skipjack Herring	Eggs																	0
Spotted Sucker	Larvae																160	<0.1
Sunfish *Lepomis* spp.	Larvae	6,744	11,272	5,416	5,249	4,246	3,806	3,086	14,160	738	1,325	277					67,877	3.7
Threadfin Shad	Eggs																3,808	0.2
	Larvae	16,219	20,224	8,546	32,383	944	3,410	2,687	5,639	887	3,582	928	512				781,290	42.6
Topminnow *Fundulus* spp.	Larvae																103	<0.1
Western Mosquitofish	Larvae								65								65	<0.1
White Bass	Eggs																75	<0.1
	Larvae																28,572	1.6
Yellow Bass	Larvae				46												46	<0.1
Yellow Perch	Larvae																95	<0.1
Total	All	27,329	32,236	14,841	41,214	5,699	9,205	5,773	22,734	1,761	7,848	2,060	512	0	0	0	1,834,861	100.0

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Table 3-26. Estimated mortality (thousands of individuals) of entrainable fish eggs and larvae from impingement ("converts") if 0.5-mm fine mesh screens were installed at Browns Ferry Nuclear Plant based on intake samples collected in each sample period during 2019 and physical size exclusion.

Taxon	Life Stage	Sample Period														
		32	34	35	36	37	38	39	40	41	42	43	44	45	46	47
		28-Jan	4-Mar	11-Mar	18-Mar	25-Mar	1-Apr	8-Apr	15-Apr	22-Apr	29-Apr	6-May	13-May	20-May	27-May	3-Jun
Blue Catfish	Larvae															
Buffalofish *Ictiobus* spp.	Larvae					247	848	2,222	2,328	1,295		50	48	52		
Channel Catfish	Larvae															
Common Carp	Larvae									140				141		
Crappie *Pomoxis* spp.	Larvae					436		286	351	89	178	89	256			
Darter *Etheostoma* spp.	Larvae						87			822	992	464				
Emerald Shiner	Larvae								56							
Freshwater Drum	Eggs										678	28,486		2,326	9,772	287
	Larvae											1,655	2,382	1,802	3,711	1,208
Gizzard Shad	Eggs															
	Larvae															
Grass Carp	Larvae															
Logperch	Larvae			1,019	1,759	2,143	700	3,828	1,170	2,284	1,266	278	173			
Mississippi Silverside	Eggs															
	Larvae								63	65	190		730	395	7,172	5,914
Sauger	Larvae						71	225								
Shiner *Pimephales* spp.	Larvae											114		59	337	
Skipjack Herring	Eggs					48										
Spotted Sucker	Larvae							111								
Sunfish *Lepomis* spp.	Larvae												257	279	7,384	27,115
Threadfin Shad	Eggs									102		53				
	Larvae					382	342	8,846	51,450	155,193	60,503	207,792	293,508	35,785	402,084	85,282
Topminnow *Fundulus* spp.	Larvae															
Western Mosquitofish	Larvae															
White Bass	Eggs															
	Larvae					581	9,088	110,382	15,817	73,330	34,290	33,947	4,056	274	345	
Yellow Bass	Larvae															
Yellow Perch	Larvae					64	33	38			35	145	227	73	32	
Total	All	0	0	1,019	1,759	3,901	11,169	125,938	71,235	233,319	98,132	273,072	301,636	41,186	430,837	119,805

(extended)

ADEM Watermark

Table 3-26. (extended)

Taxon	Life Stage	Sample Period																Total	%
		48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63		
		10-Jun	17-Jun	24-Jun	1-Jul	8-Jul	15-Jul	22-Jul	29-Jul	5-Aug	12-Aug	19-Aug	26-Aug	16-Sep	28-Oct	25-Nov	16-Dec		
Blue Catfish	Larvae																		0
Buffalofish *Ictiobus* spp.	Larvae																	7,090	0.4
Channel Catfish	Larvae					38												38	<0.1
Common Carp	Larvae																	281	<0.1
Crappie *Pomoxis* spp.	Larvae																	1,686	0.1
Darter *Etheostoma* spp.	Larvae																	2,365	0.1
Emerald Shiner	Larvae																	56	<0.1
Freshwater Drum	Eggs	70																41,618	2.4
	Larvae	102	51															10,912	0.6
Gizzard Shad	Eggs																		0
	Larvae																		0
Grass Carp	Larvae																		0
Logperch	Larvae																	14,620	0.8
Mississippi Silverside	Eggs																		0
	Larvae	392	64															14,986	0.9
Sauger	Larvae																	296	<0.1
Shiner *Pimephales* spp.	Larvae					1,838												2,347	0.1
Skipjack Herring	Eggs																	48	<0.1
Spotted Sucker	Larvae																	111	<0.1
Sunfish *Lepomis* spp.	Larvae	728	181	356	475	920	273	351	272	185	370							39,146	2.3
Threadfin Shad	Eggs																	154	<0.1
	Larvae	12,061	100	98		105												1,313,529	75.8
Topminnow *Fundulus* spp.	Larvae																		0
Western Mosquitofish	Larvae																		0
White Bass	Eggs																		0
	Larvae																	282,108	16.3
Yellow Bass	Larvae																		0
Yellow Perch	Larvae																	647	<0.1
Total	All	13,354	397	453	475	2,901	273	351	272	185	370	0	0	0	0	0	0	1,732,039	100.0

ADEM Watermark

Table 3-27. Estimated mortality (thousands of individuals) of fish eggs and larvae entrained or impinged (converts) if 0.5-mm fine mesh screens were installed at Browns Ferry Nuclear Plant based on intake samples collected in each sample period during 2018 and physical size exclusion.

Taxon	Life Stage	Sample Period															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		19-Feb	26-Feb	5-Mar	12-Mar	19-Mar	26-Mar	2-Apr	9-Apr	16-Apr	23-Apr	30-Apr	7-May	14-May	21-May	28-May	4-Jun
Blue Catfish	Larvae															38	
Buffalofish *Ictiobus* spp.	Larvae			73		197	618	732	746	1,183	219	305	54				
Channel Catfish	Larvae																
Common Carp	Larvae																
Crappie *Pomoxis* spp.	Larvae				140				600	351	84		81				
Darter *Etheostoma* spp.	Larvae			73										86		93	
Emerald Shiner	Larvae														108		
Freshwater Drum	Eggs												339	280	2,372	10,933	
	Larvae												73	82	1,471	4,114	5,013
Gizzard Shad	Eggs									76		141	3,013	395	150		
	Larvae									180	1,997	4,979	41,122	466,032	156,869	463,889	53,266
Grass Carp	Larvae																67
Logperch	Larvae		155	488	72	1,969	741	2,470	902	2,007	877	89		88			
Mississippi Silverside	Eggs								23			68					
	Larvae										207	135	1,176	3,418	27,734	38,178	15,166
Sauger	Larvae										77						
Shiner *Pimephales* spp.	Larvae														112	2,052	54
Skipjack Herring	Eggs																
Spotted Sucker	Larvae									160							
Sunfish *Lepomis* spp.	Larvae										99			707	5,534	4,964	254
Threadfin Shad	Eggs									80		149	3,182	417	159		
	Larvae									170	1,883	4,694	38,772	439,401	147,905	437,380	
Topminnow *Fundulus* spp.	Larvae													157			
Western Mosquitofish	Larvae																
White Bass	Eggs								48	27							
	Larvae		120					79	13,100	17,072	6,122	224	413	811	500	6,640	264
Yellow Bass	Larvae																
Yellow Perch	Larvae			25				71									
Total	All	0	274	659	211	2,165	1,359	3,351	15,418	21,305	11,566	10,783	88,224	911,873	342,914	968,282	74,082

(extended)

ADEM Watermark

Table 3-27. (extended)

Taxon	Life Stage	Sample Period																
		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
		11-Jun	18-Jun	25-Jun	2-Jul	9-Jul	16-Jul	23-Jul	30-Jul	6-Aug	13-Aug	20-Aug	24-Sep	22-Oct	19-Nov	24-Dec	Total	%
Blue Catfish	Larvae																38	<0.1
Buffalofish *Ictiobus* spp.	Larvae																4,126	0.2
Channel Catfish	Larvae				196		328		79		79						682	<0.1
Common Carp	Larvae																	0
Crappie *Pomoxis* spp.	Larvae																1,256	<0.1
Darter *Etheostoma* spp.	Larvae																251	<0.1
Emerald Shiner	Larvae																108	<0.1
Freshwater Drum	Eggs	22			289				46		23	259					14,563	0.5
	Larvae	5,559															16,312	0.6
Gizzard Shad	Eggs																3,774	0.1
	Larvae																1,188,334	44.3
Grass Carp	Larvae																67	<0.1
Logperch	Larvae																9,857	0.4
Mississippi Silverside	Eggs																90	<0.1
	Larvae	599	681	878	547	509	210		190	136	2,054						91,818	3.4
Sauger	Larvae																77	<0.1
Shiner *Pimephales* spp.	Larvae	258	59		2,503		1,450		2,556		785	595					10,424	0.4
Skipjack Herring	Eggs																	0
Spotted Sucker	Larvae																160	<0.1
Sunfish *Lepomis* spp.	Larvae	6,744	11,272	5,416	5,249	4,246	3,806	3,086	14,160	738	1,325	277					67,877	2.5
Threadfin Shad	Eggs																3,986	0.1
	Larvae	25,328	31,581	13,346	50,570	1,474	5,325	4,196	8,806	1,385	5,593	1,449	800				1,220,057	45.5
Topminnow *Fundulus* spp.	Larvae																157	<0.1
Western Mosquitofish	Larvae								88								88	<0.1
White Bass	Eggs																75	<0.1
	Larvae																45,346	1.7
Yellow Bass	Larvae				73												73	<0.1
Yellow Perch	Larvae																95	<0.1
Total	All	38,510	43,594	19,640	59,428	6,229	11,120	7,282	25,923	2,259	9,859	2,581	800	0	0	0	2,679,692	100.0

ADEM Watermark

Table 3-28. Estimated mortality (thousands of individuals) of fish eggs and larvae entrained or impinged (converts) if 0.5-mm fine mesh screens were installed at Browns Ferry Nuclear Plant based on intake samples collected in each sample period during 2019 and physical size exclusion.

Taxon	Life Stage	Sample Period														
		32	34	35	36	37	38	39	40	41	42	43	44	45	46	47
		28-Jan	4-Mar	11-Mar	18-Mar	25-Mar	1-Apr	8-Apr	15-Apr	22-Apr	29-Apr	6-May	13-May	20-May	27-May	3-Jun
Blue Catfish	Larvae															
Buffalofish *Ictiobus* spp.	Larvae					247	848	2,222	2,328	1,295		50	48	52		
Channel Catfish	Larvae															
Common Carp	Larvae									140				141		
Crappie *Pomoxis* spp.	Larvae					436		286	351	89	178	89	256			
Darter *Etheostoma* spp.	Larvae						87			822	992	464				
Emerald Shiner	Larvae								56							
Freshwater Drum	Eggs										678	28,486		2,326	9,772	287
	Larvae											2,638	3,798	2,873	5,918	1,927
Gizzard Shad	Eggs															
	Larvae															
Grass Carp	Larvae															
Logperch	Larvae			1,019	1,759	2,143	700	3,828	1,170	2,284	1,266	278	173			
Mississippi Silverside	Eggs															
	Larvae								63	65	190		730	395	7,172	5,914
Sauger	Larvae						71	225								
Shiner *Pimephales* spp.	Larvae											114		59	337	
Skipjack Herring	Eggs					48										
Spotted Sucker	Larvae							111								
Sunfish *Lepomis* spp.	Larvae												257	279	7,384	27,115
Threadfin Shad	Eggs									106		55				
	Larvae					597	534	13,814	80,344	242,349	94,481	324,487	458,340	55,881	627,891	133,175
Topminnow *Fundulus* spp.	Larvae															
Western Mosquitofish	Larvae															
White Bass	Eggs															
	Larvae					922	14,422	175,180	25,102	116,377	54,420	53,875	6,437	435	547	
Yellow Bass	Larvae															
Yellow Perch	Larvae					64	33	38			35	145	227	73	32	
Total	All	0	0	1,019	1,759	4,456	16,696	195,705	109,413	363,527	152,240	410,681	470,265	62,514	659,053	168,417

ADEM Watermark

(extended)

Table 3-28. (extended)

Taxon	Life Stage	Sample Period																	
		48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63		
		10-Jun	17-Jun	24-Jun	1-Jul	8-Jul	15-Jul	22-Jul	29-Jul	5-Aug	12-Aug	19-Aug	26-Aug	16-Sep	28-Oct	25-Nov	16-Dec	Total	%
Blue Catfish	Larvae																		0
Buffalofish *Ictiobus* spp.	Larvae																	7,090	0.3
Channel Catfish	Larvae					38												38	<0.1
Common Carp	Larvae																	281	<0.1
Crappie *Pomoxis* spp.	Larvae																	1,686	0.1
Darter *Etheostoma* spp.	Larvae																	2,365	0.1
Emerald Shiner	Larvae																	56	<0.1
Freshwater Drum	Eggs	70																41,618	1.6
	Larvae	163	82															17,399	0.7
Gizzard Shad	Eggs																		0
	Larvae																		0
Grass Carp	Larvae																		0
Logperch	Larvae																	14,620	0.6
Mississippi Silverside	Eggs																		0
	Larvae	392	64															14,986	0.6
Sauger	Larvae																	296	<0.1
Shiner *Pimephales* spp.	Larvae					1,838												2,347	0.1
Skipjack Herring	Eggs																	48	<0.1
Spotted Sucker	Larvae																	111	<0.1
Sunfish *Lepomis* spp.	Larvae	728	181	356	475	920	273	351	272	185	370							39,146	1.5
Threadfin Shad	Eggs																	161	<0.1
	Larvae	18,835	155	152		164												2,051,200	77.6
Topminnow *Fundulus* spp.	Larvae																		0
Western Mosquitofish	Larvae																		0
White Bass	Eggs																		0
	Larvae																	447,717	16.9
Yellow Bass	Larvae																		0
Yellow Perch	Larvae																	647	<0.1
Total	All	20,188	483	508	475	2,960	273	351	272	185	370	0	0	0	0	0	0	2,641,812	100.0

ADEM Watermark

Table 3-29. Estimated entrainment abundance reductions (by number and percent) relative to the existing cooling water intake structure (CWIS) if a closed-cycle recirculating system (CCRS) or 0.5-mm fine mesh screens (FMS) were installed at Browns Ferry Nuclear Plant based on density from intake samples collected during 2018 and five-year actual intake flow.

Taxon	Life Stage	Existing CWIS	Reduction from the Existing CWIS			
			CCRS		FMS	
			N	%	N	%
Blue Catfish	Larvae	92,186	85,180	92.4	92,186	100.0
Buffalofish *Ictiobus* spp.	Larvae	7,262,912	6,710,930	92.4	7,262,912	100.0
Channel Catfish	Larvae	1,643,680	1,518,760	92.4	1,643,680	100.0
Common Carp	Larvae					
Crappie *Pomoxis* spp.	Larvae	1,279,369	1,182,137	92.4	1,279,369	100.0
Darter *Etheostoma* spp.	Larvae	250,213	231,197	92.4	250,213	100.0
Emerald Shiner	Larvae	169,259	156,395	92.4	169,259	100.0
Freshwater Drum	Eggs	57,854,199	53,457,280	92.4	57,854,199	100.0
	Larvae	18,583,052	17,170,740	92.4	12,501,823	67.3
Gizzard Shad	Eggs	6,447,827	5,957,793	92.4	6,278,982	97.4
	Larvae	1,222,221,492	1,129,332,657	92.4	839,463,584	68.7
Grass Carp	Larvae	86,609	80,027	92.4	86,609	100.0
Logperch	Larvae	9,812,582	9,066,826	92.4	9,812,582	100.0
Mississippi Silverside	Eggs	320,534	296,174	92.4	320,534	100.0
	Larvae	128,432,935	118,672,032	92.4	128,432,935	100.0
Sauger	Larvae	93,443	86,341	92.4	93,443	100.0
Shiner *Pimephales* spp.	Larvae	16,278,857	15,041,663	92.4	16,278,857	100.0
Skipjack Herring	Eggs					
Spotted Sucker	Larvae	281,659	260,253	92.4	281,659	100.0
Sunfish *Lepomis* spp.	Larvae	68,094,636	62,919,444	92.4	68,094,636	100.0
Threadfin Shad	Eggs	6,809,667	6,292,133	92.4	6,631,348	97.4
	Larvae	1,405,607,735	1,298,781,548	92.4	966,840,047	68.8
Topminnow *Fundulus* spp.	Larvae	170,522	157,562	92.4	116,599	68.4
Western Mosquitofish	Larvae	96,488	89,155	92.4	73,756	76.4
White Bass	Eggs	265,937	245,726	92.4	265,937	100.0
	Larvae	58,449,774	54,007,590	92.4	41,676,582	71.3
Yellow Bass	Larvae	94,180	87,022	92.4	67,157	71.3
Yellow Perch	Larvae	249,317	230,369	92.4	249,317	100.0
Total	**All**	**3,010,949,064**	**2,782,116,934**	**92.4**	**2,166,118,205**	**71.9**

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Table 3-30. Estimated entrainment abundance reductions (by number and percent) relative to the existing cooling water intake structure (CWIS) if a closed-cycle recirculating system (CCRS) or 0.5-mm fine mesh screens (FMS) were installed at Browns Ferry Nuclear Plant based on density from intake samples collected during 2019 and five-year actual intake flow.

Taxon	Life Stage	Existing CWIS	Reduction from the Existing CWIS			
			CCRS		FMS	
			N	%	N	%
Blue Catfish	Larvae					
Buffalofish *Ictiobus* spp.	Larvae	12,483,713	11,534,951	92.4	12,483,713	100.0
Channel Catfish	Larvae	92,286	85,272	92.4	92,286	100.0
Common Carp	Larvae	365,236	337,478	92.4	365,236	100.0
Crappie *Pomoxis* spp.	Larvae	1,716,685	1,586,216	92.4	1,716,685	100.0
Darter *Etheostoma* spp.	Larvae	2,355,536	2,176,516	92.4	2,355,536	100.0
Emerald Shiner	Larvae	87,668	81,005	92.4	87,668	100.0
Freshwater Drum	Eggs	165,300,161	152,737,348	92.4	165,300,161	100.0
	Larvae	19,820,001	18,313,681	92.4	13,333,510	67.3
Gizzard Shad	Eggs					
	Larvae					
Grass Carp	Larvae					
Logperch	Larvae	14,555,058	13,448,873	92.4	14,555,058	100.0
Mississippi Silverside	Eggs					
	Larvae	20,962,410	19,369,267	92.4	20,962,410	100.0
Sauger	Larvae	361,129	333,683	92.4	361,129	100.0
Shiner *Pimephales* spp.	Larvae	3,666,139	3,387,512	92.4	3,666,139	100.0
Skipjack Herring	Eggs	83,587	77,234	92.4	83,587	100.0
Spotted Sucker	Larvae	194,753	179,952	92.4	194,753	100.0
Sunfish *Lepomis* spp.	Larvae	39,270,788	36,286,207	92.4	39,270,788	100.0
Threadfin Shad	Eggs	275,914	254,944	92.4	268,689	97.4
	Larvae	2,363,089,034	2,183,494,267	92.4	1,625,418,610	68.8
Topminnow *Fundulus* spp.	Larvae					
Western Mosquitofish	Larvae					
White Bass	Eggs					
	Larvae	577,046,128	533,190,623	92.4	411,436,944	71.3
Yellow Bass	Larvae					
Yellow Perch	Larvae	1,694,035	1,565,288	92.4	1,694,035	100.0
Total	**All**	**3,223,420,261**	**2,978,440,317**	**92.4**	**2,313,646,937**	**71.8**

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Table 3-31. Estimated two-year average entrainment abundance reductions (by number and percent) relative to the existing cooling water intake structure (CWIS) if a closed-cycle recirculating system (CCRS) or 0.5-mm fine mesh screens (FMS) were installed at Browns Ferry Nuclear Plant based on density from intake samples collected during 2018 and 2019 and five-year actual intake flow.

Taxon	Life Stage	Existing CWIS	Reduction from the Existing CWIS			
			CCRS		FMS	
			N	%	N	%
Blue Catfish	Larvae	46,093	42,590	92.4	46,093	100.0
Buffalofish *Ictiobus* spp.	Larvae	9,873,313	9,122,941	92.4	9,873,313	100.0
Channel Catfish	Larvae	867,983	802,016	92.4	867,983	100.0
Common Carp	Larvae	182,618	168,739	92.4	182,618	100.0
Crappie *Pomoxis* spp.	Larvae	1,498,027	1,384,177	92.4	1,498,027	100.0
Darter *Etheostoma* spp.	Larvae	1,302,875	1,203,857	92.4	1,302,875	100.0
Emerald Shiner	Larvae	128,464	118,700	92.4	128,464	100.0
Freshwater Drum	Eggs	111,577,180	103,097,314	92.4	111,577,180	100.0
	Larvae	19,201,527	17,742,211	92.4	12,917,667	67.3
Gizzard Shad	Eggs	3,223,914	2,978,897	92.4	3,139,491	97.4
	Larvae	611,110,746	564,666,329	92.4	419,731,792	68.7
Grass Carp	Larvae	43,305	40,014	92.4	43,305	100.0
Logperch	Larvae	12,183,820	11,257,850	92.4	12,183,820	100.0
Mississippi Silverside	Eggs	160,267	148,087	92.4	160,267	100.0
	Larvae	74,697,673	69,020,650	92.4	74,697,673	100.0
Sauger	Larvae	227,286	210,012	92.4	227,286	100.0
Shiner *Pimephales* spp.	Larvae	9,972,498	9,214,588	92.4	9,972,498	100.0
Skipjack Herring	Eggs	41,794	38,617	92.4	41,794	100.0
Spotted Sucker	Larvae	238,206	220,103	92.4	238,206	100.0
Sunfish *Lepomis* spp.	Larvae	53,682,712	49,602,826	92.4	53,682,712	100.0
Threadfin Shad	Eggs	3,542,791	3,273,539	92.4	3,450,019	97.4
	Larvae	1,884,348,385	1,741,137,908	92.4	1,296,129,329	68.8
Topminnow *Fundulus* spp.	Larvae	85,261	78,781	92.4	58,300	68.4
Western Mosquitofish	Larvae	48,244	44,578	92.4	36,878	76.4
White Bass	Eggs	132,969	122,863	92.4	132,969	100.0
	Larvae	317,747,951	293,599,107	92.4	226,556,763	71.3
Yellow Bass	Larvae	47,090	43,511	92.4	33,579	71.3
Yellow Perch	Larvae	971,676	897,829	92.4	971,676	100.0
Total	**All**	**3,117,184,663**	**2,880,278,626**	**92.4**	**2,239,882,571**	**71.9**

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Table 3-32. Estimated entrainment mortality reductions (by number and percent) relative to the existing cooling water intake structure (CWIS) if a closed-cycle recirculating system (CCRS) or 0.5-mm fine mesh screens (FMS) were installed at Browns Ferry Nuclear Plant based on density from intake samples collected during 2018 and five-year actual intake flow.

Taxon	Life Stage	Existing CWIS	Reduction from the Existing CWIS			
			CCRS		FMS	
			N	%	N	%
Blue Catfish	Larvae	92,186	85,180	92.4	53,947	58.5
Buffalofish *Ictiobus* spp.	Larvae	7,262,912	6,710,930	92.4	3,137,087	43.2
Channel Catfish	Larvae	1,643,680	1,518,760	92.4	961,867	58.5
Common Carp	Larvae					
Crappie *Pomoxis* spp.	Larvae	1,279,369	1,182,137	92.4	23,009	1.8
Darter *Etheostoma* spp.	Larvae	250,213	231,197	92.4	-1,161	-0.5
Emerald Shiner	Larvae	169,259	156,395	92.4	60,853	36.0
Freshwater Drum	Eggs	57,854,199	53,457,280	92.4	43,291,390	74.8
	Larvae	18,583,052	17,170,740	92.4	2,271,325	12.2
Gizzard Shad	Eggs	6,447,827	5,957,793	92.4	2,673,629	41.5
	Larvae	1,222,221,492	1,129,332,657	92.4	33,887,411	2.8
Grass Carp	Larvae	86,609	80,027	92.4	20,069	23.2
Logperch	Larvae	9,812,582	9,066,826	92.4	-44,526	-0.5
Mississippi Silverside	Eggs	320,534	296,174	92.4	230,158	71.8
	Larvae	128,432,935	118,672,032	92.4	36,614,788	28.5
Sauger	Larvae	93,443	86,341	92.4	16,755	17.9
Shiner *Pimephales* spp.	Larvae	16,278,857	15,041,663	92.4	5,855,006	36.0
Skipjack Herring	Eggs					
Spotted Sucker	Larvae	281,659	260,253	92.4	121,708	43.2
Sunfish *Lepomis* spp.	Larvae	68,094,636	62,919,444	92.4	217,311	0.3
Threadfin Shad	Eggs	6,809,667	6,292,133	92.4	2,823,671	41.5
	Larvae	1,405,607,735	1,298,781,548	92.4	185,550,491	13.2
Topminnow *Fundulus* spp.	Larvae	170,522	157,562	92.4	13,402	7.9
Western Mosquitofish	Larvae	96,488	89,155	92.4	8,571	8.9
White Bass	Eggs	265,937	245,726	92.4	190,962	71.8
	Larvae	58,449,774	54,007,590	92.4	13,104,186	22.4
Yellow Bass	Larvae	94,180	87,022	92.4	21,126	22.4
Yellow Perch	Larvae	249,317	230,369	92.4	154,094	61.8
Total	**All**	**3,010,949,064**	**2,782,116,934**	**92.4**	**331,257,129**	**11.0**

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Table 3-33. Estimated entrainment mortality reductions (by number and percent) relative to the existing cooling water intake structure (CWIS) if a closed-cycle recirculating system (CCRS) or 0.5-mm fine mesh screens (FMS) were installed at Browns Ferry Nuclear Plant based on density from intake samples collected during 2019 and five-year actual intake flow.

Taxon	Life Stage	Existing CWIS	Reduction from the Existing CWIS			
			CCRS		FMS	
			N	%	N	%
Blue Catfish	Larvae					
Buffalofish *Ictiobus* spp.	Larvae	12,483,713	11,534,951	92.4	5,393,711	43.2
Channel Catfish	Larvae	92,286	85,272	92.4	54,009	58.5
Common Carp	Larvae	365,236	337,478	92.4	84,597	23.2
Crappie *Pomoxis* spp.	Larvae	1,716,685	1,586,216	92.4	30,899	1.8
Darter *Etheostoma* spp.	Larvae	2,355,536	2,176,516	92.4	-9,495	-0.4
Emerald Shiner	Larvae	87,668	81,005	92.4	31,530	36.0
Freshwater Drum	Eggs	165,300,161	152,737,348	92.4	123,681,850	74.8
	Larvae	19,820,001	18,313,681	92.4	2,421,239	12.2
Gizzard Shad	Eggs					
	Larvae					
Grass Carp	Larvae					
Logperch	Larvae	14,555,058	13,448,873	92.4	-65,140	-0.4
Mississippi Silverside	Eggs					
	Larvae	20,962,410	19,369,267	92.4	5,976,629	28.5
Sauger	Larvae	361,129	333,683	92.4	64,748	17.9
Shiner *Pimephales* spp.	Larvae	3,666,139	3,387,512	92.4	1,318,698	36.0
Skipjack Herring	Eggs	83,587	77,234	92.4	35,571	42.6
Spotted Sucker	Larvae	194,753	179,952	92.4	84,151	43.2
Sunfish *Lepomis* spp.	Larvae	39,270,788	36,286,207	92.4	124,733	0.3
Threadfin Shad	Eggs	275,914	254,944	92.4	114,423	41.5
	Larvae	2,363,089,034	2,183,494,267	92.4	311,889,340	13.2
Topminnow *Fundulus* spp.	Larvae					
Western Mosquitofish	Larvae					
White Bass	Eggs					
	Larvae	577,046,128	533,190,623	92.4	129,328,961	22.4
Yellow Bass	Larvae					
Yellow Perch	Larvae	1,694,035	1,565,288	92.4	1,047,406	61.8
Total	**All**	**3,223,420,261**	**2,978,440,317**	**92.4**	**581,607,860**	**18.0**

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Table 3-34. Estimated two-year average entrainment mortality reductions (by number and percent) relative to the existing cooling water intake structure (CWIS) if a closed-cycle recirculating system (CCRS) or 0.5-mm fine mesh screens (FMS) were installed at Browns Ferry Nuclear Plant based on density from intake samples collected during 2018 and 2019 and five-year actual intake flow.

Taxon	Life Stage	Existing CWIS	Reduction from the Existing CWIS			
			CCRS		FMS	
			N	%	N	%
Blue Catfish	Larvae	46,093	42,590	92.4	26,974	58.5
Buffalofish *Ictiobus* spp.	Larvae	9,873,313	9,122,941	92.4	4,265,399	43.2
Channel Catfish	Larvae	867,983	802,016	92.4	507,938	58.5
Common Carp	Larvae	182,618	168,739	92.4	42,299	23.2
Crappie *Pomoxis* spp.	Larvae	1,498,027	1,384,177	92.4	26,954	1.8
Darter *Etheostoma* spp.	Larvae	1,302,875	1,203,857	92.4	-5,328	-0.4
Emerald Shiner	Larvae	128,464	118,700	92.4	46,192	36.0
Freshwater Drum	Eggs	111,577,180	103,097,314	92.4	83,486,620	74.8
	Larvae	19,201,527	17,742,211	92.4	2,346,282	12.2
Gizzard Shad	Eggs	3,223,914	2,978,897	92.4	1,336,815	41.5
	Larvae	611,110,746	564,666,329	92.4	16,943,706	2.8
Grass Carp	Larvae	43,305	40,014	92.4	10,035	23.2
Logperch	Larvae	12,183,820	11,257,850	92.4	-54,833	-0.5
Mississippi Silverside	Eggs	160,267	148,087	92.4	115,079	71.8
	Larvae	74,697,673	69,020,650	92.4	21,295,709	28.5
Sauger	Larvae	227,286	210,012	92.4	40,752	17.9
Shiner *Pimephales* spp.	Larvae	9,972,498	9,214,588	92.4	3,586,852	36.0
Skipjack Herring	Eggs	41,794	38,617	92.4	17,786	42.6
Spotted Sucker	Larvae	238,206	220,103	92.4	102,930	43.2
Sunfish *Lepomis* spp.	Larvae	53,682,712	49,602,826	92.4	171,022	0.3
Threadfin Shad	Eggs	3,542,791	3,273,539	92.4	1,469,047	41.5
	Larvae	1,884,348,385	1,741,137,908	92.4	248,719,916	13.2
Topminnow *Fundulus* spp.	Larvae	85,261	78,781	92.4	6,701	7.9
Western Mosquitofish	Larvae	48,244	44,578	92.4	4,286	8.9
White Bass	Eggs	132,969	122,863	92.4	95,481	71.8
	Larvae	317,747,951	293,599,107	92.4	71,216,574	22.4
Yellow Bass	Larvae	47,090	43,511	92.4	10,563	22.4
Yellow Perch	Larvae	971,676	897,829	92.4	600,750	61.8
Total	**All**	**3,117,184,663**	**2,880,278,626**	**92.4**	**456,432,495**	**14.6**

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4 Biological Benefits of Entrainment Reduction Technologies Pursuant to §122.21(r)(11)(ii)

4.1 Overview

The technical approach used in this assessment to evaluate the non-monetized biological benefits from entrainment reduction technologies at BFN follows the general approach described by the EPA (2004, 2014) in their benefits valuation, which converts entrained species and life stages to equivalent loss (numbers of fish), and then directly and indirectly into harvest foregone (biomass) of commercial and recreational fishery species. In most benefit evaluations where commercial fisheries are present, an equivalent fishery yield model (also known as harvest foregone model) is used to estimate the loss in commercial catch in pounds (EPRI 2012; EPA 2004, 2014) and often relies on regional fishing mortality rates derived from stock assessments. This approach was considered inappropriate and not relevant because there is no commercial fishery in Wheeler Reservoir and catch-and-release practice is popular in the recreational fishery (i.e. few fish kept or "harvested"). Instead, the equivalent fishery yield model was adapted to estimate the number of fish that would have died as a result of angling if the entrained life stages of fish had survived. From the equivalent fishery yield (fishery deaths), equivalent harvest and catch estimates were used to assess the direct and indirect benefit to the recreational fishery from reductions in entrainment abundance (and mortality) if entrainment reduction technologies (CCRS and 0.5-mm fine mesh screens) were implemented at BFN. The equivalent fishery yield model of the number of equivalent predatory species (assumed to be age-3 Blue Catfish) was estimated from the lifetime total production foregone from entrainment of forage species after a 10:1 forage-to-predator biomass conversion. Atypical of other Benefits Valuation Study approaches by EPA (2006) and EPRI (2012), the biomass from natural mortalities (assuming 100% predation) that would have resulted if fishery species had not been entrained would provide as indirect forage benefit to predatory species (age-3 Blue Catfish) at 10:1 forage-to-predator biomass conversion.

4.1.1 Species Evaluated for Biological Benefits

This biological benefits evaluation included 23 species of fish entrained at BFN, after apportioning entrainment densities of higher taxonomic levels of fish to species level, based on two years of entrainment sampling (Table 4-1). Incremental gains in fish from reductions in entrainment mortality at BFN were modelled using parameters based on species-specific life history tables of a population at equilibrium (Appendix 1) or related taxa for surrogate information.

4.1.2 Commercial and Recreational Fishery Benefits

There are no commercial fisheries in Wheeler Reservoir, so entrainment reduction alternatives at BFN were not analyzed for commercial fisheries benefits.

The recreational fishery benefits were estimated directly from entrainment reduction of species considered important to recreational fisheries and indirectly from gains in forage species or unharvested fishery species as an additional food source. Entrained species at BFN were classified by species importance to the recreational fishery, game fish status in Alabama, and EPA's economic value categories (Table 4-1).

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4.2 Biological Benefits Estimation Methods

4.2.1 Equivalent Adult Models

The number of equivalent adults based on entrained ichthyoplankton was estimated following established methods by Saila et al. (1997), EPA (2004), EPRI (2004, 2012), and Barnthouse (2005). This analysis estimates the number of adult fish (age at first sexual maturity) that would have resulted if the larvae had not been entrained (Horst 1975; Goodyear 1978). It was conservatively assumed that entrainment mortality was 100% (i.e., fish entrained through the screens did not survive), and all entrained species were lost to the environment. For each taxon, the number of equivalent adult fish (N_A) for each life stage entrained was estimated as follows:

$$N_A = (EM_i)(S_{i,A}) \qquad \text{Equation 7}$$

where, N_A = number of equivalent individuals that would have survived to adulthood (stage A) if they had not been entrained during early life stage i,

$S_{i,A}$ = fraction of fish expected to survive from life stage i to adulthood (age of equivalence) as determined by age at first maturity, and

EM_i = number of individuals that died from entrainment during life stage i (*e.g.*, eggs, larvae) that would be protected by a technology alternative.

The $S_{i,A}$ parameter was estimated as follows:

$$S_{i,A} = (S_{\text{adj},i}) \prod_{j=i+1}^{j_{\max}} (S_j) \qquad \text{Equation 8}$$

where, $S_{\text{adj},i}$ = survival fraction adjusted for mixed ages within the entrained life stage i and calculated as $2S_i\exp(-\text{Log}_e(1+S_i))$ (EPRI 2004, 2012),

S_j = survival fraction from life stage j to j+1, and

$j_{\max}$ = the life stage immediately prior to adulthood.

The survival fractions were calculated from the instantaneous total mortality rate (Z) for each life stage by $S = \exp(-Z)$, $\exp(-(M+F))$ for fully recruited ages of exploited species, or $-\ln[(1-v)\exp(-M) + (v)\exp(-M+F)]$ for partially recruited ages of exploited species, where M is the instantaneous natural mortality rate, F is the instantaneous fishing mortality rate, and v is the fraction vulnerable to the fishery. Table 4-1 presents the age of adult equivalence, maximum age, and age first partially or fully recruited to the fishery. These and other life-history parameters based on a population at equilibrium are presented by life stage or age in Appendix 1.

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4.2.2 Production Foregone

The production foregone of forage species identified in Table 4-1 was estimated following standard methods established by EPA (2004) and EPRI (2004, 2012). Production foregone is the reduction in prey biomass available to predators due to, in this case, entrainment at BFN and includes the expected future growth prior to consumption by predators if the fish was not entrained. In this assessment, 100% of foregone production was assumed to be consumed by a single recreationally valuable predator species (age-3 Blue Catfish). Blue Catfish was selected because it is the most abundant predatory and highly targeted fish in the local recreational fishery, and was identified in the entrainment density data. While the entrained fish may span across multiple trophic levels in Wheeler Reservoir, modelling the trophic cascade was simplified to a single trophic level and a single species to avoid introducing additional uncertainties and purposefully overestimating the potential forage benefit. Specifically, the Rago (1984) model was used to estimate production foregone of a particular species due to fish entrained at any given life stage by integrating the instantaneous growth and mortality rates over the life stage *i* as follows:

$$P_i = \frac{G_i N_i W_i [\exp(G_i - Z_i) - 1]}{(G_i - Z_i)} \qquad \text{Equation 9}$$

where, P_i = production foregone (number of individuals) for age or life stage *i*,

G_i = instantaneous growth rate for individuals of age or life stage *i*,

Z_i = instantaneous total mortality rate for individuals of age or life stage *i*,

W_i = average weight of individuals at start of age or life stage *i*, and

N_i = number of individuals lost due to entrainment or impingement at age or life stage *i*.

While Equation 9 estimates the production foregone for the entrained life stage *i*, the equation may also be used to estimate production foregone at a later life stage *j* instead of *i* by accounting N_i for mortality from stage *i* to *j*. Therefore, production foregone at any future life stage *j*, for a fish entrained at life stage *i* ($P_{i,j}$) is equal to:

$$P_{i,j} = \frac{G_j N_i S_{i,j} W_j [\exp(G_j - Z_j) - 1]}{(G_j - Z_j)} \qquad \text{Equation 10}$$

where, S_{ij} = proportion of individuals that survive from entrained *i* to later stage *j*, and by analogy to Equation 8 is calculated as:

$$S_{i,j} = S_{\text{adj},i} \prod_{j=i+1}^{j-1} S_j \qquad \text{Equation 11}$$

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Analogous to the adjustment to survival fraction for the entrained life stage to account for individuals entrained at any age within the life stage (i.e., median age-at-entrainment) rather than assuming individuals were entrained at the beginning of the stage, Equation 12 is similarly adjusted to account for a median life-stage length over which production can occur:

$$P_i = \frac{G_i N_i W_i \left[\exp\left\{(g_i - z_i)\left(d_i - \widehat{d}_i\right)\right\} - 1\right]}{(G_i - Z_i)} \qquad \text{Equation 12}$$

where, P_i = production foregone for age or life stage i,

G_i = instantaneous growth rate for individuals of age or life stage i,

Z_i = instantaneous total mortality rate for individuals of age or life stage i,

d_i = duration (in days) of age or life stage i with $d_i/2$ equal to time interval between assumed median age-at-entrainment and end of the life stage,

$\widehat{d}_i$ = median age-at-death as $\widehat{d}_i = (\log_e 2 - \log_e(1 + e^{-z_i d_i}))/z_i$,

g_i = daily instantaneous growth rate for individuals of age or life stage i ($=G_i/d_i$),

z_i = daily instantaneous total mortality rate for individuals of age or life stage i ($=Z_i/d_i$),

W_i = average weight (kilograms) of individuals at start of age or life stage i, and

N_i = number of individuals lost due to entrainment (assuming 100% mortality) of age or life stage i.

The total production foregone (P_T) of all life stages entrained for a given species is then estimated by the adjusted Rago (1984) model as:

$$P_T = \sum_{i=i_{\min}}^{i_{\max}} \sum_{j=i}^{A_{\max}} P_{i,j} \qquad \text{Equation 13}$$

where, $P_{i,j}$ = P_i for entrained stage (i.e., $j=i$) as calculated by Equation 12 otherwise by Equation 10 for later stages,

$A_{\max}$ = theoretical maximum age,

$i_{\min}$ = the earliest entrained life stage, and

$i_{\max}$ = the oldest entrained life stages (i.e., number of life stages entrained).

The Rago (1984) model for production foregone estimates the biomass production lost but does not include biomass lost at time of entrainment that is not consumed by predators. To correct for this bias, the entrained biomass lost (B_L), as calculated by Equation 14 below, was added to the total production foregone estimate from Equation 13.

$$B_L = N_i \widehat{W}_i \qquad \text{Equation 14}$$

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where, B_L = direct biomass lost (in kilograms) of the number of individuals at entrained stage i (N_i), and

$\widehat{W}_i$ = median weight at stage i calculated as $W_i e^{g_i \hat{d}_i}$.

Herein, the adjusted total production foregone model estimate (P_F) is defined as

$$P_F = P_T + B_L \qquad \text{Equation 15}$$

To evaluate the reduction of economically valuable predators as a result of the foregone production that would be consumed, the P_F estimate for entrained forage species was then converted to predator biomass lost due to entrainment of forage species (B_P) by

$$B_P = (k)(P_F) \qquad \text{Equation 16}$$

where, k = trophic transfer efficiency of 0.1 (EPA 2004, 2006; EPRI 2012).

The forage biomass was assumed to be consumed by an Age-3 Blue Catfish with a total length (TL) of 290 mm and total weight (TW) of 214 grams based on total length-total weight and age-total length relationships of $Log_{10}(W, grams) = (3.21)(Log_{10}(TL, cm)) - 5.59$ and $144[1-e^{(0.48(age+1.749))}]$ (Orth et al. 2017). The equivalent number of Blue Catfish recruits that this predator biomass would produce was estimated as

$$N_P = (B_P)/(W_R) \qquad \text{Equation 17}$$

where, W_R = beginning weight (214 g) of Blue Catfish individuals at age of recruitment (R) to the fishery (age 3).

4.2.3 Direct Equivalent Fishery Yield

Traditionally, the equivalent fishery yield model estimates the reduction in harvest due to removal of economically valuable species at early life stages, also referred to as harvest foregone. The equivalent yield model proposed by EPA (2004) and EPRI (2012) to evaluate entrainment impacts is an application of a biomass dynamic pool or yield-per-recruit model used in fisheries science (Ricker 1975; Jennings et al. 2001). In this assessment, "*equivalent fishery yield*" is defined as the number of individuals that would have been expected to die from recreational fishing, either by harvest or post-release mortality, had the taxon not been entrained at an earlier life stage. The model was modified by removal of the biomass term to estimate number of fish instead of biomass because this was the input needed for monetarizing the value of recreational fishery species based on U.S. dollars per fish. When the equivalent fishery yield estimate is expressed as numbers of fish among all ages recruited to the recreational fishery for purposes of economic valuation, the value per fish is assumed equal among all ages (i.e., sizes).

Similar to the concept of equivalent adult loss estimation previously described, which often is used to evaluate adverse environmental impacts to a population as a whole, equivalent number of individuals at each age in the fishery lost to entrainment at life stage i is multiplied by age-

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specific exploitation rate (i.e., harvest or catch rate), and then summed over the species' life span in the fishery. Specifically, EPA (2004) and EPRI (2012) present the Thompson-Bell equilibrium yield model which combines the exponential decay equation ($N_t = N_0 e^{-Zt}$, where N_t is number after t years, N_0 is the starting number of individuals, and Z is as previously defined) and Baranov's catch equation (Catch = FA/Z, where A = 1-S, and F and S are as previously defined). Explicitly, equivalent fishery yield (Y, in numbers of fish) of a given species lost to the fishery due to entrainment was calculated as:

$$Y = \sum_{i=i_{\min}}^{i_{\max}} \sum_{j=R}^{A_{\max}} N_i S_{i,j} u_j \qquad \text{Equation 18}$$

where, N_i = number of individuals lost due to entrainment (assuming 100% mortality) of age or life stage i,

$S_{i,j}$ = fraction of fish expected to survive from entrained life stage i to future age j beginning with j equal to age of entry to the fishery (R) and similarly calculated by Equation 11 for $S_{i,j}$,

u_j = exploitation rate (i.e., so-called harvest rate) at age j (=($F_j A_j / Z_j$),

F_j = instantaneous fishing mortality rate for individuals at age j,

Z_j = instantaneous total mortality rate for individuals at age j,

A_j = actual total mortality at age j calculated as 1-exp(-Z_j),

$i_{\min}$ = the earliest entrained life stage,

$i_{\max}$ = the oldest entrained life stages (i.e., number of life stages entrained), and

$A_{\max}$ = maximum age.

4.2.4 Indirect Equivalent Fishery Yield from Total Production Forgone

Despite that some forage species such as Gizzard Shad could reach sizes that effectively eliminate themselves from predation, this assessment assumes the biomass from these larger forage fish would contribute directly or indirectly to Blue Catfish production and as a result may lead to an overestimate of forage benefits from entrainment reduction technologies.

The indirect equivalent fishery yield of Blue Catfish (or 'generic' predator) as a result of foregone production of forage species (Y_{PF}) was adapted from Equation 18 starting with the equivalent number of Blue Catfish recruits estimated by Equation 17.

4.2.5 Natural Mortality Biomass Loss of Recreational Fishery Species

A fraction of recreationally important fishery species can also provide indirect benefit as prey biomass or as forage to scavengers or intermediary, especially before they mature and enter the fishery. This indirect benefit was estimated as the biomass from the natural mortalities of recreationally important fishery species that would have resulted if the early life stage had not been entrained. The biomass, in kilograms, associated with natural mortality from the entrained stage i ($B_{M,i}$) and later stage j ($B_{M,j}$) for a particular recreational fishery species was assumed to serve as forage biomass by predation and was calculated as

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$$B_M = \sum_{i=i_{\min}}^{i_{\max}} \sum_{j=R}^{A_{\max}} N_i S_{i,j} \widehat{W}_i \frac{(1-S_j)M_j}{Z_j} \quad \text{Equation 19}$$

where, $\widehat{W}_i$ = median weight at life stage i as defined in Equation 14.

M_t instantaneous natural mortality rate for individuals of age j,

$i_{\max}$, $A_{\max}$, N_i, $S_{i,j}$, and Z_j as previously defined

The indirect (secondary) benefit of a fraction of recreational fishery species serving as forage to a predator is quantified by converting the total biomass associated with natural mortalities of fishery species from Equation 19 to predator biomass (B_P) by applying a 10% trophic transfer efficiency similar to Equation 16. The indirect equivalent fishery yield of Blue Catfish from B_P associated with natural mortality biomass was estimated following Equation 17.

4.2.6 Equivalent Number of Fish Caught

Typically, benefit valuations of changes in entrainment using equivalent fishery yield (harvest foregone) models assume the equivalent biomass, or in this case number of fish harvested, to be truly harvested and do not account for catch-and-release practices. In Wheeler Reservoir where fishing tournaments regularly take place, catch-and-release practices are popular among anglers with 62% to 83% of the catch being released based on Broadbent et al. (2016; Table 4-2). The equivalent fishery yield estimated here is really the equivalent number of fish that die from angling (i.e., equivalent fishery deaths), as a result of harvest (landings) and catch-and-release mortality. As such, the equivalent number of fish that would be caught by anglers (C) if entrainment were reduced at BFN Units 1, 2, and 3 combined was estimated by the following calculations:

$$Y = H + D_{CR} \quad \text{Equation 20}$$

where Y = total equivalent fishery yield estimate from direct and indirect equivalent fishery yield estimates summed,

H = equivalent number of fish harvested,

D_{CR} = equivalent number of deaths from catch and release.

H and D_{CR} can then be substituted with expressions of equivalent number caught based on the proportions of the catch harvested and released (P_H and P_{CR}) and catch-and-release mortality (F_{CR} expressed as a proportion). After substitution, Equation 20 becomes:

$$Y = P_H C + P_{CR} F_{CR} C \quad \text{Equation 21}$$

$$C = \frac{Y}{P_H + P_{CR} F_{CR}} \quad \text{Equation 22}$$

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where P_H and P_{CR} were based on the proportions of the catch harvested and released from the creel survey data for Blue Catfish, Channel Catfish, Sunfish, White Bass, Yellow Bass, Crappie and Sauger (Table 4-2) assuming these data are representative of the whole population for a typical year; and F_{CR} was based on percent catch-and-release mortality from the literature (Table 4-3). Some species did not have creel survey data to estimate catch-and-release and were assume to be 100% harvested.

4.3 Estimates of Biological Benefits

4.3.1 Equivalent Adult Estimates

While eggs and larvae can often be entrained in large numbers, the relative impact depends on their natural survivorship from an early life stage to adulthood. The incremental gains from entrainment mortality reductions of fish by each of the technologies can be expressed as age-1 equivalents or equivalent adults. For the existing CWIS, the taxa with the greatest equivalent adult losses were Threadfin Shad (1.3 million age-1 equivalents and equivalent adults based on the mean intake samples from 2018 and 2019), Mississippi Silverside (0.5 million age-1 equivalents and equivalent adults based on the mean intake samples from 2018 and 2019), Logperch and Sunfish *Lepomis* spp. (0.08 and 0.07 million age-1 equivalents and equivalent adults, respectively, based on the mean intake samples from 2018 and 2019; Table 4-4).

Under the CCRS and FMS scenarios, total age-1 equivalent gains were greatest for the CCRS using 2018 entrainment data, with the taxa most affected including Mississippi Silverside, Threadfin Shad, and Channel Catfish (Table 4-5). Based on the mean entrainment from both years of data, the CCRS resulted in 1.96 million age-1 equivalent gains compared to 0.37 million for the FMS (Table 4-5). Results for equivalent adults were similar, with the CCRS producing 1.89 million equivalent adults and the FMS producing 0.34 million (Table 4-6).

As previously mentioned, the additional spray wash required by the FMS equates to a 0.7% increase in water withdrawal, and therefore may result in higher entrainment mortality and negative age-1 and adult equivalent gains if impingement survival is less than 0.7%. The only taxon and life stage assuming survival below this value is Darter and Logperch larvae (0.3% impingement survival).

4.3.2 Production Foregone

Using the production foregone model, both CCRS and FMS scenarios were used to estimate the biomass of forage fish corresponding to the annual entrainment mortality reductions based on both years of the entrainment data and the two-year average. The production foregone estimates were again an order of magnitude higher for the CCRS, and the taxa producing the greatest impacts were Mississippi Silverside (5,666 kg for CCRS and 1,749 kg for FMS) and Gizzard Shad (3,599 kg for CCRS and 111 kg for FMS; Table 4-7).

4.3.3 Direct and Indirect Commercial and Recreational Fishery Benefits for CCRS

Estimates of mean annual unharvested recreational fish biomass corresponding to the annual entrainment mortality reductions if a CCRS or 0.5-mm FMS were installed at the existing cooling water intake structure was 20,811 kg for CCRS and 5,195 kg for FMS. White Bass

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represented the majority of unharvested recreational fish biomass with an annual mean of 14,453 kg for CCRS and 3,506 kg for FMS; Table 4-8).

The estimated number of equivalent age-3 Blue Catfish, equivalent age-3 Blue Catfish harvested, equivalent number of age-3 Blue Catfish caught and released, and equivalent age-3 Blue Catfish catch supported by the total production foregone of forage species from annual entrainment mortality reductions based on a CCRS was installed at the existing cooling water intake structure was highest for Mississippi Silverside and Gizzard Shad. Greater benefits were estimated for the 2018 entrainment data, but the two-year mean still indicated substantial benefits (Table 4-9). Under the FMS, Blue Catfish supported by the production foregone of forage species was less than for the CCRS for each of the four estimated metrics (Table 4-10).

Using forage biomass of unharvested fishery species, the estimated number of equivalent Age-3 Blue Catfish, equivalent Blue Catfish harvested, equivalent number of Blue Catfish caught and released, and equivalent Blue Catfish catch from annual entrainment mortality reductions were 11,014 fish if a CCRS was installed (Table 4-11) and 2,749 fish for a 0.5-mm FMS (Table 4-12). White Bass contributed the highest proportion to the total estimates for both CCRS and FMS.

Using a direct equivalent fishery yield model, equivalent number of fish harvested, equivalent number of catch-and-release encounters, and equivalent total catch was apportioned to fishery species present at BFN based on years of entrainment data and CCRS and FMS scenarios. The total equivalent fishery yield from annual entrainment reductions for the CCRS in 2018 was 27,331 fish, with the majority (19,757 fish) from Channel Catfish (Table 4-13). In 2019, the total value was 22,370 fish with the majority (10,433 fish) represented by White Bass (Table 4-13). Total equivalent catch values from annual entrainment reductions for both years of data and the mean for the CCRS were at least 52,750 fish, harvest was 20,006 fish in 2018 and 11,686 fish in 2019, and CRE was 35,340 fish in 2018 and 41,064 in 2019 (Table 4-13). For all years and scenarios, 2018 was dominated by Channel Catfish and 2019 was dominated by White Bass, with large amounts of *Lepomis* spp. also included in both years. Equivalent fishery yield from annual entrainment reductions for the FMS was lower in comparison to the CCRS, with 13,204 fish in 2018 and 5,469 fish in 2019 (Table 4-13). Very few *Lepomis* spp. made up the equivalent numbers in the FMS scenario, while Channel Catfish and White Bass were dominant in both years.

These same fishery categories were estimated using a natural mortality biomass model. In both 2018 (Table 4-14) and 2019 (Table 4-15), the CCRS resulted in much higher estimates of equivalent fisheries yield, harvest, caught-and-released and catch, and values were dominated by Channel Catfish, Blue Catfish, *Lepomis* spp., and White Bass. Overall estimates for all categories were higher based on 2018 entrainment data than based on 2019 data, and the mean of both years produced an estimated fishery yield from annual entrainment reductions of 35,397 fish for the CCRS and 11,589 fish for the FMS (Table 4-16).

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Table 4-1. Species importance, economic value categories, species models, and age of adult equivalence, age at first recruitment, and maximum age of species selected to model equivalent adult loss, equivalent fishery yield and production foregone as a result of annual entrainment at Browns Ferry Nuclear Plant.

Taxon	Species Importance[a]	State Game Fish [b]	Economic Value Category[c]	Life History Model	Age at Adulthood[d]	Age at First Recruitment[e]	Maximum Age[f]
Blue Catfish	Fishery	Game	P	Blue Catfish	4	3	25
Buffalofish *Ictiobus* spp.	Fishery	Non-Game	U*	Bigmouth Buffalo	3	1	20
Channel Catfish	Fishery	Game	P	Channel Catfish	4	1	12
Common Carp	Forage	Non-Game	N/A	Common Carp	2	—	16
Crappie *Pomoxis* spp.	Fishery	Game	P	White Crappie	2	2	7
Darter *Etheostoma* spp.	Forage	Non-Game	N/A	Tessellated Darter	1	—	4
Emerald Shiner	Forage	Non-Game	N/A	Emerald Shiner	1	—	2
Freshwater Drum	Fishery	Non-Game	U*	Freshwater Drum	4	2	40
Gizzard Shad	Forage	Non-Game	N/A	Gizzard Shad	1	—	7
Grass Carp	Forage	Non-Game	N/A	Grass Carp	2	—	16
Logperch	Forage	Non-Game	N/A	Logperch	1	—	4
Mississippi Silverside	Forage	Non-Game	N/A	Mississippi Silverside	1	—	2
Sauger	Fishery	Game	WP	Sauger	2	3	7
Shiner *Notropis* spp.	Forage	Non-Game	N/A	Emerald Shiner	1	—	2
Skipjack Herring	Forage	Non-Game	N/A	Skipjack Herring	2	—	4
Spotted Sucker	Forage	Non-Game	N/A	Spotted Sucker	1	—	9
Sunfish *Lepomis* spp.	Fishery	Game	P	Bluegill	2	3	7
Threadfin Shad	Forage	Non-Game	N/A	Threadfin Shad	1	—	2
Topminnow *Fundulus* spp.	Forage	Non-Game	N/A	Banded Killifish	1	—	4
Western Mosquitofish	Forage	Non-Game	N/A	Western Mosquitofish	1	—	4
White Bass	Fishery	Game	B	White Bass	2	2	5
Yellow Bass	Fishery	Game	B	Yellow Bass	1	2	8
Yellow Perch	Fishery	Game	P	Yellow Perch	2	3	7

(continued)

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Table 4-1. (continued)

Several changes were made in the ichthyoplankton data collected outside skimmer wall at Browns Ferry Nuclear Power Plant from February 2018 to January 2019 (Year 1) and February 2019 to December 2019 (Year 2) to adjust for standard taxonomic nomenclature. High level taxon identifications were apportioned to species or genus based on proportions in densities (see Section 4.2.2):

Unspecified Catostomid (Ictiobinae-Buffalo or Carpsucker) → Buffalofish *Ictiobus* spp.

Unspecified Centrarchid (*Pomoxis* spp.) → Crappie *Pomoxis* spp.

Unspecified Percids (*Etheostoma* spp.), Unspecified Percid (Darter but not Logperch) → Darter *Etheostoma* spp.

Unspecified Cyprinids (*N. atherinoides* group) → Emerald Shiner

Unspecified Percid (Logperch type) → Logperch

Unspecified Atherinopsid (Silverside), Unspecified Atherinopsid (Silversides) → Mississippi Silverside

Unspecified Cyprinids (*Pimephales* group), Unspecified Cyprinids (*Pimephales* spp.) → Shiner *Pimephales* spp.

Unspecified Centrarchid (*Lepomis* spp.) → Sunfish *Lepomis* spp.

Unspecified Fundulidae (Topminnow) → Topminnow *Fundulus* spp.

[a] Species Importance: Fishery importance as outlined in Alabama Wildlife and Freshwater Fisheries Regulations 2020-2021 (ADCNR 2020).

[b] Considered Game or Non-Game per Alabama Department of Conservation Natural Resources (ADCNR 2020).

[c] EPA 2014 (Table 1-26): B = Bass; P =Panfish; U = Unidentified; WP = Walleye and Pike; N/A = not applicable.

[d] See life history tables for citations on age at first recruitment to the recreational fishery (i.e., age first susceptible to angling gear) for individual species in Appendix 1.

[e] See life history tables for citations on age at first sexual maturity (i.e., earliest age of adulthood) for individual species in Appendix 1.

[f] See life history tables for citations on maximum age in Appendix 1.

[*] Willingness-to-pay ("WTP") for Buffalofish *Ictiobus* spp. and Freshwater Drum did not fit cleanly into one of the aggregate species groups and was assigned to the Unidentified economic value group (EPA 2006, Table A5-2 and Table G4-1)

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Table 4-2. Effort, number caught, harvested, and released by selected species based on the 10-year mean (2007–2016) creel surveys from two Tennessee reservoirs within the Tennessee River system (Chickamauga Reservoir and Watts Bar Reservoir) provided by TVA (Broadbent et al 2016).

Taxon	Effort (hrs)	Caught (N/hr)	Harvested (N/hr)	Harvested		Released		Caught	
				N	%	N	%	N	%
Buffalofish *Ictiobus* spp.[a]	-	-	-	-	-	-	-	-	-
Freshwater Drum[b]	-	-	-	-	-	-	-	-	-
Ictalurus spp.[c]	80,369	1.44	0.53	43,626	37	68,264	63	111,890	100
Lepomis spp.[d]	3,915	7.91	3.40	13,703	38	15,178	62	28,881	100
Morone spp.[e]	25,014	0.58	0.09	2,250	17	11,653	83	13,903	100
Pomoxis spp.[f]	59,518	2.13	0.97	58,497	46	71,169	54	129,667	100
Sauger[g]	6,154	1.17	0.30	2,086	31	6,327	69	8,413	100
Yellow Perch[h]	-	-	-	-	-	-	-	-	-

10-year mean creel data (2007 to 2016) for two Tennessee reservoirs within the Tennessee River system, Chickamauga Reservoir, and Watts Bar Reservoir.

No creel data available for Chickamauga Reservoir in 2013.

[a] Buffalofish *Ictiobus* spp. → No creel data were available. Non-Game species and fishery is assumed to be nearly non-existent in Wheeler Reservoir (ADCNR 2021).

[b] Freshwater Drum → No creel data were available. Non-Game species per ADCNR (2021) and often released as bycatch while anglers are attempting to catch other species (e.g., Channel Catfish and Walleye) that can be targeted with similar gear and tackle (Card and Hasler 2021). The fishery is assumed to be nearly non-existent in Wheeler Reservoir.

[c] *Ictalurus* spp. → all catfish and used as a surrogate for Blue Catfish and Channel Catfish.

[d] *Lepomis* spp. → all sunfish; 2013 and 2014 catch rate and harvest rate are based solely on Bluegill.

[e] *Morone* spp. → Striped Bass and used as surrogate for White Bass and Yellow Bass.

[f] *Pomoxis* spp. → all crappie

[g] Sauger → No creel data available for Watts Bar Reservoir in 2015 and Chickamauga Reservoir in 2016.

[h] Yellow Perch → No creel data were available. The fishery is assumed to be nearly non-existent in Wheeler Reservoir (ADCNR 2021).

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Table 4-3. Catch-and-release mortality estimates from Bartholomew and Bohnsack (2005) for recreationally important species entrained from a 2018–2019 entrainment characterization study at Browns Ferry Nuclear Plant.

Species	Percent Catch-and-Release Mortality
Blue Catfish	8
Buffalofish *Ictiobus* spp.[a]	21
Channel Catfish	18
Freshwater Drum[b]	31
Lepomis spp.[c]	30
Pomoxis spp.[d]	32
Sauger	5
White Bass[e]	26
Yellow Bass[e]	26
Yellow Perch	11

[a] Buffalofish *Ictiobus* spp. → average of all recreationally important species (Blue Catfish, Channel Catfish, Freshwater Drum, *Lepomis* spp., *Pomoxis* spp., Sauger, White Bass, Yellow Bass, and Yellow Perch)

[b] Freshwater Drum → Forty-eight total Freshwater Drum sampled with 33 non-critically hooked in mouth (Card and Hasler 2021)

[c] *Lepomis* spp. → Bluegill

[d] Average of Black Crappie (48%) and White Crappie (16%)

[e] Average for Striped Bass (16%, n= 35), White Bass (2%, n=1), and Yellow Bass (60%, n= 1)

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Table 4-4. Estimated age-1 and adult equivalent loss from annual entrainment mortality at the existing cooling water intake structure (CWIS) of Browns Ferry Nuclear Plant based on intake samples collected February 20, 2018, through December 19, 2019, and five-year (2016-2020) actual intake flow.

Taxon	Life Stage	Age-1 Equivalents			Equivalent Adults		
		2018	2019	Mean	2018	2019	Mean
Blue Catfish	Larvae	108		54	30		15
Buffalofish *Ictiobus* spp.	Larvae	137	236	187	75	130	102
Channel Catfish	Larvae	87,889	4,935	46,412	3,615	203	1,909
Common Carp	Larvae		13	7		8	4
Crappie *Pomoxis* spp.	Larvae	846	1,135	990	284	381	333
Darter *Etheostoma* spp.	Larvae	1,494	14,060	7,777	1,494	14,060	7,777
Emerald Shiner	Larvae	24,246	12,558	18,402	24,246	12,558	18,402
Freshwater Drum	Eggs	1,024	2,927	1,975	522	1,491	1,007
	Larvae	3,506	3,739	3,623	1,787	1,906	1,846
	All	4,530	6,666	5,598	2,309	3,397	2,853
Gizzard Shad	Eggs	61		30	61		30
	Larvae	39,524		19,762	39,524		19,762
	All	39,585		19,792	39,585		19,792
Grass Carp	Larvae	3		2	2		1
Logperch	Larvae	65,014	96,436	80,725	65,014	96,436	80,725
Mississippi Silverside	Eggs	208		104	208		104
	Larvae	865,391	141,246	503,318	865,391	141,246	503,318
	All	865,598	141,246	503,422	865,598	141,246	503,422
Sauger	Larvae	124	478	301	55	211	133
Shiner *Pimephales* spp.	Larvae	44,202	9,955	27,079	44,202	9,955	27,079
Skipjack Herring	Eggs		9	4		3	1
Spotted Sucker	Larvae	464	321	392	464	321	392
Sunfish *Lepomis* spp.	Larvae	91,559	52,803	72,181	91,559	52,803	72,181
Threadfin Shad	Eggs	1,561	63	812	1,561	63	812
	Larvae	943,827	1,586,750	1,265,288	943,827	1,586,750	1,265,288
	All	945,388	1,586,813	1,266,100	945,388	1,586,813	1,266,100
Topminnow *Fundulus* spp.	Larvae	37		18	37		18
Western Mosquitofish	Larvae	12,066		6,033	12,066		6,033
White Bass	Eggs	4		2	2		1
	Larvae	11,179	110,362	60,771	5,023	49,589	27,306
	All	11,183	110,362	60,773	5,025	49,589	27,307
Yellow Bass	Larvae	24		12	24		12
Yellow Perch	Larvae	1,010	6,863	3,936	303	2,060	1,182
Total	**All**	**2,195,507**	**2,044,890**	**2,120,198**	**2,101,374**	**1,970,175**	**2,035,775**

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Table 4-5. Estimated number of age-1 equivalents corresponding to the annual entrainment mortality reductions if a closed-cycle recirculating system (CCRS) or 0.5-mm fine mesh screens (FMS) were installed at the existing cooling water intake structure of Browns Ferry Nuclear Plant based on intake samples collected February 20, 2018 through December 19, 2019 and five-year (2016-2020) actual intake flow.

Taxon	Life Stage	Age-1 Equivalents					
		2018		2019		Mean	
		CCRS	FMS	CCRS	FMS	CCRS	FMS
Blue Catfish	Larvae	100	63			50	32
Buffalofish *Ictiobus* spp.	Larvae	127	59	218	102	172	81
Channel Catfish	Larvae	81,209	51,432	4,560	2,888	42,884	27,160
Common Carp	Larvae			12	3	6	2
Crappie *Pomoxis* spp.	Larvae	782	15	1,049	20	915	18
Darter *Etheostoma* spp.	Larvae	1,380	-7	12,992	-57	7,186	-32
Emerald Shiner	Larvae	22,403	8,717	11,604	4,517	17,004	6,617
Freshwater Drum	Eggs	946	766	2,704	2,190	1,825	1,478
	Larvae	3,240	429	3,455	457	3,347	443
	All	4,186	1,195	6,159	2,647	5,173	1,921
Gizzard Shad	Eggs	56	25			28	13
	Larvae	36,520	1,096			18,260	548
	All	36,576	1,121			18,288	560
Grass Carp	Larvae	3	1			1	<1
Logperch	Larvae	60,073	-295	89,107	-432	74,590	-363
Mississippi Silverside	Eggs	192	149			96	75
	Larvae	799,621	246,713	130,512	40,271	465,066	143,492
	All	799,813	246,862	130,512	40,271	465,162	143,567
Sauger	Larvae	114	22	442	86	278	54
Shiner *Pimephales* spp.	Larvae	40,843	15,898	9,198	3,581	25,021	9,739
Skipjack Herring	Eggs			8	4	4	2
Spotted Sucker	Larvae	429	200	296	139	363	170
Sunfish *Lepomis* spp.	Larvae	84,601	292	48,790	168	66,695	230
Threadfin Shad	Eggs	1,442	647	58	26	750	337
	Larvae	872,096	124,592	1,466,157	209,425	1,169,127	167,009
	All	873,538	125,239	1,466,215	209,451	1,169,877	167,345
Topminnow *Fundulus* spp.	Larvae	34	3			17	1
Western Mosquitofish	Larvae	11,149	1,072			5,575	536
White Bass	Eggs	4	3			2	1
	Larvae	10,329	2,506	101,975	24,735	56,152	13,620
	All	10,333	2,509	101,975	24,735	56,154	13,622
Yellow Bass	Larvae	22	5			11	3
Yellow Perch	Larvae	933	624	6,341	4,243	3,637	2,434
Total	**All**	**2,028,648**	**455,029**	**1,889,478**	**292,365**	**1,959,063**	**373,697**

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Table 4-6. Estimated number of equivalent adults corresponding to the annual entrainment mortality reductions if a closed-cycle recirculating system (CCRS) or 0.5-mm fine mesh screens (FMS) were installed at the existing cooling water intake structure of Browns Ferry Nuclear Plant based on intake samples collected February 20, 2018 through December 19, 2019 and five-year (2016-2020) actual intake flow.

Taxon	Life Stage	Equivalent Adults					
		2018		2019		Mean	
		CCRS	FMS	CCRS	FMS	CCRS	FMS
Blue Catfish	Larvae	27	17			14	9
Buffalofish *Ictiobus* spp.	Larvae	70	33	120	56	95	44
Channel Catfish	Larvae	3,341	2,116	188	119	1,764	1,117
Common Carp	Larvae			8	2	4	1
Crappie *Pomoxis* spp.	Larvae	262	5	352	7	307	6
Darter *Etheostoma* spp.	Larvae	1,380	-7	12,992	-57	7,186	-32
Emerald Shiner	Larvae	22,403	8,717	11,604	4,517	17,004	6,617
Freshwater Drum	Eggs	482	391	1,378	1,116	930	753
	Larvae	1,651	218	1,761	233	1,706	226
	All	2,133	609	3,139	1,349	2,636	979
Gizzard Shad	Eggs	56	25			28	13
	Larvae	36,520	1,096			18,260	548
	All	36,576	1,121			18,288	560
Grass Carp	Larvae	2	<1			1	<1
Logperch	Larvae	60,073	-295	89,107	-432	74,590	-363
Mississippi Silverside	Eggs	192	149			96	75
	Larvae	799,621	246,713	130,512	40,271	465,066	143,492
	All	799,813	246,862	130,512	40,271	465,162	143,567
Sauger	Larvae	50	10	195	38	123	24
Shiner *Pimephales* spp.	Larvae	40,843	15,898	9,198	3,581	25,021	9,739
Skipjack Herring	Eggs			2	1	1	1
Spotted Sucker	Larvae	429	200	296	139	363	170
Sunfish *Lepomis* spp.	Larvae	84,601	292	48,790	168	66,695	230
Threadfin Shad	Eggs	1,442	647	58	26	750	337
	Larvae	872,096	124,592	1,466,157	209,425	1,169,127	167,009
	All	873,538	125,239	1,466,215	209,451	1,169,877	167,345
Topminnow *Fundulus* spp.	Larvae	34	3			17	1
Western Mosquitofish	Larvae	11,149	1,072			5,575	536
White Bass	Eggs	2	1			1	1
	Larvae	4,641	1,126	45,820	11,114	25,231	6,120
	All	4,643	1,127	45,820	11,114	25,232	6,121
Yellow Bass	Larvae	22	5			11	3
Yellow Perch	Larvae	280	187	1,904	1,274	1,092	731
Total	**All**	**1,941,670**	**403,213**	**1,820,441**	**271,597**	**1,881,056**	**337,405**

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Table 4-7. Production foregone estimates, in kilograms (kg), of forage fish corresponding to the annual entrainment mortality reductions if a closed-cycle recirculating system (CCRS) or 0.5-mm fine mesh screens (FMS) were installed at the existing cooling water intake structure of Browns Ferry Nuclear Plant based on intake samples collected from February 20, 2018 through December 19, 2019 and five-year (2016-2020) actual intake flow.

Taxon	Life Stage	Production Foregone (kg)					
		2018		2019		Mean	
		CCRS	FMS	CCRS	FMS	CCRS	FMS
Common Carp	Larvae			78.82	19.76	39.41	9.88
Darter *Etheostoma* spp.	Larvae	6.68	-0.03	62.91	-0.27	34.80	-0.15
Emerald Shiner	Larvae	49.90	19.42	25.85	10.06	37.88	14.74
Gizzard Shad	Eggs	12.16	5.46			6.08	2.73
	Larvae	7,186.15	215.63			3,593.07	107.82
	All	7,198.31	221.09			3,599.15	110.54
Grass Carp	Larvae	18.69	4.69			9.35	2.34
Logperch	Larvae	805.95	-3.96	1,195.47	-5.79	1,000.71	-4.87
Mississippi Silverside	Eggs	2.55	1.98			1.28	0.99
	Larvae	9,739.94	3,005.14	1,589.72	490.53	5,664.83	1,747.83
	All	9,742.49	3,007.12	1,589.72	490.53	5,666.10	1,748.82
Shiner *Pimephales* spp.	Larvae	325.38	126.65	73.28	28.53	199.33	77.59
Skipjack Herring	Eggs			31.14	14.34	15.57	7.17
Spotted Sucker	Larvae	59.56	27.85	41.18	19.26	50.37	23.56
Threadfin Shad	Eggs	1.93	0.87	0.08	0.04	1.00	0.45
	Larvae	210.33	30.05	353.61	50.51	281.97	40.28
	All	212.26	30.92	353.69	50.54	282.97	40.73
Topminnow *Fundulus* spp.	Larvae	0.49	0.04			0.25	0.02
Western Mosquitofish	Larvae	13.20	1.27			6.60	0.63
Total	**All**	**18,432.92**	**3,435.06**	**3,452.05**	**626.95**	**10,942.49**	**2,031.00**

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Table 4-8. Biomass estimates, in kilograms (kg), of the unharvested recreational fish corresponding to the annual entrainment mortality reductions if a closed-cycle recirculating system (CCRS) or 0.5-mm fine mesh screens (FMS) were installed at the existing cooling water intake structure of Browns Ferry Nuclear Plant based on intake samples collected from February 20, 2018 through December 19, 2019 and five-year (2016-2020) actual intake flow.

Taxon and Life Stage		Unharvested Biomass (kg)					
		2018		2019		Mean	
		CCRS	FMS	CCRS	FMS	CCRS	FMS
Blue Catfish	Larvae	22	14			11	7
Buffalofish *Ictiobus* spp.	Larvae	465	217	799	373	632	295
Channel Catfish	Larvae	1,654	1,047	93	59	873	553
Crappie *Pomoxis* spp.	Larvae	31	1	41	1	36	1
Freshwater Drum	Eggs	351	285	1,004	813	678	549
	Larvae	1,069	141	1,140	151	1,104	146
	All	1,420	426	2,144	964	1,782	695
Sauger	Larvae	56	11	215	42	135	26
Sunfish *Lepomis* spp.	Larvae	3,470	12	2,001	7	2,735	9
White Bass	Eggs	1	1			1	<1
	Larvae	2,659	645	26,246	6,366	14,453	3,506
	All	2,660	646	26,246	6,366	14,453	3,506
Yellow Bass	Larvae	<1	<1			<1	<1
Yellow Perch	Larvae	39	26	267	179	153	103
Total	**All**	**9,816**	**2,400**	**31,806**	**7,991**	**20,811**	**5,195**

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Table 4-9. Estimated number of equivalent age-3 Blue Catfish (N), equivalent Blue Catfish harvested (H), equivalent number of Blue Catfish caught and released (CRE), and equivalent Blue Catfish catch (C) supported by total production foregone of forage species from annual entrainment mortality reductions if a closed-cycle recirculating system (CCRS) was installed at the existing cooling water intake structure of Browns Ferry Nuclear Plant based on intake samples collected from February 20, 2018 through December 19, 2019 and five-year (2016-2020) actual intake flow.

Taxon	Life Stage	2018				2019				Mean			
		N	H	CRE	C	N	H	CRE	C	N	H	CRE	C
Common Carp	Larvae					37	15	27	42	18	8	13	21
Darter *Etheostoma* spp.	Larvae	3	1	3	4	29	12	21	33	16	7	11	18
Emerald Shiner	Larvae	23	10	16	26	12	5	9	14	18	7	13	20
Gizzard Shad	Eggs	6	2	4	6					3	1	2	3
	Larvae	3,358	1,395	2,408	3,803					1,679	698	1,204	1,902
Grass Carp	Larvae	9	4	6	10					4	2	3	5
Logperch	Larvae	377	157	270	427	559	232	401	633	468	194	336	530
Mississippi Silverside	Eggs	1		1	1					1		1	1
	Larvae	4,551	1,891	3,264	5,155	743	309	532	841	2,647	1,100	1,898	2,998
Shiner *Pimephales* spp.	Larvae	152	63	109	172	34	14	25	39	93	39	66	105
Skipjack Herring	Eggs					15	6	10	16	7	3	5	8
Spotted Sucker	Larvae	28	12	20	32	19	8	14	22	24	10	17	27
Threadfin Shad	Eggs	1		1	1	<1				<1		1	1
	Larvae	98	41	70	111	165	69	118	187	132	55	94	149
Topminnow *Fundulus* spp.	Larvae	<1								<1			
Western Mosquitofish	Larvae	6	3	4	7					3	1	2	3
Total		**8,614**	**3,579**	**6,176**	**9,755**	**1,613**	**670**	**1,157**	**1,827**	**5,113**	**2,125**	**3,666**	**5,791**

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Table 4-10. Estimated number of equivalent Age-3 Blue Catfish (N), equivalent Blue Catfish harvested (H), equivalent number of Blue Catfish caught and released (CRE), and equivalent Blue Catfish catch (C) supported by total production foregone of forage species from annual entrainment mortality reductions if 0.5-mm fine mesh screens were installed at the existing cooling water intake structure of Browns Ferry Nuclear Plant based on intake samples collected from February 20, 2018 through December 19, 2019 and five-year (2016-2020) actual intake flow.

Taxon	Life Stage	2018				2019				Mean			
		N	H	CRE	C	N	H	CRE	C	N	H	CRE	C
Common Carp	Larvae					9	4	6	10	5	2	3	5
Darter *Etheostoma* spp.	Larvae	-0				-0				-0			
Emerald Shiner	Larvae	9	4	6	10	5	2	3	5	7	3	5	8
Gizzard Shad	Eggs	3	1	2	3					1		1	1
	Larvae	101	42	72	114					50	21	36	57
Grass Carp	Larvae	2	1	1	2					1		1	1
Logperch	Larvae	-2	-1	-1	-2	-3	-1	-2	-3	-2	-1	-2	-3
Mississippi Silverside	Eggs	1		1	1					<1		1	1
	Larvae	1,404	584	1,007	1,591	229	95	165	260	817	339	586	925
Shiner *Pimephales* spp.	Larvae	59	25	42	67	13	6	9	15	36	15	26	41
Skipjack Herring	Eggs					7	3	5	8	3	1	3	4
Spotted Sucker	Larvae	13	6	9	15	9	4	6	10	11	4	8	12
Threadfin Shad	Eggs	<1				<1				<1			
	Larvae	14	6	10	16	24	10	17	27	19	8	13	21
Topminnow *Fundulus* spp.	Larvae	<1								<1			
Western Mosquitofish	Larvae	1		1	1					<1			
Total		**1,605**	**668**	**1,150**	**1,818**	**293**	**123**	**209**	**332**	**949**	**392**	**681**	**1,073**

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Table 4-11. Estimated number of equivalent Age-3 Blue Catfish (N), equivalent Blue Catfish harvested (H), equivalent number of Blue Catfish caught and released (CRE), and equivalent Blue Catfish catch (C) supported by forage biomass of unharvested fishery species from annual entrainment mortality reductions if a closed-cycle recirculating system (CCRS) was installed at the existing cooling water intake structure of Browns Ferry Nuclear Plant based on intake samples collected from February 20, 2018 through December 19, 2019 and five-year (2016-2020) actual intake flow.

Taxon	Life Stage	2018				2019				Mean			
		N	H	CRE	C	N	H	CRE	C	N	H	CRE	C
Blue Catfish	Larvae	10	4	8	12					5	2	4	6
Buffalofish *Ictiobus* spp.	Larvae	217	90	156	246	373	155	268	423	295	123	211	334
Channel Catfish	Larvae	773	321	554	875	43	18	31	49	408	170	292	462
Crappie *Pomoxis* spp.	Larvae	14	6	10	16	19	8	14	22	17	7	12	19
Freshwater Drum	Eggs	164	68	118	186	469	195	336	531	317	132	227	359
	Larvae	499	208	358	566	533	221	382	603	516	214	370	584
Sauger	Larvae	26	11	18	29	100	42	72	114	63	26	46	72
Sunfish *Lepomis* spp.	Larvae	1,621	674	1,162	1,836	935	389	670	1,059	1,278	531	917	1,448
White Bass	Eggs	1		1	1					<1			
	Larvae	1,242	516	891	1,407	12,265	5,097	8,794	13,891	6,754	2,806	4,843	7,649
Yellow Bass	Larvae	<1								<1			
Yellow Perch	Larvae	18	8	13	21	125	52	90	142	72	30	51	81
Total		**4,587**	**1,906**	**3,289**	**5,195**	**14,863**	**6,177**	**10,657**	**16,834**	**9,725**	**4,041**	**6,973**	**11,014**

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Table 4-12. Estimated number of equivalent Age-3 Blue Catfish (N), equivalent Blue Catfish harvested (H), equivalent number of Blue Catfish caught and released (CRE), and equivalent Blue Catfish catch (C) supported by forage biomass of unharvested fishery species from annual entrainment mortality reductions if 0.5-mm fine mesh screens were installed at the existing cooling water intake structure of Browns Ferry Nuclear Plant based on intake samples collected from February 20, 2018 through December 19, 2019 and five-year (2016-2020) actual intake flow.

Taxon	Life Stage	2018				2019				Mean			
		N	H	CRE	C	N	H	CRE	C	N	H	CRE	C
Blue Catfish	Larvae	6	3	4	7					3	1	3	4
Buffalofish *Ictiobus* spp.	Larvae	101	42	73	115	174	73	125	198	138	57	99	156
Channel Catfish	Larvae	489	203	351	554	27	11	20	31	258	108	185	293
Crappie *Pomoxis* spp.	Larvae	<1				<1				<1			
Freshwater Drum	Eggs	133	55	96	151	380	158	272	430	256	107	184	291
	Larvae	66	28	47	75	70	29	51	80	68	28	49	77
Sauger	Larvae	5	2	4	6	19	8	14	22	12	5	9	14
Sunfish *Lepomis* spp.	Larvae	6	2	4	6	3	1	3	4	4	2	3	5
White Bass	Eggs	<1		1	1					<1			
	Larvae	301	125	216	341	2,975	1,236	2,133	3,369	1,638	681	1,174	1,855
Yellow Bass	Larvae	<1								<1			
Yellow Perch	Larvae	12	5	9	14	84	35	60	95	48	20	34	54
Total		**1,122**	**465**	**805**	**1,270**	**3,734**	**1,551**	**2,678**	**4,229**	**2,428**	**1,009**	**1,740**	**2,749**

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Table 4-13. Estimates of equivalent number harvested (H), equivalent number catch-and-release encounters (CRE), and equivalent total catch (C) apportioned to fishery species from a direct equivalent fishery yield (EFY) model of annual entrainment mortality reductions if a closed-cycle recirculating system (CCRS) or 0.5-mm fine mesh screens (FMS) were installed at Browns Ferry Nuclear Plant.

			CCRS				FMS			
Year	**Taxon**	**Life Stage**	**EFY**	**H**	**CRE**	**C**	**EFY**	**H**	**CRE**	**C**
2018	Blue Catfish	Larvae	21	19	32	51	13	12	20	32
	Buffalofish *Ictiobus* spp.	Larvae	63	63		63	30	30		30
	Channel Catfish	Larvae	19,757	15,074	26,012	41,086	12,512	9,547	16,474	26,021
	Crappie *Pomoxis* spp.	Larvae	103	75	87	162	2	1	2	3
	Freshwater Drum	Eggs	145	145		145	117	117		117
		Larvae	495	495		495	65	65		65
	Sauger	Larvae	6	5	12	17	1	1	2	3
	Sunfish *Lepomis* spp.	Larvae	4,984	3,330	5,514	8,844	17	12	19	31
	White Bass	Eggs	1		2	2	<1		1	1
		Larvae	1,709	754	3,673	4,427	415	183	891	1,074
	Yellow Bass	Larvae	4	2	8	10	1		2	2
	Yellow Perch	Larvae	44	44		44	30	30		30
	Total		**27,331**	**20,006**	**35,340**	**55,346**	**13,204**	**9,998**	**17,411**	**27,409**
2019	Blue Catfish	Larvae								
	Buffalofish *Ictiobus* spp.	Larvae	109	109		109	51	51		51
	Channel Catfish	Larvae	1,109	846	1,461	2,307	703	536	925	1,461
	Crappie *Pomoxis* spp.	Larvae	138	101	117	218	3	2	2	4
	Freshwater Drum	Eggs	413	413		413	334	334		334
		Larvae	528	528		528	70	70		70
	Sauger	Larvae	22	20	45	65	4	4	9	13
	Sunfish *Lepomis* spp.	Larvae	2,874	1,920	3,180	5,100	10	7	11	18
	White Bass	Eggs								
		Larvae	16,876	7,448	36,261	43,709	4,093	1,807	8,795	10,602
	Yellow Bass	Larvae								
	Yellow Perch	Larvae	301	301		301	201	201		201
	Total		**22,370**	**11,686**	**41,064**	**52,750**	**5,469**	**3,012**	**9,742**	**12,754**
Mean	Blue Catfish	Larvae	11	9	16	25	7	6	10	16
	Buffalofish *Ictiobus* spp.	Larvae	86	86		86	40	40		40
	Channel Catfish	Larvae	10,433	7,961	13,736	21,697	6,607	5,042	8,699	13,741
	Crappie *Pomoxis* spp.	Larvae	121	88	102	190	2	2	2	4
	Freshwater Drum	Eggs	279	279		279	226	226		226
		Larvae	511	511		511	68	68		68
	Sauger	Larvae	14	13	28	41	3	2	6	8
	Sunfish *Lepomis* spp.	Larvae	3,929	2,625	4,347	6,972	14	9	15	24
	White Bass	Eggs	<1		1	1	<1		1	1
		Larvae	9,293	4,101	19,967	24,068	2,254	995	4,843	5,838
	Yellow Bass	Larvae	2	1	4	5	<1		1	1
	Yellow Perch	Larvae	173	173		173	115	115		115
	Total		**24,851**	**15,847**	**38,201**	**54,048**	**9,337**	**6,505**	**13,577**	**20,082**

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Table 4-14. Estimates of equivalent number harvested (H), equivalent number catch-and-release encounters (CRE), and equivalent total catch (C) apportioned to fishery species from a direct equivalent direct fishery yield (EFY), production foregone (PF) and unharvested natural mortality biomass (NMB) model of annual entrainment mortality reductions if a closed-cycle recirculating system (CCRS) or 0.5-mm fine mesh screens (FMS) were installed at Browns Ferry Nuclear Plant based on 2018 entrainment density estimates.

Taxon	Model	CCRS				FMS			
		EFY	H	CRE	C	EFY	H	CRE	C
Blue Catfish	EFY	21	19	32	51	13	12	20	32
	PF	10,019	8,805	15,190	23,995	1,867	1,640	2,832	4,472
	NMB	2,169	1,906	3,289	5,195	530	465	805	1,270
	Total	**12,209**	**10,730**	**18,511**	**29,241**	**2,411**	**2,117**	**3,657**	**5,774**
Buffalofish *Ictiobus* spp.	EFY	63	63		63	30	30		30
Channel Catfish	EFY	19,757	15,074	26,012	41,086	12,512	9,547	16,474	26,021
Crappie *Pomoxis* spp.	EFY	103	75	87	162	2	1	2	3
Freshwater Drum	EFY	639	640		640	182	182		182
Sauger	EFY	6	5	12	17	1	1	2	3
Sunfish *Lepomis* spp.	EFY	4,984	3,330	5,514	8,844	17	12	19	31
White Bass	EFY	1,710	754	3,675	4,429	415	183	892	1,075
Yellow Bass	EFY	4	2	8	10	1		2	2
Yellow Perch	EFY	44	44		44	30	30		30
Total		**39,519**	**30,717**	**53,819**	**84,536**	**15,601**	**12,103**	**21,048**	**33,151**

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Table 4-15. Estimates of equivalent number harvested (H), equivalent number catch-and-release encounters (CRE), and equivalent total catch (C) apportioned to fishery species from a direct equivalent direct fishery yield (EFY), production foregone (PF) and unharvested natural mortality biomass (NMB) model of annual entrainment mortality reductions if a closed-cycle recirculating system (CCRS) or 0.5-mm fine mesh screens (FMS) were installed at Browns Ferry Nuclear Plant based on 2019 entrainment density estimates.

Taxon	Model	CCRS				FMS			
		EFY	H	CRE	C	EFY	H	CRE	C
Blue Catfish	EFY								
	PF	1,876	1,649	2,845	4,494	341	300	517	817
	NMB	7,029	6,177	10,657	16,834	1,766	1,551	2,678	4,229
	Total	**8,905**	**7,826**	**13,502**	**21,328**	**2,107**	**1,851**	**3,195**	**5,046**
Buffalofish *Ictiobus* spp.	EFY	109	109		109	51	51		51
Channel Catfish	EFY	1,109	846	1,461	2,307	703	536	925	1,461
Crappie *Pomoxis* spp.	EFY	138	101	117	218	3	2	2	4
Freshwater Drum	EFY	941	941		941	404	404		404
Sauger	EFY	22	20	45	65	4	4	9	13
Sunfish *Lepomis* spp.	EFY	2,874	1,920	3,180	5,100	10	7	11	18
White Bass	EFY	16,876	7,448	36,261	43,709	4,093	1,807	8,795	10,602
Yellow Bass	EFY								
Yellow Perch	EFY	301	301		301	201	201		201
Total		**31,275**	**19,512**	**54,566**	**74,078**	**7,576**	**4,863**	**12,937**	**17,800**

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Table 4-16. Estimates of equivalent number harvested (H), equivalent number catch-and-release encounters (CRE), and equivalent total catch (C) apportioned to fishery species from a direct equivalent direct fishery yield (EFY), production foregone (PF) and unharvested natural mortality biomass (NMB) model of annual entrainment mortality reductions if a closed-cycle recirculating system (CCRS) or 0.5-mm fine mesh screens (FMS) were installed at Browns Ferry Nuclear Plant based on average of two years (2018-2019) of entrainment density estimates.

Taxon	Model	CCRS				FMS			
		EFY	H	CRE	C	EFY	H	CRE	C
Blue Catfish	EFY	11	9	16	25	7	6	10	16
	PF	5,947	5,226	9,017	14,243	1,104	968	1,676	2,644
	NMB	4,599	4,041	6,973	11,014	1,148	1,009	1,740	2,749
	Total	**10,557**	**9,276**	**16,006**	**25,282**	**2,259**	**1,983**	**3,426**	**5,409**
Buffalofish *Ictiobus* spp.	EFY	86	86		86	40	40		40
Channel Catfish	EFY	10,433	7,961	13,736	21,697	6,607	5,042	8,699	13,741
Crappie *Pomoxis* spp.	EFY	121	88	102	190	2	2	2	4
Freshwater Drum	EFY	790	790		790	293	294		294
Sauger	EFY	14	13	28	41	3	2	6	8
Sunfish *Lepomis* spp.	EFY	3,929	2,625	4,347	6,972	14	9	15	24
White Bass	EFY	9,293	4,101	19,968	24,069	2,254	995	4,844	5,839
Yellow Bass	EFY	2	1	4	5	<1		1	1
Yellow Perch	EFY	173	173		173	115	115		115
Total		**35,397**	**25,114**	**54,191**	**79,305**	**11,589**	**8,482**	**16,993**	**25,475**

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5 Biological Basis of Non-Use Benefits Pursuant to §122.21(r)(11)(iii)–(vi)

5.1 Threatened and Endangered Species

If present, species listed by federal and state agencies as threatened and endangered under the protection of the federal Endangered Species Act and analogous state laws could potentially be affected by cooling water withdrawal at BFN and result in potential non-use benefits if entrainment reduction alternatives are implemented. Information on the threatened and endangered species potentially occurring within the BFN project area was provided in the summary to address §122.21(r)(9)(i)(b) and §122.21(r)(4)(vi) (TVA 2021a, 2021b). The state of Alabama does not have a law equivalent to the federal Endangered Species Act but provides ranks for species of concern.

Electrofishing and gill net data collected since 1993 in the vicinity of BFN has contained two species of concern that were observed once in the time series: Paddlefish (*Polyodon spathula*; identified as 'state protected') and Bigeye Chub (*Hybopsis amblops*; identified as 'state vulnerable'). Additionally, Silver Redhorse (*Moxostoma anisurum*), a fish ranked 'S2' or 'imperiled' by the state, was collected in 17 of 21 years of sampling, but did not occur in impingement or entrainment samples and is not expected to be impacted by cooling water withdrawal. The federally endangered fish species identified from the §122.21(r)(4)(vi) (2021b) are either known to be extirpated from Alabama or to occur only in habitat that is vastly different from that found in Wheeler Reservoir (i.e. in smaller creek systems, in riffle and riffle-run habitat, underground pools, limestone springs, etc.). No other rare, endangered, or threatened species are expected to occur near BFN (TVA 2021b).

For the species of concern that have been found in electrofishing and gill net samples at or near BFN, occurrence appears extremely rare, and it is therefore unlikely that significant non-use benefits would be associated with entrainment reduction. The absence of any identified threatened or endangered species in the ichthyoplankton and entrainment samples indicate no or negligible non-use benefits are expected from protecting threatened and endangered species by entrainment reduction technologies.

5.2 Long-lasting or Irreversible Effects on Species Populations

The age-1 equivalent and equivalent adult loss in recreationally important and forage species as a result of annual entrainment at BFN has not caused an apparent adverse impact to populations or the recreational fishery in the Wheeler Reservoir. While data estimating the local population size or recreational catch of Channel Catfish is unavailable for Wheeler Reservoir, two surrogate reservoirs on the Tennessee River were used to make comparisons for this iconic recreational fishery species. The Watts Bar and Chickamauga reservoirs, both 100 to 150 miles upriver in Tennessee, each had creel survey data available for *Ictalurus* spp. (Blue Catfish and Channel Catfish combined; Broadbent et al. 2016). The mean annual harvest for catfish at these two reservoirs based on creel surveys from 2007–2016 was 43,626 fish (range: 8,462 [Watts Bar 2013] to 113,308 [Chickamauga 2007]; Broadbent et al. 2016). Because one of these reservoirs is greater in size and one is smaller in size than Wheeler Reservoir, mean annual harvest from the two is a reasonable approximation for Wheeler. Using these data, the mean estimate for

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equivalent adult loss of 1,921 Blue Catfish and Channel Catfish combined (Table 4-4) from the current CWIS at Brown's Ferry represents 4.4% of the annual recreational harvest. The mean estimate of equivalent adult Blue and Channel Catfish gained from entrainment reduction technologies at BFN was 1,778 fish for a CCRS and 1,126 fish for an FMS (Table 4-5), which corresponds to approximately 4.1% and 2.6% of the creel survey estimate of annual recreational harvest, respectively. This provides evidence that equivalent adult loss estimates for these species are a very small percentage of the annual harvest that are not commensurate with causing long-lasting or irreversible effects, especially considering that the creel survey estimate of harvest is a conservative proxy for population size, and the population of these two species are expected to be at least an order of magnitude higher than annual harvest.

Additionally, according to the creel surveys at Chickamauga and Watts Bar from Broadbent et al. (2016), catch-and-release plays a large role in the fishery, with less than 40% of catfish kept. The equivalent adult estimate of Blue and Channel Catfish directly lost to entrainment mortality by the existing CWIS was approximately 1.7% of the creel survey estimate for annual catch. The gains in equivalent adult Blue and Channel Catfish from installing a CCRS and FMS were estimated to be approximately 1.6% and 1.0%, respectively.

Finally, the entrainment results from the 122.21(r)(9) included an estimate of entrainment of ichthyoplankton relative to available ichthyoplankton near BFN by sampling ichthyoplankton density across a bank-to-bank transect running perpendicular to river flow. Eggs and larvae entrained made up approximately 6.4% and 10.6%, respectively, of the estimated population of ichthyoplankton transported past the plant (TVA 2021a). This does not consider the segment of the population that spawns upstream of the plant and has become non-planktonic by the time they reach the plant or the segment downstream of the plant that is not susceptible to entrainment.

Considering the available data, the entrainment losses at BFN without implementing a CCRS or FMS would not cause irreversible or long-lasting impacts to the fish populations or the recreational fishery in the Wheeler Reservoir. Therefore, no significant effects on the sustainability of non-threatened and endangered species would be expected from implementing entrainment reduction technologies.

5.3 Mitigation Efforts

While specific mitigation efforts to reduce impingement and entrainment, or to enhance the recreational fishery in Wheeler Reservoir have not been undertaken prior to 2014, TVA is invested in a host of mitigation and natural resources management projects throughout the Southeast. Additionally, TVA conducts water quality and aquatic resource monitoring and assessment programs and develops plans for the protection and enhancement of water resources (TVA 1990).

5.4 Non-Fishery Benefits

Where possible, any non-fishery benefits to the environment and local communities that may accrue as a result from entrainment reductions as specified in 40 CFR §122.21(r)(11)(v) are briefly discussed here. While data and analyses on the complex food web dynamics at BFN are lacking, the estimated entrainment reductions from CCRS and FMS at BFN are not expected to

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lead to any significant indirect benefits due to improvements for mammals, birds, and other organisms and aquatic habitats. This assumption is likely to be valid at the regional scale of the river near BFN but localized on-site impacts on mammals and birds associated with the construction and operation of the CCRS and FMS are unknown.

5.5 Thermal Discharge Reduction Benefits

Where possible, any benefits expected to result from reductions in thermal discharges from entrainment technologies as specified in 40 CFR §122.21(r)(11)(vi) are briefly discussed here. The installation and operation of FMS do not significantly increase cooling water volume, reduce once-through cooling or ultimately reduce the expected spatial extent or magnitude of the thermal discharge at BFN. As such, no thermal discharge reduction benefits are expected from FMS at BFN. However, operation of a CCRS would expect to lead to a substantial reduction in spatial extent and magnitude of the thermal discharge. Based on the results from §316(a) thermal discharge studies (Baxter and Simmons 2008), the thermal discharge from the existing CWIS operations at BFN do not cause appreciable harm or adverse environment impacts; thus, reduction of the thermal discharge from operating a CCRS and FMS is not expected to lead to meaningful biological benefits. The finding that BFN's thermal discharge under existing CWIS operations is not causing appreciable harm was substantiated by BFN being granted a §316(a) variance in their NPDES Permit. Any potential benefit to fishing near the thermal discharge, especially during winter months, has not been quantified or studied, but based on the thermal discharge size and available habitat, the reduction in fishing activity near the thermal discharge if a CCRS was installed was assumed to be negligible.

6 Summary

This evaluation provides the non-monetized estimates of biological benefits of the existing CWIS, CCRS and 0.5-mm FMS at BFN in support of a Benefits Valuation Study to address the §122.21(r)(11) reporting requirements. The biological benefits of the CCRS and FMS were estimated without through-plant entrainment survival because no information was available to support survival calculations.

The biological benefits were estimated as the incremental changes in total numbers, equivalent adults, and harvest and equivalent catch (accounting for catch and release) of species from entrainment mortality reductions for each technology alternative. Harvest levels were quantified by direct equivalent fishery yield and indirect equivalent fishery yield of Blue Catfish (an iconic predator with recreational fishery importance in the Tennessee River). The indirect equivalent fishery yield was based on Blue Catfish that would produce (at 10% trophic transfer rate) by changes in forage biomass estimated from an adjusted total production model of forage species and forage biomass coming from the lifetime natural mortality of unharvested fishery species.

The key findings are provided below:

- Section 4 provides the methods and results for estimates of the total numbers and incremental changes in number of individual organisms lost to impingement mortality and entrainment mortality, pursuant to §122.21(r)(11)(i).
- Based on the 2016–2020 average monthly actual intake flow and two years of entrainment density data, the estimates of annual entrainment abundance of fish (number

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of individuals) at BFN's existing CWIS were 3.01 billion individuals based on 2018 data and 3.22 billion individuals based on 2019 data.

- With flow reductions if a CCRS was installed at BFN, entrainment mortality would reduce by about 92.4% (2.9 billion individuals), with no entrainment survival based on the two-year mean entrainment.
- Based on physical size exclusion and estimated literature-derived impingement survival of early life stages, the entrainment mortality reductions from 0.5-mm fine mesh screens were estimated to be 72% (2.2 billion individuals) based on the two-year mean entrainment.
- Assuming no through-plant entrainment survival, FMS would reduce entrainment mortality by 14.6% (456 million based on the two-year mean entrainment).
- Based on direct equivalent fishery yield of recreationally important fish using the two-year average entrainment data, the highest equivalent catch from annual entrainment mortality reductions with a CCRS at BFN were 24,069 White Bass, 21,697 Channel Catfish, and 6,972 Sunfish *Lepomis* spp.
- While direct fishery benefit in equivalent catch of Blue Catfish with a CCRS averaged 25 fish annually, the equivalent catch of Blue Catfish from gains in production of forage species was estimated to be 14,243 fish annually.
- An equivalent catch of 11,014 Blue Catfish was estimated to correspond to predator biomass supported by the natural mortality biomass from unharvested fishery species gained by annual entrainment mortality reductions by a CCRS.
- Based on direct equivalent fishery yield of recreationally important fish using the two-year average entrainment data, the highest equivalent catch from annual entrainment mortality reductions with a 0.5-mm FMS at BFN were 13,741 Channel Catfish, 5,839 White Bass, and 294 Freshwater Drum.
- While direct fishery benefit in equivalent catch of Blue Catfish with a 0.5-mm FMS averaged 16 fish annually, the equivalent catch of Blue Catfish from gains in production of forage species was estimated to be 2,644 fish annually.
- An equivalent catch of 2,749 Blue Catfish was estimated to correspond to predator biomass supported by the natural mortality biomass from unharvested fishery species gained by annual entrainment mortality reductions by 0.5-mm FMS.
- Negligible non-use benefits are expected from protecting threatened and endangered species by implementing a CCRS or 0.5-mm FMS at BFN.
- Entrainment losses at BFN without implementing a CCRS or 0.5-mm FMS would not cause irreversible or long-lasting impacts to the fish populations or cause an adverse impact to populations or the recreational fishery in the Wheeler Reservoir.

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Appendix 1. Life History Tables

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Appendix Table 1-1. Life history parameters for a Banded Killifish population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	1.040	0	0	1.040	0.353	0.522	8.44E-06	8	4.442	0	0.00	0.5	1,000,000	353,455	0
Larvae	7.700	0	0	7.700	0.000	0.001	7.17E-04	34	5.718	0	0.00	0.5	353,455	160	0
YOY	1.440	0	0	1.440	0.237	0.383	0.218	323	0.484	0	0.00	0.5	160	38	0
Age 1	1.354	0	0	1.354	0.258	0.411	0.354	365	1.223	38,206	1.00	0.5	38	10	724,525
Age 2	1.081	0	0	1.081	0.339	0.506	1.20	365	0.599	38,206	1.00	0.5	10	3	187,165
Age 3	0.938	0	0	0.938	0.391	0.563	2.19	365	0.431	38,206	1.00	0.5	3	1	63,468
Age 4	0.847	0	0	0.847	0.429	0.600	3.37	365	0.000	38,206	1.00	0.5	1	1	24,843

YOY= young of the year

[a] Egg and larval instantaneous mortality rates were based on Table D1-34 for Other Forage Species (EPA 2006). Natural mortality of Age 1 and older was based on estimated M at mid-age weight for ages 1-4 (Lorenzen 1996) which were scaled to the expected lifetime cumulative mortality for a fish with this maximum age (Hewitt and Hoenig 2005).

[b] There were no Age-specific fishing mortality parameters for these species according to EPA (2006).

[c] No Vulnerability to fishing assumed.

[d] Total instantaneous mortality Z = M+F.

[e] S_i = Probability of survival of stage *i* to the next stage = e^{-Z}

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Egg, larvae, and YOY (Juvenile) start weights were based on Table D1-34 (EPA 2006). Age-specific start weights were based on mean lengths and weight parameters according to Fritz and Garside (1975) (as cited in Abraham 1985).

[h] Stage duration of 8 days for Egg (Abraham 1985). Larval duration days was based Bay Anchovy according to the summed cumulative duration days for Prolarvae (2-day duration), Postlarvae 1 (11-day duration) and Post larvae 2 (21-day duration) according to Table 5-11 (EPRI 2012). YOY duration days was based on 365 days in a year minus Egg and Larvae duration.

[i] Growth rate (G) was estimated as Loge (Wi+1/Wi) (EPRI 2012).

[j] Mean fecundity for Ages 1-4 was based on Bay Anchovy fecundity according to Table 5-10 (EPRI 2012).

k Proportion at age that are sexually mature (Abraham 1985).

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Appendix Table 1-2. Life history parameters for a Bigmouth Buffalo population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=2Se$^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	2.010	0.000	0.00	2.010	0.134	0.236	0.00180	10	0.000	0	0.00	0.50	1,000,000	133,989	0
Larvae	0.804	0.000	0.00	0.804	0.448	0.618	0.00180	40	3.262	0	0.00	0.50	133,989	59,965	0
YOY	9.931	0.000	0.00	9.931	0.000	0.000	0.05	315	7.118	0	0.00	0.50	59,965	3	0
Age 1	0.150	0.150	1.00	0.300	0.741	0.851	58	365	1.812	0	0.00	0.50	3	2	0
Age 2	0.150	0.150	1.00	0.300	0.741	0.851	355	365	0.822	0	0.00	0.50	2	2	0
Age 3	0.150	0.150	1.00	0.300	0.741	0.851	808	365	0.545	80,834	1.00	0.50	2	1	64,732
Age 4	0.150	0.150	1.00	0.300	0.741	0.851	1,393	365	0.401	139,286	1.00	0.50	1	1	82,631
Age 5	0.150	0.150	1.00	0.300	0.741	0.851	2,081	365	0.346	208,053	1.00	0.50	1	1	91,437
Age 6	0.150	0.150	1.00	0.300	0.741	0.851	2,940	365	0.269	294,050	1.00	0.50	1	0	95,737
Age 7	0.150	0.150	1.00	0.300	0.741	0.851	3,847	365	0.338	384,669	1.00	0.50	0	0	92,781
Age 8	0.150	0.150	1.00	0.300	0.741	0.851	5,394	365	0.111	539,410	1.00	0.50	0	0	96,384
Age 9	0.150	0.150	1.00	0.300	0.741	0.851	6,026	365	0.170	602,641	1.00	0.50	0	0	79,773
Age 10	0.150	0.150	1.00	0.300	0.741	0.851	7,145	365	0.292	714,470	1.00	0.50	0	0	70,063
Age 11	0.150	0.150	1.00	0.300	0.741	0.851	9,572	365	0.248	957,211	1.00	0.50	0	0	69,539
Age 12	0.150	0.150	1.00	0.300	0.741	0.851	12,265	365	0.035	1,226,512	1.00	0.50	0	0	66,009
Age 13	0.150	0.150	1.00	0.300	0.741	0.851	12,700	365	0.034	1,269,955	1.00	0.50	0	0	50,633
Age 14	0.150	0.150	1.00	0.300	0.741	0.851	13,144	365	0.034	1,314,438	1.00	0.50	0	0	38,823
Age 15	0.150	0.150	1.00	0.300	0.741	0.851	13,600	365	0.034	1,359,975	1.00	0.50	0	0	29,757
Age 16	0.150	0.150	1.00	0.300	0.741	0.851	14,066	365	0.033	1,406,580	1.00	0.50	0	0	22,800
Age 17	0.150	0.150	1.00	0.300	0.741	0.851	14,543	365	0.033	1,454,265	1.00	0.50	0	0	17,464
Age 18	0.150	0.150	1.00	0.300	0.741	0.851	15,030	365	0.033	1,503,045	1.00	0.50	0	0	13,371
Age 19	0.150	0.150	1.00	0.300	0.741	0.851	15,529	365	0.032	1,552,932	1.00	0.50	0	0	10,234
Age 20	0.150	0.150	1.00	0.300	0.741	0.851	16,039	365	0.000	1,603,940	1.00	0.50	0	0	7,831

YOY= young of the year

[a] Egg and Larvae instantaneous mortality rate was based on apportioning the cumulative mortality in EPRI (2012) based on Table 5-104. YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs, larvae, and Ages 1-2 from the total mortality from egg to Age 20 = 2/ *f*a where *f*a =lifetime average fecundity. Age 1 to Age 20 instantaneous mortality was based on Table 5-103 (EPRI 2012).

[b] Age-specific fishing mortality of Age 1 and older was based on Table 5-103 (EPRI 2012).

[c] Fraction vulnerable to fishing based on Table 5-103 (EPRI 2012).

[d] Total instantaneous mortality Z = M+F

[e] S_i = Probability of survival of stage *i* to the next stage = e^{-Z}

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Egg and larval start weights were based on figures used by EPRI (2012) for combined eggs and larvae. YOY start weight was based on the juvenile start weight used by EPRI (2012).

Age-specific start weights was based on growth and mortality parameters for this species used by EPRI (2012) table 5-104.

[h] Stage duration was based on EPRI (2012) table 5-104 with larvae duration based on the cumulative days of yolk-sac larvae (YSL) (4-day duration) and post yolk-sac larvae (PYSL; 36-day duration). YOY duration days was based on the cumulative days of juvenile fish (315-day duration) according to EPRI (2012).

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ (EPRI 2012).

[j] Mean fecundity for Ages 3-20 based on EPRI (2012) Table 5-104.

[k] Proportion at age that are sexually mature based on EPRI (2012) Table 5-104.

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Appendix Table 1-3. Life history parameters for a Blue Catfish population at equilibrium.

Stage	i	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	Ni	Ni+1	Eggs Produced
Egg	1	0.520	0.000	0.00	0.520	0.595	0.746	0.002	8	0.000	0	0.00	0.5	1,000,000	594,521	0
Larvae	2	1.495	0.000	0.00	1.495	0.224	0.366	0.002	23	3.298	0	0.00	0.5	594,521	133,320	0
YOY	3	5.744	0.000	0.00	5.744	0.003	0.006	0.046	334	5.351	0	0.00	0.5	133,320	427	0
Age 1	4	0.445	0.000	0.00	0.445	0.641	0.781	10	365	2.412	0	0.00	0.5	427	274	0
Age 2	5	0.358	0.000	0.00	0.358	0.699	0.823	108	365	0.685	0	0.00	0.5	274	191	0
Age 3	6	0.302	0.193	1.00	0.495	0.610	0.757	214	365	0.540	0	0.00	0.5	191	117	0
Age 4	7	0.263	0.232	1.00	0.495	0.610	0.757	368	365	0.442	2,471	1.00	0.5	117	71	144,118
Age 5	8	0.234	0.261	1.00	0.495	0.610	0.757	572	365	0.371	3,843	1.00	0.5	71	43	136,622
Age 6	9	0.212	0.283	1.00	0.495	0.610	0.757	829	365	0.318	5,568	1.00	0.5	43	26	120,683
Age 7	10	0.195	0.300	1.00	0.495	0.610	0.757	1,138	365	0.276	7,650	1.00	0.5	26	16	101,070
Age 8	11	0.181	0.314	1.00	0.495	0.610	0.757	1,500	365	0.243	10,082	1.00	0.5	16	10	81,195
Age 9	12	0.170	0.325	1.00	0.495	0.610	0.757	1,913	365	0.215	12,852	1.00	0.5	10	6	63,090
Age 10	13	0.160	0.335	1.00	0.495	0.610	0.757	2,372	365	0.193	15,941	1.00	0.5	6	4	47,701
Age 11	14	0.152	0.066	1.00	0.218	0.804	0.891	2,876	365	0.173	19,328	1.00	0.5	4	3	35,256
Age 12	15	0.145	0.073	1.00	0.218	0.804	0.891	3,421	365	0.157	22,989	1.00	0.5	3	2	33,720
Age 13	16	0.139	0.079	1.00	0.218	0.804	0.891	4,003	365	0.143	26,899	1.00	0.5	2	2	31,726
Age 14	17	0.133	0.085	1.00	0.218	0.804	0.891	4,618	365	0.130	31,029	1.00	0.5	2	2	29,430
Age 15	18	0.129	0.089	1.00	0.218	0.804	0.891	5,261	365	0.120	35,354	1.00	0.5	2	1	26,964
Age 16	19	0.125	0.093	1.00	0.218	0.804	0.891	5,930	365	0.110	39,847	1.00	0.5	1	1	24,437
Age 17	20	0.121	0.097	1.00	0.218	0.804	0.891	6,619	365	0.101	44,481	1.00	0.5	1	1	21,936
Age 18	21	0.118	0.100	1.00	0.218	0.804	0.891	7,326	365	0.094	49,230	1.00	0.5	1	1	19,523
Age 19	22	0.115	0.103	1.00	0.218	0.804	0.891	8,047	365	0.087	54,072	1.00	0.5	1	1	17,243
Age 20	23	0.112	0.106	1.00	0.218	0.804	0.891	8,777	365	0.081	58,983	1.00	0.5	1	0	15,125
Age 21	24	0.109	0.109	1.00	0.218	0.804	0.891	9,515	365	0.075	63,941	1.00	0.5	0	0	13,184
Age 22	25	0.107	0.111	1.00	0.218	0.804	0.891	10,257	365	0.070	68,927	1.00	0.5	0	0	11,429
Age 23	26	0.105	0.113	1.00	0.218	0.804	0.891	11,001	365	0.065	73,923	1.00	0.5	0	0	9,856
Age 24	27	0.103	0.115	1.00	0.218	0.804	0.891	11,743	365	0.061	78,912	1.00	0.5	0	0	8,460
Age 25	28	0.101	0.117	1.00	0.218	0.804	0.891	12,482	365	0.000	83,878	1.00	0.5	0	0	7,231

(continued)

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Appendix Table 1-3. (continued)

YOY= young of the year

[a] Egg and larval instantaneous mortality rate was based on apportioning the cumulative mortality of the egg/larvae stages (2.01 for Channel Catfish) in EPRI (2012) based on 8-day time to hatch (Small and Bates 2001) and a 31-day duration from egg to YOY (Channel Catfish, EPRI 2012). YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs, larvae, and Ages 1-3 from the total mortality from egg to Age 25 = 2/ *f*a where *f*a =lifetime average fecundity. Hewitt and Hoenig (2005) constant M estimates were used to scale the Lorenzen (1996) estimated M at mid-age weight for ages 1-25.

[b] Age-specific fishing mortality was estimated as Z-M where Z was the catch curve estimate of 0.495 for Age 3-10 and 0.218 for Ages 11-25 based on Holley et al. (2009).

[c] Fraction vulnerable to fishing based on recruitment to the fishery at Age 3 (Holley et al. 2009)

[d] Total instantaneous mortality Z = M+F

[e] S_i = Probability of survival of stage *i* to the next stage = e^{-Z}

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Egg, larval, and YOY start weights were based on Channel Catfish according to Table 5-78 for combined eggs and larvae (EPRI 2012). YOY start weight was based on Channel Catfish for the juvenile start weight according to Table 5-37 (EPRI 2012). Start weights for ages 1-25 were calculated as lengths (Orth *et al*. 2017) and converted to weights (Stewart *et al*. 2009).

[h] Stage duration was based on EPRI (2012) of 31 days for both Eggs and larvae combined with (Small and Bates 2001) 8 day time to hatch resulting in egg s (8-day duration) and larvae (23-day duration). YOY duration days was based on the cumulative days of juvenile fish (334-day duration) according to EPRI (2012).

[i] Growth rate (G) was estimated as $Log_e(W_{i+1}/W_i)$ (EPRI 2012)

[j] Mean fecundity was based on 7,500 eggs/kg (EPRI 2012).

[k] Proportion at age that are sexually mature based on Channel Catfish from Table 5-37 (EPRI 2012).

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Appendix Table 1-4. Life history parameters for a Bluegill population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	0.044	0.000	0.00	0.04	0.957	0.978	0.00094	2	0.000	0	0.000	0.50	1,000,000	956,763	0
Larvae	2.338	0.000	0.00	2.34	0.097	0.176	0.00094	28	4.173	0	0.000	0.50	956,763	92,347	0
YOY	4.875	0.000	0.00	4.87	0.008	0.015	0.06120	335	4.442	0	0.000	0.50	92,347	705	0
Age 1	1.264	0.000	0.00	1.26	0.282	0.441	5	365	1.907	671	0.000	0.50	705	199	0
Age 2	0.918	0.223	1.00	1.14	0.319	0.484	35	365	0.914	3,818	1.000	0.50	199	64	380,326
Age 3	0.758	0.223	1.00	0.98	0.375	0.545	87	365	0.541	8,634	1.000	0.50	64	24	274,773
Age 4	0.671	0.223	1.00	0.89	0.409	0.580	150	365	0.350	14,322	1.000	0.50	24	10	170,797
Age 5	0.618	0.223	1.00	0.84	0.431	0.603	213	365	0.238	19,636	1.000	0.50	10	4	95,751
Age 6	0.583	0.223	1.00	0.81	0.446	0.617	270	365	0.167	24,548	1.000	0.50	4	2	51,612
Age 7	0.557	0.223	1.00	0.78	0.458	0.629	319	365	0.000	28,503	1.000	0.50	2	1	26,742

YOY= young of the year

[a] Instantaneous mortality rates were based on an literature-derived values: EPRI (2012, Table 5-121) for egg stage and Partridge and DeVries (1999) for larvae. YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs and larvae from the total mortality from egg to Age 7 = 2/ *f*a where *f*a =lifetime average fecundity. Age 1 and older mortality rates was based on Lorenzen (1996) relation with mid-age weight for ages 1-7.

[b] Age-specific fishing derived from Crawford and Allen (2006) catch-curve and tag-recapture studies in Florida lake.

[c] Vulnerability to fishing inferred from Crawford and Allen (2006) observation of near-constant exploitation larger than 13cm and this size representative of age 2 (Jackson et *al.* 2008).

[d] Total instantaneous mortality Z = -ln(S).

[e] S_i = Probability of survival of stage *i* to the next stage accounting for vulnerability associated mortality.

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Start weights for based multiple studies reviewed in EPRI (2012, Table 5-123).

[h] Stage duration (days) was based on EPRI (2012, Table 5-123).

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ where W_i is the weight at start of stage *i*.

[j] Mean fecundity calculated from length-at-age using Panek and Cofield (1978) length-fecundity relation.

[k] Maturity taken from EPRI (2012, Table 5-123).

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Appendix Table 1-5. Life history parameters for a Channel Catfish population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	0.520	0.000	0.00	0.520	0.595	0.746	1.70E-03	8	0.000	0	0.00	0.50	1,000,000	594,521	0
Larvae	1.495	0.000	0.00	1.495	0.224	0.366	1.70E-03	23	3.298	0	0.00	0.50	594,521	133,320	0
YOY	1.924	0.000	0.00	1.924	0.146	0.255	4.60E-02	334	3.341	0	0.00	0.50	133,320	19,459	0
Age 1	1.028	0.410	0.50	1.212	0.298	0.459	1.30	365	2.748	0	0.00	0.50	19,459	5,792	0
Age 2	0.664	0.410	1.00	1.074	0.341	0.509	20	365	1.345	0	0.00	0.50	5,792	1,978	0
Age 3	0.495	0.410	1.00	0.905	0.405	0.576	78	365	0.921	0	0.00	0.50	1,978	800	0
Age 4	0.395	0.410	1.00	0.805	0.447	0.618	196	365	0.714	859	1.00	0.50	800	358	343,802
Age 5	0.331	0.410	1.00	0.741	0.477	0.645	400	365	0.563	1,214	1.00	0.50	358	170	217,137
Age 6	0.284	0.410	1.00	0.694	0.500	0.666	701	365	0.525	1,743	1.00	0.50	170	85	148,557
Age 7	0.251	0.410	1.00	0.661	0.516	0.681	1186	365	0.358	2,134	1.00	0.50	85	44	90,899
Age 8	0.222	0.410	1.00	0.632	0.532	0.694	1697	365	0.473	2,847	1.00	0.50	44	23	62,614
Age 9	0.197	0.410	1.00	0.607	0.545	0.706	2725	365	0.376	3,478	1.00	0.50	23	13	40,660
Age 10	0.190	0.410	1.00	0.600	0.549	0.709	3968	365	0.000	4,481	1.00	0.50	13	7	28,550
Age 11	0.185	0.410	1.00	0.595	0.552	0.711	3595	365	0.284	11,190	1.00	0.50	7	4	39,122
Age 12	0.172	0.410	1.00	0.582	0.559	0.717	4774	365	0.000	14,858	1.00	0.50	4	2	28,660

YOY= young of the year

[a] Egg and larval instantaneous mortality rate was based on apportioning the cumulative mortality of egg/larvae (2.01) in EPRI (2012) based on 8-day time to hatch (Small and Bates 2001) and a 31-day duration from egg to YOY (EPRI 2012). YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs, larvae, and Ages 1-3 from the total mortality from egg to Age 12 = 2/ *f*a where *f*a =lifetime average fecundity. Natural mortality of Age 1 and older based cumulative mortality scaled relation of mortality with mid-stage weight (Lorenzen 1996, Hewitt and Hoenig 2005).

[b] Age-specific fishing mortality of Age 1 and older was based on table F1-12 (EPA 2006).

[c] Fraction vulnerable to fishing based on table F1-12 (EPA 2006).

[d] Total instantaneous mortality Z = M+F

[e] S_i = Probability of survival of stage *i* to the next stage = e^{-Z}

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Egg and larval start weights were based on figures used by EPRI (2012) for combined eggs and larvae. YOY start weight was based on the juvenile start weight used by EPRI (2012). Age-specific start weights was based on growth and mortality parameters for this species used by EPRI (2012) for channel catfish from the Mississippi River.

[h] Stage duration was based on EPRI (2012) of 31 days for both Eggs and larvae combined with (Small and Bates 2001) 8-day time to hatch resulting in egg s (8-day duration) and larvae (23-day duration). YOY duration days was based on the cumulative days of juvenile fish (334-day duration) according to EPRI (2012).

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ (EPRI 2012).

[j] Mean fecundity for Ages 4-12 based on EPRI (2012).

[k] Proportion at age that are sexually mature based on EPRI (2012).

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Appendix Table 1-6. Life history parameters for a Common Carp population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	1.900	0.000	0.00	1.90	0.150	0.260	0.0018	6	0.000	0	0.000	0.50	1,000,000	149,569	0
Larvae	4.610	0.000	0.00	4.61	0.010	0.020	0.0018	44	3.241	0	0.000	0.50	149,569	1,488	0
YOY	6.280	0.000	0.00	6.28	0.002	0.004	0.0465	315	9.737	0	0.000	0.50	1,488	3	0
Age 1	0.47	0.000	0.00	0.47	0.625	0.769	787	365	0.779	0	0.000	0.50	3	2	0
Age 2	0.36	0.000	0.00	0.36	0.698	0.822	1,715	365	0.541	367,000	0.250	0.50	2	1	79,986
Age 3	0.30	0.000	0.00	0.30	0.741	0.851	2,947	365	0.402	367,000	0.500	0.50	1	1	111,609
Age 4	0.26	0.000	0.00	0.26	0.771	0.871	4,403	365	0.310	367,000	1.000	0.50	1	1	165,364
Age 5	0.23	0.000	0.00	0.23	0.795	0.886	6,003	365	0.246	367,000	1.000	0.50	1	1	127,504
Age 6	0.21	0.000	0.00	0.21	0.811	0.895	7,677	365	0.199	367,000	1.000	0.50	1	0	101,306
Age 7	0.20	0.000	0.00	0.20	0.819	0.900	9,367	365	0.163	367,000	1.000	0.50	0	0	82,117
Age 8	0.19	0.000	0.00	0.19	0.827	0.905	11,027	365	0.135	367,000	1.000	0.50	0	0	67,232
Age 9	0.18	0.000	0.00	0.18	0.835	0.910	12,625	365	0.113	367,000	1.000	0.50	0	0	55,598
Age 10	0.17	0.000	0.00	0.17	0.844	0.915	14,138	365	0.095	367,000	1.000	0.50	0	0	46,439
Age 11	0.17	0.000	0.00	0.17	0.844	0.915	15,554	365	0.081	367,000	1.000	0.50	0	0	39,179
Age 12	0.16	0.000	0.00	0.16	0.852	0.920	16,863	365	0.069	367,000	1.000	0.50	0	0	33,054
Age 13	0.16	0.000	0.00	0.16	0.852	0.920	18,065	365	0.059	367,000	1.000	0.50	0	0	28,167
Age 14	0.15	0.000	0.00	0.15	0.861	0.925	19,159	365	0.050	367,000	1.000	0.50	0	0	24,002
Age 15	0.15	0.000	0.00	0.15	0.861	0.925	20,149	365	0.043	367,000	1.000	0.50	0	0	20,659
Age 16	0.15	0.000	0.00	0.15	0.861	0.925	21,041	365	0.000	367,000	1.000	0.50	0	0	17,781

YOY= young of the year

[a] Egg and larval mortality from EPA 2006 Table G1-9, YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs and larvae from the total mortality from egg to Age 16 = 2/ *f*a where *f*a =lifetime average fecundity. Ages 1 and older mortality from Stich et al 2013

[b] Age-specific fishing mortality was assumed to be zero (forage species).

[c] Vulnerability to fishing assumed zero.

[d] Total instantaneous mortality Z = -ln(S).

[e] S_i = Probability of survival of stage *i* to the next stage accounting for vulnerability associated mortality.

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Start weights for based on Victor and Brothers (1982) growth of Fallfish in length and length-weight conversion.

[h] Stage duration (days) was based on EPRI (2012) for eggs (Yellow Perch), Mukhaysin and Jawad (2012) for *Barbus sharpeyi* larval duration.

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ where W_i is the weight at start of stage i.

[j] Fecundity Shireman and Smith 1983 for USA average fecundity.

[k] Maturity from Trial et *al.* (1983), 'some Fallfish reach maturity at age 2 or three and all by age 4.

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Appendix Table 1-7. Life history parameters for an Emerald Shiner population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	0.183	0.000	0.00	0.18	0.833	0.909	0.002	3	0.000	0	0.000	0.50	1,000,000	832,768	0
Larvae	2.562	0.000	0.00	2.56	0.077	0.143	0.002	42	3.241	0	0.000	0.50	832,768	64,248	0
YOY	3.966	0.000	0.00	3.97	0.019	0.037	0.047	320	2.666	0	0.000	0.50	64,248	1,218	0
Age 1	2.356	0.000	0.00	2.36	0.095	0.173	0.669	365	1.515	1,500	1.000	0.50	1,218	115	913,384
Age 2	1.918	0.000	0.00	1.92	0.147	0.256	3.043	365	0.000	1,500	1.000	0.50	115	17	86,616

YOY= young of the year

[a] Instantaneous mortality rates were based on population dynamics of Emerald Shiner but limited to maximum age of about 2 years (Finger 2001) and using the scaled Lorenzen estimate (Lorenzen 1996; Hewitt and Hoenig 2005). YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs and larvae from the total mortality from egg to Age 2= 2/ *f*a where *f*a =lifetime average fecundity.

[b] No age-specific fishing mortality, assumed F=0.

[c] No vulnerability to fishing assumed.

[d] Total instantaneous mortality Z = -ln(S).

[e] S_i = Probability of survival of stage *i* to the next stage accounting for vulnerability and maturity associated mortality.

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Start weights for based growth curve developed for Fuchs (1967) observed lengths and length-weight relationship from Atkinson et *al*. (2014).

[h] Stage duration (days) was based on EPRI (2012, Table 5-92).

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ where W_i is the weight at start of stage *i*.

[j] Fecundity bases on EPRI (2012, Table 5-91).

[k] Maturity is based on EPRI (2012, Table 5-91).

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Appendix Table 1-8. Life history parameters for a Freshwater Drum population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	2.270	0.000	0.00	2.270	0.103	0.187	0.00052	2	0.942	0	0.00	0.50	1,000,000	103,312	0
Larvae	6.130	0.000	0.00	6.130	0.002	0.004	0.00134	43	3.803	0	0.00	0.50	103,312	225	0
YOY	3.137	0.000	0.00	3.137	0.043	0.083	0.060	320	7.104	0	0.00	0.50	225	10	0
Age 1	0.227	0.000	0.00	0.227	0.797	0.887	73	365	0.446	0	0.00	0.50	10	8	0
Age 2	0.203	0.04	0.50	0.243	0.784	0.879	114	365	0.364	0	0.00	0.50	8	6	0
Age 3	0.184	0.04	1.00	0.224	0.799	0.888	164	365	0.307	0	0.00	0.50	6	5	0
Age 4	0.170	0.04	1.00	0.210	0.811	0.895	223	365	0.263	21,764	0.50	0.50	5	4	26,541
Age 5	0.159	0.04	1.00	0.199	0.820	0.901	290	365	0.225	28,271	1.00	0.50	4	3	55,894
Age 6	0.149	0.04	1.00	0.189	0.828	0.906	363	365	0.199	35,456	1.00	0.50	3	3	57,477
Age 7	0.141	0.04	1.00	0.181	0.834	0.910	443	365	0.174	43,221	1.00	0.50	3	2	57,987
Age 8	0.135	0.04	1.00	0.175	0.840	0.913	527	365	0.156	51,467	1.00	0.50	2	2	57,592
Age 9	0.129	0.04	1.00	0.169	0.844	0.916	616	365	0.138	60,096	1.00	0.50	2	2	56,456
Age 10	0.125	0.04	1.00	0.165	0.848	0.918	707	365	0.125	69,016	1.00	0.50	2	1	54,734
Age 11	0.120	0.04	1.00	0.160	0.852	0.920	801	365	0.112	78,139	1.00	0.50	1	1	52,566
Age 12	0.117	0.04	1.00	0.157	0.855	0.922	896	365	0.101	87,388	1.00	0.50	1	1	50,075
Age 13	0.114	0.04	1.00	0.154	0.858	0.923	991	365	0.092	96,689	1.00	0.50	1	1	47,365
Age 14	0.111	0.04	1.00	0.151	0.860	0.925	1,086	365	0.084	105,950	1.00	0.50	1	1	44,512
Age 15	0.108	0.04	1.00	0.148	0.862	0.926	1,181	365	0.076	115,205	1.00	0.50	1	1	41,626
Age 16	0.106	0.04	1.00	0.146	0.864	0.927	1,274	365	0.070	124,315	1.00	0.50	1	1	38,728
Age 17	0.104	0.04	1.00	0.144	0.866	0.928	1,366	365	0.064	133,270	1.00	0.50	1	0	35,878
Age 18	0.102	0.04	1.00	0.142	0.867	0.929	1,456	365	0.058	142,034	1.00	0.50	0	0	33,109
Age 19	0.101	0.04	1.00	0.141	0.869	0.930	1,543	365	0.054	150,579	1.00	0.50	0	0	30,448
Age 20	0.099	0.04	1.00	0.139	0.870	0.931	1,628	365	0.050	158,883	1.00	0.50	0	0	27,914
Age 21	0.098	0.04	1.00	0.138	0.871	0.931	1,711	365	0.045	166,927	1.00	0.50	0	0	25,519
Age 22	0.097	0.04	1.00	0.137	0.872	0.932	1,790	365	0.042	174,697	1.00	0.50	0	0	23,271
Age 23	0.095	0.04	1.00	0.135	0.873	0.932	1,867	365	0.039	182,185	1.00	0.50	0	0	21,171
Age 24	0.094	0.04	1.00	0.134	0.874	0.933	1,941	365	0.036	189,383	1.00	0.50	0	0	19,221
Age 25	0.093	0.04	1.00	0.133	0.875	0.933	2,012	365	0.033	196,288	1.00	0.50	0	0	17,416
Age 26	0.093	0.04	1.00	0.133	0.876	0.934	2,079	365	0.031	202,900	1.00	0.50	0	0	15,754
Age 27	0.092	0.04	1.00	0.132	0.877	0.934	2,144	365	0.029	209,219	1.00	0.50	0	0	14,227

(continued)

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Appendix Table 1–8. (continued)

Stage	i	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Growth Rate[i]	Mean Fecundity[g]	Fraction Mature[h]	Fraction Female	Ni	Ni+1	Eggs Produced
Age 28	31	0.091	0.04	1.00	0.131	0.877	0.935	2,206	365	0.026	215,250	1.00	0.50	0	0	12,830
Age 29	32	0.090	0.04	1.00	0.130	0.878	0.935	2,265	365	0.024	220,996	1.00	0.50	0	0	11,554
Age 30	33	0.090	0.04	1.00	0.130	0.878	0.935	2,321	365	0.023	226,464	1.00	0.50	0	0	10,392
Age 31	34	0.089	0.04	1.00	0.129	0.879	0.935	2,374	365	0.021	231,661	1.00	0.50	0	0	9,336
Age 32	35	0.089	0.04	1.00	0.129	0.879	0.936	2,425	365	0.020	236,594	1.00	0.50	0	0	8,379
Age 33	36	0.088	0.04	1.00	0.128	0.880	0.936	2,473	365	0.018	241,272	1.00	0.50	0	0	7,512
Age 34	37	0.088	0.04	1.00	0.128	0.880	0.936	2,518	365	0.017	245,704	1.00	0.50	0	0	6,730
Age 35	38	0.087	0.04	1.00	0.127	0.880	0.936	2,561	365	0.016	249,899	1.00	0.50	0	0	6,023
Age 36	39	0.087	0.04	1.00	0.127	0.881	0.937	2,602	365	0.014	253,866	1.00	0.50	0	0	5,387
Age 37	40	0.087	0.04	1.00	0.127	0.881	0.937	2,640	365	0.014	257,614	1.00	0.50	0	0	4,814
Age 38	41	0.086	0.04	1.00	0.126	0.881	0.937	2,676	365	0.013	261,154	1.00	0.50	0	0	4,300
Age 39	42	0.086	0.04	1.00	0.126	0.882	0.937	2,711	365	0.012	264,494	1.00	0.50	0	0	3,838
Age 40	43	0.086	0.04	1.00	0.126	0.882	0.937	2,743	365	0.000	267,644	1.00	0.50	0	0	3,424

YOY= young of the year

[a] Egg and Larvae instantaneous mortality rate was based on Table F1-13 (EPA 2006). YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs, larvae, and Ages 1-3 from the total mortality from egg to Age 40 = 2/ *f*a where *f*a =lifetime average fecundity. Natural mortality of Age 1 and older was based a scaled Lorenzen (1996) age-specific M expected given weights-at-age and longevity (Hewitt and Hoenig 2005).

[b] Fishing mortality was estimated as 0.04 based on the difference between the average natural mortality of Ages 1-40 (0.11) and the total instantaneous mortality (0.15) from on Table 5-82 (EPRI 2012). This F estimate is similar to F = 0.046 for Black Drum (ASMFC-BDAS 2015), another long-lived drum under low fishing pressure.

[c] Fraction vulnerable to fishing based on table F1-13 (EPA 2006).

[d] Total instantaneous mortality Z = M+F

[e] S_i = Probability of survival of stage *i* to the next stage = e^{-Z}

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Egg and larval start weights were based on table F1-13 (EPA 2006). YOY and Age 1 to Age 40 start weight was based on Table 5-82 and Table 5-79, respectively (EPRI 2012).

[h] Stage duration for eggs was based on Table 5-88 (EPRI 2012) for Gizzard shad. Larvae (duration 43 days) and YOY (duration 320 days) was based on BPJ from egg duration and Table 5-81 (EPRI 2012).

[i] Growth rate (G) was estimated as $Log_e(W_{i+1}/W_i)$ (EPRI 2012)

[j] Mean fecundity for Ages 3-20 based on EPRI (2012) Table 5-80.

[k] Proportion at age that are sexually mature based on EPRI (2012) Table 5-80.

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Appendix Table 1-9. Life history parameters for a Gizzard Shad population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=2Se$^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	0.896	0.000	0.00	0.896	0.408	0.580	5.68E-05	2	0.000	0	0.00	0.50	1,000,000	408,199	0
Larvae	6.449	0.000	0.00	6.449	0.002	0.003	5.68E-05	27	6.982	0	0.00	0.50	408,199	646	0
YOY	4.582	0.000	0.00	4.582	0.010	0.020	0.061	336	5.838	0	0.00	0.50	646	7	0
Age 1	0.939	0.000	0.00	0.939	0.391	0.562	21	365	1.656	59,482	0.50	0.50	7	3	98,303
Age 2	0.715	0.000	0.00	0.715	0.489	0.657	110	365	0.724	341,997	1.00	0.50	3	1	442,222
Age 3	0.622	0.000	0.00	0.622	0.537	0.699	227	365	0.340	341,997	1.00	0.50	1	1	216,348
Age 4	0.573	0.000	0.00	0.573	0.564	0.721	319	365	0.249	341,997	1.00	0.50	1	0	116,131
Age 5	0.535	0.000	0.00	0.535	0.586	0.739	409	365	0.226	341,997	1.00	0.50	0	0	65,498
Age 6	0.505	0.000	0.00	0.505	0.603	0.753	513	365	0.176	341,997	1.00	0.50	0	0	38,357
Age 7	0.482	0.000	0.00	0.482	0.617	0.763	611	365	0.000	341,997	1.00	0.50	0	0	23,140

YOY= young of the year

[a] Egg instantaneous mortality rate was based on the cumulative mortality of eggs over a 2-day duration according to Table 5-88 (EPRI 2012). Larval mortality was based on cumulative mortality of larvae over a 27-day duration as described in Table 5-88 (EPRI 2012). YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs and larvae from the total mortality from egg to Age 7 = 2/ *f*a where *f*a =lifetime average fecundity. Natural mortality of Age 1 and older was based a scaled Lorenzen (1996) age-specific M expected given weights-at-age and longevity (Hewitt and Hoenig 2005).

[b] Age-specific fishing mortality assumed to be zero (forage species).

[c] Vulnerability to fishing assumed zero.

[d] Total instantaneous mortality Z = M+F

[e] S_i = Probability of survival of stage *i* to the next stage = e^{-Z}

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Egg, Larvae, and YOY (Juvenile) start weights were based on Table 5-89 (EPRI 2012). Age-specific start weights were based on growth and mortality parameters for this species according to Table 5-89 (EPRI 2012).

[h] Stage duration of 2 days for Egg starting weight was based on Table 5-88 (EPRI 2012). Larval duration of 27 days for larvae starting weights was based on Table 5-88 (EPRI 2012). YOY duration of 336 days for Juvenile starting weight was based on Table 5-88 (EPRI 2012).

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ (EPRI 2012).

[j] Mean fecundity for Ages 1-7 was based on Table 5-87 (EPRI 2012).

[k] Proportion at age that are sexually mature was based on Table 5-87 (EPRI 2012).

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Appendix Table 1-10. Life history parameters for a Grass Carp population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	1.900	0.000	0.00	1.90	0.150	0.260	0.0018	6	0.000	0	0.000	0.50	1,000,000	149,569	0
Larvae	4.610	0.000	0.00	4.61	0.010	0.020	0.0018	44	3.241	0	0.000	0.50	149,569	1,488	0
YOY	6.280	0.000	0.00	6.28	0.002	0.004	0.0465	315	9.737	0	0.000	0.50	1,488	3	0
Age 1	0.47	0.000	0.00	0.47	0.625	0.769	787	365	0.779	0	0.000	0.50	3	2	0
Age 2	0.36	0.000	0.00	0.36	0.698	0.822	1,715	365	0.541	367,000	0.250	0.50	2	1	79,986
Age 3	0.30	0.000	0.00	0.30	0.741	0.851	2,947	365	0.402	367,000	0.500	0.50	1	1	111,609
Age 4	0.26	0.000	0.00	0.26	0.771	0.871	4,403	365	0.310	367,000	1.000	0.50	1	1	165,364
Age 5	0.23	0.000	0.00	0.23	0.795	0.886	6,003	365	0.246	367,000	1.000	0.50	1	1	127,504
Age 6	0.21	0.000	0.00	0.21	0.811	0.895	7,677	365	0.199	367,000	1.000	0.50	1	0	101,306
Age 7	0.20	0.000	0.00	0.20	0.819	0.900	9,367	365	0.163	367,000	1.000	0.50	0	0	82,117
Age 8	0.19	0.000	0.00	0.19	0.827	0.905	11,027	365	0.135	367,000	1.000	0.50	0	0	67,232
Age 9	0.18	0.000	0.00	0.18	0.835	0.910	12,625	365	0.113	367,000	1.000	0.50	0	0	55,598
Age 10	0.17	0.000	0.00	0.17	0.844	0.915	14,138	365	0.095	367,000	1.000	0.50	0	0	46,439
Age 11	0.17	0.000	0.00	0.17	0.844	0.915	15,554	365	0.081	367,000	1.000	0.50	0	0	39,179
Age 12	0.16	0.000	0.00	0.16	0.852	0.920	16,863	365	0.069	367,000	1.000	0.50	0	0	33,054
Age 13	0.16	0.000	0.00	0.16	0.852	0.920	18,065	365	0.059	367,000	1.000	0.50	0	0	28,167
Age 14	0.15	0.000	0.00	0.15	0.861	0.925	19,159	365	0.050	367,000	1.000	0.50	0	0	24,002
Age 15	0.15	0.000	0.00	0.15	0.861	0.925	20,149	365	0.043	367,000	1.000	0.50	0	0	20,659
Age 16	0.15	0.000	0.00	0.15	0.861	0.925	21,041	365	0.000	367,000	1.000	0.50	0	0	17,781

YOY= young of the year

[a] Egg and larval mortality from EPA 2006 Table G1-9, YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs and larvae from the total mortality from egg to Age 16 = 2/ *f*a where *f*a =lifetime average fecundity. Ages 1 and older mortality from Stich et al 2013.

[b] Age-specific fishing mortality was assumed to be zero (forage species).

[c] Vulnerability to fishing assumed zero.

[d] Total instantaneous mortality Z = -ln(S).

[e] S_i = Probability of survival of stage *i* to the next stage accounting for vulnerability associated mortality.

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Start weights for based on Victor and Brothers (1982) growth of Fallfish in length and length-weight conversion.

[h] Stage duration (days) was based on EPRI (2012) for eggs (Yellow Perch), Mukhaysin and Jawad (2012) for *Barbus sharpeyi* larval duration.

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ where W_i is the weight at start of stage i.

[j] Fecundity Shireman and Smith 1983 for USA average fecundity.

[k] Maturity from Trial et *al.* (1983), some Fallfish reach maturity at age 2 or three and all by age 4.

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Appendix Table 1-11. Life history parameters for a Logperch population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	0.35	0.000	0.000	0.350	0.705	0.827	1.88E-03	8	0.000	0	0.00	0.5	1,000,000	704,688	0
Larvae	1.74	0.000	0.000	1.740	0.176	0.299	1.88E-03	40	3.208	0	0.00	0.5	704,688	123,687	0
YOY	3.81	0.000	0.000	3.808	0.022	0.043	4.65E-02	317	3.879	0	0.00	0.5	123,687	2,744	0
Age 1	1.50	0.000	0.000	1.500	0.223	0.365	2.25	365	1.211	1,060	0.10	0.5	2,744	612	145,445
Age 2	1.50	0.000	0.000	1.500	0.223	0.365	7.55	365	0.616	2,000	1.00	0.5	612	137	612,324
Age 3	1.50	0.000	0.000	1.500	0.223	0.365	13.98	365	0.208	2,899	1.00	0.5	137	30	198,042
Age 4	1.50	0.000	0.000	1.500	0.223	0.365	17.21	365	0.000	2,899	1.00	0.5	30	7	44,189

YOY= young of the year

[a] Egg and larval mortality from EPA 2006 Table G1-9, YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs and larvae from the total mortality from egg to Age 16 = 2/ *f*a where *f*a =lifetime average fecundity. Ages 1 and older mortality from Stich et al 2013.

[b] Age-specific fishing mortality was assumed to be zero (forage species).

[c] Vulnerability to fishing assumed zero.

[d] Total instantaneous mortality Z = -ln(S).

[e] S_i = Probability of survival of stage *i* to the next stage accounting for vulnerability associated mortality.

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Start weights for based on Victor and Brothers (1982) growth of Fallfish in length and length-weight conversion.

[h] Stage duration (days) was based on EPRI (2012) for eggs (Yellow Perch), Mukhaysin and Jawad (2012) for *Barbus sharpeyi* larval duration.

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ where W_i is the weight at start of stage i.

[j] Fecundity Shireman and Smith 1983 for USA average fecundity.

[k] Maturity from Trial et *al.* (1983), 'some Fallfish reach maturity at age 2 or three and all by age 4.

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Appendix Table 1-12. Life history parameters for a Mississippi Silverside population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=2Se$^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	2.300	0.000	0.000	2.300	0.100	0.182	2.21E-04	8	2.431	0	0.00	0.50	1,000,000	100,259	0
Larvae	2.900	0.000	0.000	2.900	0.055	0.104	2.51E-03	36	1.662	0	0.00	0.50	100,259	5,517	0
YOY	2.740	0.000	0.000	2.740	0.065	0.121	0.013	321	6.010	0	0.00	0.50	5,517	356	0
Age 1	2.100	0.000	0.000	2.100	0.122	0.218	5	365	0.633	5,000	1.00	0.50	356	44	890,903
Age 2	2.100	0.000	0.000	2.100	0.122	0.218	10	365	0.000	5,000	1.00	0.50	44	5	109,097

YOY= young of the year

[a] Egg and larvae instantaneous mortality rate based on Table E1-24 for Silversides (EPA 2006). YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs and larvae from the total mortality from egg to Age 2 = 2/ *f*a where *f*a =lifetime average fecundity. Natural mortality rate of Age 1 and older based on Table E1-24 (EPA 2006).

[b] There were no Age-specific fishing mortality parameters for Silversides according to EPA (2006).

[c] No Vulnerability to fishing assumed.

[d] Total instantaneous mortality Z = M+F

[e] S_i = Probability of survival of stage *i* to the next stage = e^{-Z}

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Egg, larvae, and YOY (Juvenile) start weights were based on Table E1-24 (EPA 2006). Age-specific start weights were based on Table E1-24 (EPA 2006).

[h] Stage durations based on Table 5-18 for Atlantic Silversides (EPRI 2012).

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ (EPRI 2012).

[j] Mean fecundity for Ages 1-2 was based on Table 5-18 (EPRI 2012).

[k] Proportion at age that are sexually mature was based on Table 5-18 (EPRI 2012).

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Appendix Table 1-13. Life history parameters for a Sauger population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	2.622	0.000	0.00	2.62	0.073	0.135	0.00055	6	0.000	0	0.000	0.50	1,000,000	72,657	0
Larvae	6.400	0.000	0.00	6.40	0.002	0.003	0.00055	25	3.776	0	0.000	0.50	72,657	121	0
YOY	0.919	0.000	0.00	0.92	0.399	0.570	0.02400	334	9.099	0	0.000	0.50	121	48	0
Age 1	0.818	0.000	0.00	0.82	0.441	0.612	215	365	0.878	0	0.000	0.50	48	21	0
Age 2	0.688	0.000	0.00	0.69	0.503	0.669	516	365	0.463	40,655	0.100	0.50	21	11	43,208
Age 3	0.622	0.250	0.50	0.74	0.477	0.646	820	365	0.268	82,554	0.500	0.50	11	5	220,540
Age 4	0.586	0.250	1.00	0.84	0.434	0.605	1,072	365	0.163	137,167	1.000	0.50	5	2	349,894
Age 5	0.564	0.250	1.00	0.81	0.443	0.614	1,262	365	0.102	172,336	1.000	0.50	2	1	190,615
Age 6	0.551	0.250	1.00	0.80	0.449	0.620	1,397	365	0.064	254,451	1.000	0.50	1	0	124,695
Age 7	0.543	0.250	1.00	0.79	0.453	0.623	1,490	365	0.000	322,930	1.000	0.50	0	0	71,048

YOY= young of the year

[a] Natural instantaneous mortality rates for eggs and larvae were based on an equilibrium population (EPRI 2012, Table 5-117). YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs, larvae, and Age 1 from the total mortality from egg to Age 7= 2/ *fa* where *fa* =lifetime average fecundity. Age 1 to Age 7 instantaneous mortality was estimated from the Lorenzen (1996) relation applied to mid-age weights estimated from Seibert et al. 2018 and Murphy et al. 1991 and scaled to the expected cumulative mortality given the observed life span (Hewitt and Hoenig 2005).

[b] Age-specific fishing mortality of Age 1 and older was based on table 5-116 for Walleye (EPRI 2012).

[c] Fraction vulnerable to fishing based on table 5-116 for Walleye (EPRI 2012).

[d] Total instantaneous mortality Z = M+F

[e] S_i = Probability of survival of stage *i* to the next stage = e^{-Z}

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Egg, larval, YOY and age specific start weights were based on table 5-117 for Walleye (EPRI 2012).

Age-specific start weights was based on EPRI (2012) table 5-117 for Walleye.

[h] Stage duration was based on EPRI (2012) table 5-117 for Walleye.

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ (EPRI 2012).

[j] Mean fecundity for Ages 2-7 based on EPRI (2012) table 5-116 for Walleye.

[k] Proportion at age that are sexually mature based on EPRI (2012) table 5-116 for Walleye.

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Appendix Table 1-14. Life history parameters for a Skipjack Herring population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=2Se$^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	2.300	0.000	0.000	2.300	0.100	0.182	1.03E-02	2	2.820	0	0.00	0.5	1,000,000	100,259	0
Larvae	4.250	0.000	0.000	4.250	0.014	0.028	0.17	27	5.012	0	0.00	0.5	100,259	1,430	0
YOY	3.213	0.000	0.000	3.213	0.040	0.077	25.95	336	2.342	0	0.00	0.5	1,430	58	0
Age 1	1.201	0.000	0.000	1.201	0.301	0.462	270	365	0.529	0	0.00	0.5	58	17	0
Age 2	1.088	0.000	0.000	1.088	0.337	0.504	458	365	0.215	66,175	1.00	0.5	17	6	572,470
Age 3	1.037	0.000	0.000	1.037	0.355	0.524	568	365	0.129	100,659	1.00	0.5	6	2	293,304
Age 4	1.001	0.000	0.000	1.001	0.367	0.537	646	365	0.000	129,897	1.00	0.5	2	1	134,226

YOY= young of the year, YSL = post sac larvae

[a] Egg and larval natural mortality rate was based on Table G1-25 (EPA 2006). YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs, larvae, and Age 1 from the total mortality from egg to Age 4= 2/ *f*a where *f*a =lifetime average fecundity. Ages 1-4 natural mortality was estimated from the Lorenzen (1996) relation applied to mid-age weights and scaled to the expected cumulative mortality given the observed life span (Hewitt and Hoenig 2005).

[b] Age-specific fishing mortality was assumed to be zero (forage species).

[c] Vulnerability to fishing assumed zero.

[d] Total instantaneous mortality Z = M+F

[e] S_i = Probability of survival of stage *i* to the next stage = e^{-Z}

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Egg, Larvae, and YOY (Juvenile) start weights were based on Table G1-25 (EPA 2006). Age-specific start weights were based on growth and weight parameters (mean male and female weight) according to Ingram (2007).

[h] Stage duration was based on duration days for American Shad according to Table 5-3 (EPRI 2012).

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ (EPRI 2012).

[j] Mean fecundity according to Table 2 (Ingram 2007).

[k] Maturity based on Ingram (2007).

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Appendix Table 1-15. Life history parameters for a Spotted Sucker population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	1.790	0.000	0.00	1.79	0.167	0.286	0.0005	4	0.236	0	0.000	0.50	1,000,000	166,960	0
Larvae	2.810	0.000	0.00	2.81	0.060	0.114	0.0009	46	4.032	0	0.000	0.50	166,960	10,052	0
YOY	4.233	0.000	0.00	4.23	0.015	0.029	9.6615	315	0.304	0	0.000	0.50	10,052	146	0
Age 1	0.849	0.000	0.00	0.85	0.428	0.599	19	365	0.917	496	1.000	0.50	146	62	36,175
Age 2	0.612	0.000	0.00	0.61	0.543	0.703	161	365	0.399	4,099	1.000	0.50	62	34	127,792
Age 3	0.508	0.000	0.00	0.51	0.602	0.751	403	365	0.223	10,281	1.000	0.50	34	20	173,888
Age 4	0.453	0.000	0.00	0.45	0.636	0.777	673	365	0.137	17,160	1.000	0.50	20	13	174,700
Age 5	0.422	0.000	0.00	0.42	0.656	0.792	922	365	0.088	23,499	1.000	0.50	13	8	152,032
Age 6	0.402	0.000	0.00	0.40	0.669	0.802	1,129	365	0.058	28,780	1.000	0.50	8	6	122,136
Age 7	0.389	0.000	0.00	0.39	0.678	0.808	1,291	365	0.040	32,925	1.000	0.50	6	4	93,476
Age 8	0.381	0.000	0.00	0.38	0.683	0.812	1,414	365	0.027	36,061	1.000	0.50	4	3	69,365
Age 9	0.375	0.000	0.00	0.38	0.687	0.815	1,505	365	0.000	38,377	1.000	0.50	3	2	50,437

YOY= young of the year

[a] Egg and Larvae instantaneous mortality rate was based on table F1-21 (EPA 2006). YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs and larvae from the total mortality from egg to Age 9= 2/ *f*a where *f*a =lifetime average fecundity. Age 1 to Age 9 instantaneous mortality was estimated from the Lorenzen (1996) relation applied to mid-age weights estimated from Bur (1976) and scaled to the expected cumulative mortality given the observed life span (Hewitt and Hoenig 2005).

[b] There were no Age-specific fishing mortality parameters for these species according to EPA (2006).

[c] No Vulnerability to fishing assumed.

[d] Total instantaneous mortality Z = M+F

[e] S_i = Probability of survival of stage *i* to the next stage = e^{-Z}

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Egg, larval, and YOY start weights were based on table F1-21 (EPA 2006). Age-specific start weights was based on growth and mortality parameters for this species used by Bur 1976.

[h] Stage duration was based on EPRI (2012) table 5-106 for Shorthead Redhorse.

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ (EPRI 2012).

[j] Mean fecundity for Ages 1-9 based on Grabowski et al. 2012.

[k] Proportion at age that are sexually mature based on Grabowski et al. 2012.

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Appendix Table 1-16. Life history parameters for a Tessellated Darter population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=2Se$^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	0.183	0.000	0.00	0.18	0.833	0.909	0.002	3	0.000	0	0.000	0.50	1,000,000	832,768	0
Larvae	2.562	0.000	0.00	2.56	0.077	0.143	0.002	42	3.241	0	0.000	0.50	832,768	64,248	0
YOY	3.178	0.000	0.00	3.18	0.042	0.080	0.047	320	2.893	0	0.000	0.50	64,248	2,676	0
Age 1	2.572	0.000	0.00	2.57	0.076	0.142	0.839	365	0.753	688	1.000	0.50	2,676	204	920,648
Age 2	2.180	0.000	0.00	2.18	0.113	0.203	1.782	365	0.478	688	1.000	0.50	204	23	70,287
Age 3	1.957	0.000	0.00	1.96	0.141	0.248	2.873	365	0.307	688	1.000	0.50	23	3	7,943
Age 4	1.832	0.000	0.00	1.83	0.160	0.276	3.904	365	0.000	688	1.000	0.50	3	1	1,122

[a] Instantaneous mortality rates were based on an literature-derived values (EPRI 2012, Table 5-92, for Emerald shiner egg and larvae) and Lorenzen (1996) M relation at mid-age weight derived from Layzer and Reed (1978) for Tessellated darter back-calculated sizes for ages 1-4.

[b] No fishing assumed for this group.

[c] No vulnerability to fishing assumed for this group.

[d] Total instantaneous mortality Z = F+M or -ln(S)

[e] S_i = Probability of survival of stage *i* to the next stage accounting for vulnerability and maturity associated mortality.

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Start weights from weights calculated for Layzer and Reed (1978) average back-calculated size at age for tessellated darter, using Emerald shiner length weight relation reported in Carlander (1997).

[h] Stage duration (days) based on Emerald shiner from EPRI (2012).

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ where W_i is the weight at start of stage *i*.

[j] Fecundity from maximum eggs in Tsai (1972) for Eastern Johnny Darter.

[k] Maturity is derived from Gilbert (1992) reported maturity at 40 mm TL for Tessellated Darter.

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Appendix Table 1-17. Life history parameters for a Threadfin Shad population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=2Se$^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	0.670	0.000	0.000	0.670	0.512	0.677	0.00006	3	2.197	0	0.000	0.50	1,000,000	511,709	0
Larvae	4.790	0.000	0.000	4.790	0.008	0.016	0.00006	27	2.518	0	0.000	0.50	511,709	4,254	0
YOY	3.201	0.000	0.000	3.201	0.041	0.078	0.06120	335	0.086	0	0.000	0.50	4,254	173	0
Age 1	3.000	0.000	0.000	3.000	0.050	0.095	8.8	365	0	21,000	0.500	0.50	173	9	909,443
Age 2	0.900	0.000	0.000	0.900	0.407	0.578	27.6	365	0	21,000	1.000	0.50	9	4	90,557

YOY= young of the year

[a] Natural instantaneous mortality rates for egg and larvae, age-specific were based on an equilibrium population (EPRI 2012, Table 5-90). YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs and larvae from the total mortality from egg to Age 4= 2/ *f*a where *f*a =lifetime average fecundity.

[b] Age-specific fishing mortality was assumed to be zero (forage species).

[c] Vulnerability to fishing assumed zero.

[d] Total instantaneous mortality Z = M+F

[e] S_i = Probability of survival of stage *i* to the next stage = e^{-Z}

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Start weights were based on EPRI (2012, Table 5-90).

[h] Stage duration (days) was based on EPRI (2012, Table 5-90).

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ (EPRI 2012).

[j] Mean fecundity was based on Fishbase.org compiled information and Jenkins and Burkhead (1994).

[k] Maturity taken from EPRI (2012, Table 5-90).

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Appendix Table 1-18. Life history parameters for a Western Mosquitofish population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	0.183	0.000	0.00	0.183	0.833	0.909	8.44E-06	3	4.442	0	0.000	0.50	1,000,000	832,768	0
Larvae	2.562	0.000	0.00	2.562	0.077	0.143	7.17E-04	42	5.718	0	0.000	0.50	832,768	64,248	0
YOY	0.136	0.000	0.00	0.136	0.873	0.932	0.218	320	1.526	0	0.000	0.50	64,248	56,087	0
Age 1	1.585	0.000	0.00	1.585	0.205	0.340	1.004	365	0.353	5	1.000	0.50	56,087	11,491	131,154
Age 2	1.432	0.000	0.00	1.432	0.239	0.386	1.429	365	0.145	74	1.000	0.50	11,491	2,744	424,035
Age 3	1.373	0.000	0.00	1.373	0.253	0.404	1.653	365	0.061	230	1.000	0.50	2,744	695	315,606
Age 4	1.349	0.000	0.00	1.349	0.259	0.412	1.757	365	0.000	372	1.000	0.50	695	180	129,205

YOY= young of the year

[a] Instantaneous mortality rates were based on an literature-derived values (EPRI 2012, Table 5-92, for Emerald shiner egg and larvae) and Lorenzen (1996) M relation at mid-age weight derived from Sellaoui and Bouncaceur (2020) back-calculated sizes for ages 1-4. YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs and larvae from the total mortality from egg to Age 4= 2/ *f*a where *f*a =lifetime average fecundity.

[b] There were no Age-specific fishing mortality parameters for these species according to EPA (2006).

[c] No Vulnerability to fishing assumed.

[d] Total instantaneous mortality Z = M+F

[e] S_i = Probability of survival of stage *i* to the next stage = e^{-Z}

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Egg, larvae, and YOY (Juvenile) start weights were based on Table G1-36 (EPA 2006). Age-specific start weights were based on growth and weight relationships derived from Sellaoui and Bouncaceur (2020)

[h] Stage duration (days) based on Emerald shiner from EPRI (2012).

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ (EPRI 2012).

[j] Mean fecundity for Ages 1-4 was based on fecundity by weight relationships from Jawad and Busneina (2000).

[k] Proportion at age that are sexually mature was based on Table 5-10 (EPRI 2012).

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Appendix Table 1-19. Life history parameters for a White Bass population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	2.440	0.0000	0.00	2.440	0.087	0.160	1.31E-03	3	0.000	0	0.00	0.50	1,000,000	87,161	0
Larvae	7.150	0.0000	0.00	7.150	0.001	0.002	1.31E-03	50	4.239	0	0.00	0.50	87,161	68	0
YOY	2.104	0.0000	0.00	2.104	0.122	0.217	0.091	312	7.596	0	0.00	0.50	68	8	0
Age 1	0.800	0.0000	0.00	0.800	0.449	0.620	180.8	365	0.569	0	0.00	0.50	8	4	0
Age 2	0.800	0.7000	0.50	1.090	0.336	0.503	319	365	0.330	327,782	1.00	0.50	4	1	614,274
Age 3	0.800	0.7000	1.00	1.500	0.223	0.365	444	365	0.000	455,777	1.00	0.50	1	0	287,187
Age 4	0.800	0.7000	1.00	1.500	0.223	0.365	544	365	0.131	558,803	1.00	0.50	0	0	78,565
Age 5	0.800	0.7000	1.00	1.500	0.223	0.365	620	365	0.000	636,710	1.00	0.50	0	0	19,974

YOY= young of the year

[a] Egg and Larvae instantaneous mortality rate was based on apportioning the cumulative southern mortality in EPRI (2012) based on Table 5-86. YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs, larvae, and Age 1 from the total mortality from egg to Age 5 = 2/ fa where fa =lifetime average fecundity. Age 1 to Age 5 instantaneous mortality was based on table 5-86 southern cumulative mortality (EPRI 2012).

[b] Age-specific fishing mortality of Age 2 and older was based on table G1-32 (EPA 2006).

[c] Fraction vulnerable to fishing based on table G1-32 (EPA 2006).

[d] Total instantaneous mortality Z = M+F

[e] S_i = Probability of survival of stage *i* to the next stage = e^{-Z}

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Egg, larval, and YOY start weights were based on table 5-86 (EPRI 2012) for combined eggs and larvae. Age-specific start weights was based on table 5-83 for Lake Martin (EPRI 2012).

[h] Stage duration was based on EPRI (2012) table 5-85.

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ (EPRI 2012).

[j] Mean fecundity for Ages 2-5 based on EPRI (2012) table 5-83 for Lake Marin populations.

[k] Proportion at age that are sexually mature based on EPRI (2012) table 5-86.

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Appendix Table 1-20. Life history parameters for a White Crappie population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	0.750	0.000	0.00	0.75	0.472	0.642	0.00094	5	0.000	0	0.000	0.50	1,000,000	472,367	0
Larvae	3.600	0.000	0.00	3.60	0.027	0.053	0.00094	40	4.173	0	0.000	0.50	472,367	12,907	0
YOY	4.388	0.000	0.00	4.39	0.012	0.025	0.06120	320	4.403	0	0.000	0.50	12,907	160	0
Age 1	1.091	0.000	0.00	1.09	0.336	0.503	5	365	2.117	0	0.000	0.50	160	54	0
Age 2	0.767	0.429	1.00	1.20	0.303	0.465	42	365	1.035	17,873	0.500	0.50	54	16	240,723
Age 3	0.615	0.505	1.00	1.12	0.326	0.492	117	365	0.645	45,224	1.000	0.50	16	5	368,579
Age 4	0.533	0.542	1.00	1.08	0.341	0.509	223	365	0.413	80,657	1.000	0.50	5	2	214,357
Age 5	0.482	0.562	1.00	1.04	0.352	0.521	337	365	0.304	116,837	1.000	0.50	2	1	105,927
Age 6	0.448	0.573	1.00	1.02	0.360	0.530	456	365	0.218	153,413	1.000	0.50	1	0	48,957
Age 7	0.435	0.579	1.00	1.01	0.363	0.532	568	365	0.000	186,613	1.000	0.50	0	0	21,457

YOY= young of the year

[a] Natural instantaneous mortality rates were based on an equilibrium population (EPRI 2012, p.5-124). Egg stage includes a very short yolk-sac larvae development stage. Mortality for ages 1-7 are derived from the Lorenzen (1996) equation predicting mortality from mid-age weight.

[b] Age-specific fishing mortality based on Paukert et *al.* (2001) Z's for Midwest lakes and given age-specific M, F=Z-M.

[c] Vulnerability to fishing inferred from Carrier and Greis (2014) size frequencies for New Hampshire landings and predicted size at age.

[d] Total instantaneous mortality Z = -ln(S).

[e] S_i = Probability of survival of stage *i* to the next stage accounting for vulnerability and maturity associated mortality.

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Start weights are based on Jackson and Hurley (2005) predicted lengths and Neumann and Murphy (1992) length-weight relation.

[h] Stage duration (days) was based on EPRI (2012, 5-125).

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ where W_i is the weight at start of stage *i*.

[j] Mean fecundity was based on Thomas and Kilambi fecundity relationship (1981)

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Appendix Table 1-21. Life history parameters for a Yellow Bass population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	2.440	0.000	0.00	2.440	0.087	0.160	1.31E-03	3	0.000	0	0.00	0.50	1,000,000	87,161	0
Larvae	7.150	0.000	0.00	7.150	0.001	0.002	1.31E-03	50	4.239	0	0.00	0.50	87,161	68	0
YOY	1.831	0.000	0.00	1.831	0.160	0.276	0.091	312	3.606	0	0.00	0.50	68	11	0
Age 1	0.899	0.000	0.00	0.899	0.407	0.578	3.3	365	1.356	120,591	1.00	0.50	11	4	660,759
Age 2	0.687	0.700	0.50	0.977	0.376	0.547	13.0	365	0.791	103,768	1.00	0.50	4	2	231,335
Age 3	0.575	0.700	1.00	1.275	0.279	0.437	28.6	365	0.524	94,656	1.00	0.50	2	0	79,446
Age 4	0.508	0.700	1.00	1.208	0.299	0.460	48.3	365	0.371	87,212	1.00	0.50	0	0	20,446
Age 5	0.464	0.700	1.00	1.164	0.312	0.476	70.1	365	0.274	81,132	1.00	0.50	0	0	5,682
Age 6	0.434	0.700	1.00	1.134	0.322	0.487	92.2	365	0.207	76,165	1.00	0.50	0	0	1,665
Age 7	0.412	0.700	1.00	1.112	0.329	0.495	113.4	365	0.160	72,108	1.00	0.50	0	0	507
Age 8	0.403	0.700	1.00	1.103	0.332	0.499	133.0	365	0.000	68,794	1.00	0.50	0	0	159

YOY= young of the year

[a] Egg and Larvae instantaneous mortality rate was based on apportioning the cumulative southern mortality in EPRI (2012) based on table 5-86 for White Bass. YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs and larvae from the total mortality from egg to Age 5 = 2/ fa where fa =lifetime average fecundity. Age 1 to Age 8 instantaneous mortality was estimated from the Lorenzen (1996) relation applied to mid-age weights estimated from Zervas (2010) and Bister et al. (2000) and scaled to the expected cumulative mortality given the observed life span (Hewitt and Hoenig 2005).

[b] Age-specific fishing mortality of Age 2 and older was based on table G1-32 (EPA 2006).

[c] Fraction vulnerable to fishing based on table G1-32 (EPA 2006).

[d] Total instantaneous mortality Z = M+F

[e] S_i = Probability of survival of stage *i* to the next stage = e^{-Z}

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Egg, larval, and YOY start weights were based on table 5-86 for White Bass (EPRI 2012) for combined eggs and larvae. Age-specific start weights were based on Bister et al. (2000).

[h] Stage duration was based on EPRI (2012) table 5-85.

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ (EPRI 2012).

[j] Mean fecundity for Ages 1-8 based on Bulkley (1970).

[k] Proportion at age that are sexually mature based on EPRI (2012) table 5-86 and BPJ assumed for Age 1.

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Appendix Table 1-22. Life history parameters for a Yellow Perch population at equilibrium.

Stage	M_i[a]	F_i[b]	Fraction Vulnerable to Fishing[c] (v)	Z_i[d]	S_i[e]	Adjusted[f] S_i (=$2Se^{-Ln(1+S)}$)	Start Weight[g] (g)	Duration[h] (days)	Instant. Growth Rate[i]	Mean Fecundity[j]	Fraction Mature[k]	Fraction Female	N_i	N_{i+1}	Eggs Produced
Egg	2.020	0.000	0.000	2.020	0.133	0.234	0.00057	6	0.000	0	0.00	0.50	1,000,000	132,655	0
Larvae	4.930	0.000	0.000	4.930	0.007	0.014	0.00057	25	4.623	0	0.00	0.50	132,655	959	0
YOY	1.265	0.000	0.000	1.265	0.282	0.440	0.05800	334	5.056	0	0.00	0.50	959	271	0
Age 1	1.203	0.000	0.000	1.203	0.300	0.462	9.1	365	1.810	0	0.00	0.50	271	81	0
Age 2	0.714	0.000	0.000	0.714	0.489	0.657	55.6	365	0.772	6,406	1.00	0.50	81	40	260,274
Age 3	0.572	0.360	0.500	0.736	0.479	0.648	120.3	365	0.411	15,015	1.00	0.50	40	19	298,611
Age 4	0.508	0.360	1.000	0.868	0.420	0.591	181.4	365	0.238	23,627	1.00	0.50	19	8	225,095
Age 5	0.475	0.360	1.000	0.835	0.434	0.605	230.2	365	0.145	30,733	1.00	0.50	8	3	122,885
Age 6	0.455	0.360	1.000	0.815	0.443	0.614	266.0	365	0.089	36,049	1.00	0.50	3	2	62,569
Age 7	0.444	0.360	1.000	0.804	0.448	0.619	290.9	365	0.000	39,790	1.00	0.50	2	1	30,565

YOY= young of the year

[a] Egg instantaneous mortality rate was based on the cumulative mortality of eggs over a 6-day duration according to Table 5-115 (EPRI 2012). Larval instantaneous mortality rate was based on cumulative mortality of larvae over a 25-day duration (Table 5-115; EPRI 2012). YOY mortality was adjusted to balance the life history table assuming population is at equilibrium by subtracting mortalities for eggs, larvae, and Age from the total mortality from egg to Age 7 = 2/ *f*a where *f*a =lifetime average fecundity. Natural mortality of Age 1 and older was calculated based on a cumulative mortality scaled Lorenzen estimate (Lorenzen 1996, Hewitt and Hoenig 2005).

[b] Age-specific fishing mortality of Age 1 and older was based on Table F1-27 (EPA 2006).

[c] Fraction vulnerable to fishing based on Table F1-27 (EPA 2006).

[d] Total instantaneous mortality Z = M+F

[e] S_i = Probability of survival of stage *i* to the next stage = e^{-Z}

[f] Adjustment to the survival for the stage at which entrainment occurs to account for multiple ages within a stage, with the assumption of equal vulnerability throughout a stage (EPRI 2012).

[g] Egg, Larvae, and YOY (Juvenile) start weights were based on Table 5-115 (EPRI 2012). Age-specific start weights were based on growth and mortality parameters for this species according to Table 5-115 (EPRI 2012).

[h] Stage duration of 6 days for Egg starting weight was based on Table 5-115 (EPRI 2012). Larval duration of 25 days for larvae starting weights was based on Table 5-115 (EPRI 2012). YOY duration of 334 days for Juvenile starting weight was based on Table 5-115 (EPRI 2012).

[i] Growth rate (G) was estimated as $Log_e (W_{i+1}/W_i)$ (EPRI 2012).

[j] Fecundity from EPRI (2012) cited relation, $\log_{10}F = 1.88057 + 1.10369 \log_{10}W$

[k] Proportion at age that are sexually mature based on Table 5-115 (EPRI 2012).

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Appendix B. Social Benefits Evaluation of Entrainment Reducing Technologies at Browns Ferry Nuclear Plant

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Social Benefits Evaluation of Entrainment Reducing Technologies at Browns Ferry Nuclear Plant

Tennessee Valley Authority

20 January 2022

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I. Introduction and Background

This report provides estimates of the social benefits of installing and operating two cooling water intake structure ("CWIS") alternatives for reducing entrainment at Browns Ferry Nuclear Plant ("BFN"). The social benefits estimates are based upon estimates of biological gains developed in the biological evaluation developed by Normandeau Associates, Inc. ("Normandeau Report").[1] As noted below, the two CWIS alternatives are: (1) 0.5 millimeter ("mm") fine-mesh screens; and (2) a closed-cycle recirculating system.

A. Clean Water Act Requirements

The final rule promulgated by the U.S. Environmental Protection Agency ("EPA") to regulate CWIS under Section 316(b) of the Clean Water Act ("Final Section 316(b) Rule") requires regulated existing facilities to submit a Benefits Valuation Study consistent with the following requirements.[2]

> *The owner or operator of an existing facility that withdraws greater than 125 mgd AIF must develop for submission to the Director an evaluation of the benefits of the candidate entrainment reduction technologies and operational measures evaluated in paragraph (r)(10) of this section including using the Entrainment Characterization Study completed in paragraph (r)(9) of this section. Each category of benefits must be described narratively, and when possible, benefits should be quantified in physical or biological units and monetized using appropriate economic valuation methods. The benefits valuation study must include, but is not limited to, the following elements:*
>
> *(i) incremental changes in the numbers of individual fish and shellfish lost due to impingement mortality and entrainment as defined in 40 CFR 125.92, for all life stages of each exposed species;*
> *(ii) description of basis for any estimates of changes in the stock sizes or harvest levels of commercial and recreational fish or shellfish species or forage fish species;*
> *(iii) description of basis for any monetized values assigned to changes in the stock size or harvest levels of commercial and recreational fish or shellfish species, forage fish, and to any other ecosystem or nonuse benefits;*
> *(iv) a discussion of mitigation efforts completed prior to October 14, 2014, including how long they have been in effect and how effective they have been;*
> *(v) discussion, with quantification and monetization, where possible, of any other benefits expected to accrue to the environment and local communities, including but not limited to improvements for mammals, birds, and other organisms and aquatic habitats; and,*
> (vi) *discussion, with quantification and monetization, where possible, of any benefits expected to result from any reductions in thermal discharges from entrainment technologies.*

[1] Normandeau 2022.

[2] See 40 CFR §122.21 (r)(11).

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This report deals with the monetization of benefits, including the potential categories of commercial and recreational fish, forage fish, and nonuse benefits, and thus represents compliance with Section (iii) of the required Benefits Valuation Study.

B. Browns Ferry Nuclear Plant

BFN is owned and operated by the Tennessee Valley Authority and is located on the eastern shore of the Tennessee River on Wheeler Reservoir in Athens, Limestone County, Alabama. BFN has three nuclear generating units with a total design electrical rating of 3,300 megawatts ("MW"), with Unit 1 in operation since 1973, Unit 2 in operation since 1974, and Unit 3 in operation since 1976. The current permits from the Nuclear Regulatory Commission for the three units end by July 2, 2036.[3]

BFN is subject to compliance with the Final Section 316(b) Rule. Entrainment compliance requirements are specified in National Pollutant Discharge Elimination System Permit No. AL-0022080 ("NPDES Permit") issued by the Alabama Department of Environmental Management ("ADEM") effective September 1, 2016. The NPDES Permit requires the Plant's CWIS to reflect the Best Technology Available ("BTA") for minimizing adverse environmental impacts from entrainment and impingement. Since the annual intake flow ("AIF") for BFN is substantially greater than 125 Million Gallons per Day ("MGD"), a Benefits Valuation Study for the plant is required as specified by §122.21 (r)(11).

C. Cooling Water Intake Structure Alternatives

As described in the study prepared by ENERCON to comply with 40 CFR §122.21 (r)(10), the following two CWIS alternatives are evaluated at BFN (ENERCON 2022).

1. 0.5-mm fine mesh traveling water screens ("FMS")
2. Closed cycle recirculating system ("CCRS")

The social benefits of these two alternatives are evaluated relative to the existing CWIS, which includes 0.25 inch x 0.30 inch traveling mesh screens. Thus, benefits are estimated as additional social benefits for each of the two CWIS alternatives relative to the existing CWIS. These two CWIS technologies are being considered as BTA alternatives for reducing entrainment mortality at BFN under the Final Section 316(b) Rule.

D. Organization of the Report

The remainder of this report is organized as follows. Section II provides information on the social benefits methodology, including the major components of social benefits and the social discount rates used to translate annual values into present value estimates. Section III summarizes the biological gains estimated in the Normandeau Report. Section IV provides estimates of the monetized social benefits for each technology alternative. Section V provides an evaluation of

[3] This date marks the end of the Unit 3 permit. The Unit 1 permit ends on December 20, 2033 and the Unit 2 permit ends on June 28, 2034.

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potential additional indirect benefits. Section VI provides an evaluation of potential non-use benefits. Section VII concludes with a summary of the total monetized benefits for each alternative as well as qualitative conclusions for benefits that are not monetized.

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II. Overview of Social Benefits Methodology

As noted in the Final 316(b) Rule, social benefits represent the "increase in social welfare that results from taking an action," including "private benefits and those benefits not taken into consideration by private decision makers in the actions they chose to take" (EPA 2014a, p. 48432). We rely on the standard economic approach of using the willingness-to-pay ("WTP") of those who receive benefits to measure social benefits. This approach is consistent with the Final 316(b) Rule as well as with sound cost-benefit methodology as reflected in textbooks (see, e.g., Boardman et al. 2011) and in the guidelines that the EPA has developed for preparing economic assessments of environmental regulations (EPA 2014b, subsequently "EPA *Guidelines*").

A. Potential Components of Social Benefits

The EPA *Guidelines* provide a framework for evaluating benefit categories relevant for ecological improvements, which is the general category of benefits relevant for this assessment. The EPA uses these benefit categories as a framework to develop estimates of monetary benefits in the Final 316(b) Rule (see EPA 2014c, pp. 4-3, 4-4). Economic textbooks provide similar frameworks for categorizing benefits related to ecological improvements.[4]

Figure 1, adapted from the 2000 EPA *Guidelines* (EPA 2000) for assessing ecological benefits, provides a useful way of organizing and visualizing these potential benefit categories.[5] The figure divides the ecological benefits into two major categories: "use" benefits and "non-use" benefits. Use benefits consist of gains to those who use the additional resources provided by the various alternatives (e.g., fishermen), while non-use benefits consist of potential gains to those who do not expect any potential use gains (e.g. those who might value the bequest of gains to future generations). Use benefits can be further subdivided into three subcategories—market benefits (e.g., gains to commercial fishermen), non-market benefits (e.g., gains to recreational fishermen), and indirect benefits (e.g., gains from additional forage fish, which lead to gains for fishermen)—resulting in a total of four potentially relevant general ecological benefits categories.

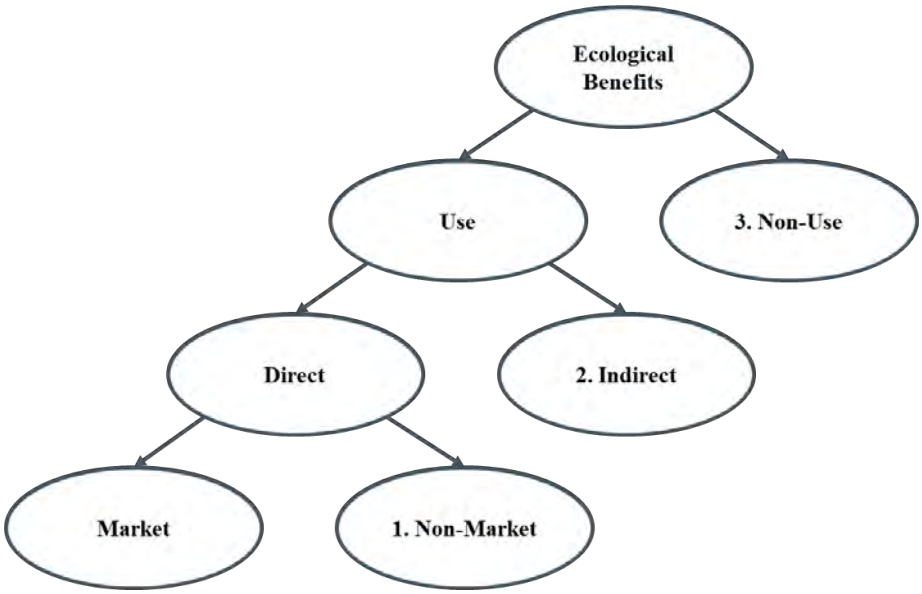
The Normandeau Report concludes that there are no relevant commercial fisheries and thus we conclude there are no gains to commercial fishermen, which corresponds to the category of market use benefits. Thus, we develop monetary estimates for two of the categories shown in Figure 1: (a) recreational benefits (non-market use benefits); and (b) forage benefits (indirect use benefits). In addition, we develop qualitative information for two other general categories: (a) indirect use benefits other than forage gains; and (b) non-use benefits.

[4] See, e.g., Kolstad 2011, pp. 138-140; Boardman et al. 2011, Chapters 4 and 9; and Freeman 2003, Chapters 5 and 13.

[5] The updated 2014 *Guidelines* provide a similar categorization but do not include this figure. See EPA (2014b, p. 7-15).

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Figure 1: Summary of Benefit Classification Scheme from EPA 2000 Guidelines



Source: EPA (2000, p. 70); see also EPA (2014d, p. 7-9).

The following list summarizes the three benefit categories we evaluate, including monetary valuations and qualitative assessments.

1. *Non-Market Direct Use Benefits.* These benefits consist of goods and services that have direct uses but are not traded in the marketplace. We develop dollar values of benefits of increased catch to recreational fishermen based upon estimates of biological gains provided in the Normandeau Report.

2. *Indirect Use Benefits.* These benefits occur through indirect or secondary effects on non-marketed and marketed goods (in primary and secondary markets). We include monetary benefit values for estimates of the increases in recreational catch due to additional forage. We evaluate other potential indirect use benefits qualitatively.

3. *Non-Use Benefits.* These benefits occur when individuals value improved environmental quality without any past, present, or anticipated future use of the resources in question. We develop qualitative evaluations of this category based upon quantitative biological information provided in the Normandeau Report.

B. Overview of Biological Gains at Browns Ferry Nuclear Plant

The biological gains due to the two CWIS alternatives are provided in the Normandeau Report. As noted, because of the conclusion that no commercial fisheries are affected, the Normandeau Report includes three major types of biological information relevant for this report.

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(a) Direct gains in recreational fishery catch;

(b) Indirect gains in recreational fishery catch due to additional forage; and

(c) Gains relevant to potential nonuse benefits.

The Normandeau Report provides estimates of total gains for the first and second category, i.e., the sum of direct and indirect gains to recreational fishermen due to the two CWIS alternatives in the Wheeler Reservoir—assumed to be the waterbody relevant for recreational fishery by Normandeau. The recreational biological gains are reported as additional recreational catch—measured by the additional number of fish that would be caught due to the two CWIS alternatives—which includes additional recreational harvest (i.e., catch and keep) and additional recreational catch-and-release (Normandeau Section 5.2.6). These numbers are based upon (a) estimates of the number of fish that would have resulted if the eggs and larvae had not been entrained due to the CWIS alternatives (Normandeau Report, Section 5.2.1) and (b) estimated catch rates, i.e., the average number of fish caught per fish harvested (Normandeau Report, Section 5.2.6).

The biological gains for the two CWIS alternatives are measured relative to a baseline that incorporates the current CWIS technologies, as noted above. Thus, the biological gains are based on the difference between (a) the recreational catch losses (by species) with the CWIS alternative in place and (b) the recreational catch losses with the CWIS baseline configuration. Note that because Normandeau developed biological information for all species, it is not necessary to adjust the biological benefit estimates to account for omitted species. Further note that since Normandeau expressed its results as the numbers of additional recreational catch for all ages of catchable fish, the value per fish caught is assumed equal among all ages (Normandeau Report, Section 5.2.3).

C. Discounting of Social Benefits

Annual social benefits are discounted at social discount rates to develop estimates of the present value of benefits over the analysis period, which is from January 1, 2022 to July 2, 2036. The benefits for each CWIS alternative begin to accrue once the CWIS alternative is installed and operational, which is 2030 for CCRS and 2027 for FMS. We use social discount rates of 3 and 7 percent, as recommended in the Final 316(b) Rule (EPA 2014a, p. 48367) for social costs. We develop estimates of the present value of social benefits for the two CWIS alternatives. (To be consistent with the Final 316(b) Rule terminology, we refer to the discounted values as “present values”).

The social benefits are calculated as of January 1, 2022 for benefits estimated over the analysis period from January 1, 2022 to July 2, 2036, the same period as used to estimate social costs. As noted in the ENERCON Report, the analysis start date reflects the assumed permit reissuance date for BFN. The analysis end date reflects the end date of the Unit 3 operating permit, which has the latest end date of any of the three BFN units.

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III. Summary of Biological Fish Gains

This section summarizes estimates in the Normandeau Report of the additional recreational fish catch due to the two CWIS alternatives. As noted above, forage fish that are not directly caught, and therefore have no direct monetary value, still contribute indirectly to potential use benefits of alternatives by providing additional forage for predator species. Non-harvested game fish also contribute indirectly to the additional forage available to game fish.

A. Classification of Fish Species

Table 1 provides a list of species in the Normandeau Report classified as either fishery fish (i.e., possessing some value to anglers) or forage fish. Ten species are included in the recreational fishery; as noted, above there is no commercial fishery. The indirect benefits of additional forage are calculated based upon the assumption that Blue Catfish is the relevant predator species.

Table 1: Categorization of Species

Forage Species	Fishery Species
Common Carp	Blue Catfish
Darter Etheostoma sp.	Buffalofish Ictiobus sp.
Emerald Shiner	Channel Catfish
Gizzard Shad	Crappie Pomoxis sp.
Grass Carp	Freshwater Drum
Logperch	Sauger
Mississippi Silverside	Sunfish Lepomis sp.
Shiner Pimephales sp.	White Bass
Skipjack Herring	Yellow Bass
Spotted Sucker	Yellow Perch
Threadfin Shad	
Topminnow Fundulus sp.	
Western Mosquitofish	

Note: Blue Catfish is the predator assumed to consume forage gains.
Source: Normandeau Report, Table 5-1.

B. Recreational Fishing Biological Gains

Recreational fishing biological gains are based on estimates of the increases in the number of additional fish caught by recreational anglers, which includes fish that are caught and kept (i.e., harvested) as well as those that are caught and released. Table 2 provides estimates from the Normandeau Report of additional recreational catch due to the two CWIS technologies for the ten species with recreational value. Note that the values in Table 2 include both the direct gains as well as the indirect gains from additional forage due to the two CWIS alternatives. As noted, the indirect gains are assumed to accrue to Blue Catfish, recognizing that the actual gains would be spread among many predator species.

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Table 2: Annual Biological Recreational Gains (Direct and Indirect) by Species (Number of Fish)

	0.5-mm Fine Mesh Screens			Closed-Cycle Recirculating System		
Species	**Harvest**	**Catch and Release**	**Total Catch**	**Harvest**	**Catch and Release**	**Total Catch**
Blue Catfish	1,983	3,426	5,409	9,276	16,006	25,282
Buffalofish Ictiobus sp.	40	-	40	86	-	86
Channel Catfish	5,042	8,699	13,741	7,961	13,736	21,697
Crappie Pomoxis sp.	2	2	4	88	102	190
Freshwater Drum	294	-	294	790	-	790
Sauger	2	6	8	13	28	41
Sunfish Lepomis sp.	9	15	24	2,625	4,347	6,972
White Bass	995	4,844	5,839	4,101	19,968	24,069
Yellow Bass	-	1	1	1	4	5
Yellow Perch	115	-	115	173	-	173
Total	**8,482**	**16,993**	**25,475**	**25,114**	**54,191**	**79,305**

Note: Values for Blue Catfish include indirect gains due to increased forage. These values assume that all indirect gains are attributed to Blue Catfish (recognizing that the actual gains would be spread among many predator species).

Source: Normandeau Report, Table 5-16

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IV. Estimation of Recreational Fishing Benefits

This section describes the methodologies used to evaluate the monetary value of the biological gains due to the two CWIS alternatives as well as the resulting estimates of social benefits.

A. Methods to Estimate Social Benefits of Additional Recreational Catch

As noted above, recreational fishing benefits are classified as non-market direct use benefits, since the benefit in question—the value of catching an additional fish recreationally—is not purchased in a market. There are therefore no market prices that reflect the value of the recreational experience. Instead of a market price, economists measure the monetary value by what can be inferred about anglers' WTP for additional catch.

The EPA *Guidelines* describe two types of methods for directly estimating WTP for non-market goods. The first type is "revealed preference" methods, which estimate values based on observed choices that "reveal" individuals' valuations of different goods and services. The principal revealed preference method for recreational fishing is the travel cost model, in which differences in catch rates and travel costs (and other factors) among fishing sites are used to estimate the "revealed" value of additional catch. The second type is "stated preference" methods that rely on preferences that are "stated" in responses to survey questions that posit hypothetical situations and monetary trade-offs involving the environmental good (EPA 2014b).

The EPA *Guidelines* also describe an alternative to developing direct estimates of the WTP for environmental goods, referred to as "benefit transfer." In benefit transfer, results from an existing study or set of studies are used to infer WTP for the benefits in a new study, in this case the study of recreational gains due to CWIS alternatives at BFN. Thus, results are "transferred" from one study or set of studies to the new study. The *Guidelines* recommend benefits transfer as a cost-effective means of developing dollar WTP values. (EPA 2014b) Indeed, in in its analysis of the national benefits of the Final 316(b) rule (EPA 2014d), EPA uses benefit transfer to develop estimates of value of additional recreational fish catch based upon a 2006 EPA meta-analysis study of numerous earlier recreational fishing studies (EPA 2006, Chapter A5).

B. Benefit Transfer Method to Estimate the Monetary Value of Additional Recreational Catch

We use the benefit transfer methodology to value the additional recreational catch due to the CWIS alternatives. As described above and in the EPA *Guidelines*, benefit transfer is the "process of applying values estimated in previous studies to new policy cases" (EPA 2014b, p. 7-3). As the basis for recreational catch values, we use results from the same detailed meta-analysis study that EPA used to develop its national estimates, tailoring our estimates to the relevant types of recreational fish and the specific region relevant to BFN.

The 2006 EPA study develops a statistical model that combines results from numerous recreational fishing studies to provide a means of estimating the marginal value per fish of additional catch by

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species as a function of catch rates and other variables. Note that the EPA meta-analysis is based on underlying studies that estimate the value of additional recreational fish *catch* and does not develop separate value estimates for harvested fish and catch-and-release fish. The meta-analysis is described in more detail in the EPA benefits analysis for the Final 316(b) Rule (EPA 2014d, Chapter 7 Recreational Fishing Benefits). As noted, EPA used the same 2006 meta-analysis for recreational benefits by region in its evaluation of the potential benefits of the Final Rule.

We note that NERA has developed direct estimates of the value of additional recreational catch in prior studies. It is our professional opinion, however, that use of the detailed values from this EPA study—via benefit transfer based upon the specific types of fish and water body type relevant to BFN—is superior to developing direct estimates for BFN because: (a) benefit transfer provides substantial time and cost savings compared to developing an original study; and (b) the detailed region- and species-specific values in the EPA meta-analysis study provide estimates likely to be similar in magnitude and reliability to those from an original study.[6]

C. Valuations of Additional Recreational Catch by Species

The EPA meta-analysis provides separate values for different species groups and regions. We used the relevant species groups for the Inland region based on their most likely relevant species groups as defined by Normandeau (Table 5-1). Table 3 shows the recreational values for the species in this study, measured in dollars per additional fish caught recreationally. The dollar values in the meta-analysis are translated into 2018 dollars using inflation information provided by the US Bureau of Economic Analysis (BEA) to be consistent with the cost information in the social cost analyses.

[6] See EPA *Guidelines* for discussion of the benefit transfer approach and when it is appropriate (EPA 2014b, p. 7-45).

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Table 3: Recreational Catch Values by Species (2018$)

Species	EPA Species Group	Recreational Catch Value ($/Fish)
Blue Catfish	Panfish	$1.23
Buffalofish Ictiobus sp.	Unidentified	$2.59
Channel Catfish	Panfish	$1.23
Crappie Pomoxis sp.	Panfish	$1.23
Freshwater Drum	Unidentified	$2.59
Sauger	Walleye/Pike	$4.77
Sunfish Lepomis sp.	Panfish	$1.23
White Bass	Bass	$10.48
Yellow Bass	Bass	$10.48
Yellow Perch	Panfish	$1.23

Note: Dollar year conversions based on inflation information from BEA (2019).
Source: US EPA (2014d, p. I-23); NERA calculations as explained in text.

D. Annual Recreational Fishing Benefits

We calculate the annual recreational benefits of the two CWIS alternatives for each species group as the product of the estimated increases in recreational catch (i.e., harvest plus catch and release, measured in number of fish caught) and the recreational value per fish ($/fish). Table 4 provides our resulting estimates of annual recreational benefits of the two CWIS alternatives. The estimated annual benefits are about $85,900 per year for the 0.5 mm fine mesh screens and about $321,800 per year for CCRS.

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Table 4: Annual Recreational Fishing Benefits by Species (2018$)

Species	0.5-mm Fine Mesh Screens	Closed-Cycle Recirculating System
Blue Catfish	$6,674	$31,195
Buffalofish Ictiobus sp.	$104	$223
Channel Catfish	$16,955	$26,772
Crappie Pomoxis sp.	$5	$234
Freshwater Drum	$761	$2,046
Sauger	$38	$196
Sunfish Lepomis sp.	$30	$8,603
White Bass	$61,207	$252,302
Yellow Bass	$10	$52
Yellow Perch	$142	$213
Total	**$85,926**	**$321,836**

Note: Values for Blue Catfish include indirect benefits due to additional forage. These values assume that all indirect gains are attributed to Blue Catfish (recognizing that the actual gains would be spread among many predator species). Values may not sum to totals due to rounding.
Source: NERA calculations as explained in text.

E. Present Values of Recreational Fishing Benefits

Table 5 provides our estimates of the present values of recreational benefits for the CWIS alternatives over the period from 2022 to 2036, calculated using real discount rates of both 3 percent and 7 percent. The benefits for each CWIS alternative would begin to accrue once the CWIS alternative is installed and operational, which is 2030 for CCRS and 2027 for FMS. The present values of recreational benefits for the FMS are about $0.65 million using a 3 percent discount rate and about $0.46 million using a 7 percent discount rate. The present values of recreational benefits for the CCRS are about $1.63 million using a 3 percent discount rate and about $1.08 million using a 7 percent discount rate.

Table 5: Present Values of Total Recreational Benefits, 2022 – 2036 (2018$)

	Discount Rate	
Technology	**3%**	**7%**
0.5-mm Fine-Mesh Screens	$651,231	$460,414
Closed-Cycle Recirculating System	$1,630,354	$1,080,139

Note: Benefits are assumed to occur annually in each year in which the plant operates. Note that this assumption may overstate benefits in 2033-2036, years in which one or more units may cease operation following permit expiration. For the purposes of present value calculations, the benefits are assumed to occur at the start of each year.
Source: NERA calculations as explained in text.

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V. Evaluation of Potential Additional Indirect Benefits

As discussed, the estimates of recreational benefits include indirect benefits in the form of the gains from additional recreational fish catch due to additional forage from the CWIS alternatives. The economic literature notes the possibility of additional indirect benefits, which can be divided into market and non-market effects (see, e.g., EPA 2014b). This section provides qualitative assessments of these two additional categories of indirect social benefits:

- Market indirect use benefits; and
- Non-market indirect use benefits.

As discussed below, we conclude that no category of indirect benefits (i.e., no category other than forage gains) is likely to result in social benefits that are significant relative to the monetary benefits we estimate.

A. Assessment of Potential Market Indirect Use Benefits

Market indirect use benefits are benefits that occur through indirect (or secondary) effects on *marketed* goods. The following are the specific items listed in the EPA summary of market indirect use benefits in its benefits analysis for the Final 316(b) Rule (EPA 2014d, p. 4-3).

1. Increases in equipment sales, rental, and repair;
2. Increases in bait and tackle sales;
3. Increases in consumer market choices;
4. Increases in choices in restaurant meals;
5. Increases in property values near the water; and
6. Increases in ecotourism (charter trips, festivals, and other organized activities with fees such as river walks).

These market indirect use benefits can be categorized as potential *secondary* markets impacts i.e., impacts on other markets due to the increase in harvest and catch by commercial and recreational fishermen. Many other markets in theory could be affected; for example, increases in fishing could increase the demand for fishing boats and equipment, which in turn could increase the demand for aluminum, which could increase the demand for electricity. The question for a social benefits study is the following: is it necessary to estimate these market effects to develop appropriate estimates of social benefits?

The economic literature indicates that these secondary market effects can be ignored (for purposes of estimating social benefits) as long as market prices in the affected markets do not change (see, e.g., Kolstad 2011, p. 117). Under the assumption of constant long-run marginal costs—which is

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the standard assumption in economic evaluations (see, e.g., Kolstad 2011, p. 118)—changes in recreational fishing due to the CWIS alternatives would have no effect on the prices of fishing equipment, and thus would not lead to gains to either buyers or sellers. Thus, secondary effects of changes in recreational fishing on these other markets (e.g., fishing equipment) would not lead to additional social benefits (i.e., consumer and producer surplus). It is worth noting that the EPA in its benefits evaluation for the Final 316(b) Rule also does not develop estimates of these secondary market effects, noting data constraints and lack of information on the relationship between changes in catch and these various secondary impacts (EPA 2014d, p. 4-3).

B. Assessment of Potential Non-Market Indirect Use Benefits

Non-market indirect use benefits are benefits that occur through indirect or secondary effects on *non-marketed* goods. The following are the specific items listed in the EPA summary of non-market indirect goods in its benefits study for the Final 316(b) Rule, apart from forage-related gains (EPA 2014d, p. 4-4).

1. Increase in value of boating, scuba diving, and near-water recreational experiences due to enjoying/observing fish while boating, scuba diving, hiking or picnicking, and watching aquatic birds catch fish or aquatic invertebrates; and

2. Increase in boating, scuba diving and near-water recreational participation.

Consistent with EPA's benefit assessment in the Final 316(b) Rule, we do not develop estimates of changes in trip value or recreational participation due to improved boating or birdwatching opportunities due to the CWIS alternatives (EPA 2014d, p. 4-4). As EPA concludes in the context of the national regulation, we conclude that these benefits would be negligible on the Tennessee River. Even if those engaged in other recreation on the Tennessee River (e.g., boating) valued seeing fish in the river, the changes in fish populations due to the CWIS alternatives are negligible (as discussed below in the context of non-use benefits). As discussed below (Section V.E.2), the Normandeau Report concludes that the two CWIS alternatives at BFN would have very small effects on harvest and catch in the Wheeler Reservoir (Section 6.2). The Normandeau Report also provides information on the potential effects of BFN on eggs and larvae, concluding that BFN entrainment has small effects on these populations. With regard to indirect non-market effects, It seems inconceivable that these very small changes in the fish population in the Wheeler Reservoir, let along the entire Tennessee River, could have any significant effects on the value people derive from boating, bird watching or other "indirect non-market use benefits."

C. Conclusions Regarding Indirect Benefits

In summary, we do not expect the relatively small increases in fish populations and catch from the CWIS alternatives to lead to any significant indirect market or non-market benefits. We conclude that omitting any such benefits from the monetized social benefits estimates is unlikely to significantly affect the overall results and conclusions of the study.

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VI. Evaluation of Potential Non-Use Benefits

This section provides background on non-use benefits and our evaluation of potential non-use benefits for the two CWIS alternatives at BFN.

A. Background on Non-Use Benefits

Non-use benefits may arise if people value the change in an ecological resource apart from the prospect of using the resource or enjoying the option to use it in the future. The EPA *Guidelines*, for example, note that there are various possible types of non-use values an individual might have (EPA 2014b, p. xiv).

1. Bequest value, in which the individual places a value on the availability of a resource to future generations;

2. Existence value, in which the individual values the mere knowledge of the existence of a good or resource; and

3. Paternalistic altruism, in which the individual places a value on others' enjoyment of the resource.

The 2014 *Guidelines* note that environmental policies may have non-use benefits from improvements to "relevant species populations, communities, or ecosystems" (EPA 2014b, p. 7-9). In terms of improvements to relevant species populations, for instance, people may attach non-use benefits to preserving an endangered species (EPA 2014b, p. 7-18).

In its analysis of the national benefits of the Final Rule, the EPA describes non-use benefits as including the value that individuals place on knowing that increased fish protection would enable a species to exist or an aquatic ecosystem to be healthy (EPA 2014a, p. 48350, EPA 2014b, p. 4-7). In its guidance for site-specific analyses, the EPA notes that efforts should be made to determine if there are relevant existing studies (or studies that could be used via benefit transfer) to assess the value of potential non-use benefits (EPA 2014a, p. 48371).

B. Overview of Assessment of Potential Non-Use Benefits

In accordance with economic principles and the guidance in the EPA 2014 Final Rule, our assessment of non-use benefits from the CWIS alternatives proceeds in the following four steps: (1) determine whether existing information is available to provide a monetary estimate of the non-use benefits due to reduced entrainment at BFN, either directly from an existing study or through benefits transfer; (2) if no existing information is available, use guidance from the economic literature and quantitative information to determine whether non-use benefits are likely to be significant; (3) given the results of the economic assessment, determine whether it would be appropriate to develop an independent study of non-use benefits; and (4) if no study is available or warranted to provide a monetary valuation, provide a non-monetary evaluation of non-use benefits based on the existing information. The results of these steps allow us to provide

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conclusions regarding the potential significance of non-use benefits from the two CWIS alternatives.

C. Assessment of Existing Studies on Non-use Benefits

The EPA indicated in its guidance for site-specific evaluations in the Final §316(b) Rule that non-use benefits should be monetized if suitable results exist from an existing study or a study that could be used as the basis for benefit transfer. No existing study of non-use benefits at BFN has been performed. We thus focus on determining if there are existing studies that can be used as the basis for benefit transfer.

1. Criteria for Suitability of Benefit Transfer

As a threshold matter, benefit transfer analysis is only a valid approach when a prior study has evaluated a comparable commodity, where comparability includes (a) the nature of the environmental changes (in this case, potential increases in various fish populations) and (b) the location of the changes (in this case, the Tennessee River). The EPA has noted this comparability element of the benefits transfer approach, cautioning that "the less similar are the commodities valued in the existing ecological benefit studies …the less valid will be the transfer of the resulting value estimate or function (EPA 2014b, p. 7-19). In the EPA *Guidelines*, the EPA states:

> Study cases potentially suitable for use in benefit transfer should be similar to the policy case in their: (1) definition of the environmental commodity being valued (include scale and presence of substitutes); (2) baseline and extent of environmental changes; and (3) characteristics of affected populations. Analysts should avoid using benefit transfer in cases where the policy or study case is focused on a "good" with unique attributes or where the magnitude of the change or improvement across the two cases differs substantially (EPA 2014b, p. 7-46).

2. Literature Search for Comparable Non-Use Studies

NERA performed a literature review of non-use valuation studies to determine if there are any studies that might be used as the basis for benefit transfer. Consistent with the EPA recommendation to "develop an explicit set of selection criteria to evaluate each of the potentially relevant studies for quality and applicability to the policy case," NERA used the following two criteria for an appropriate non-use benefit study to be used as the basis of benefit transfer (EPA 2014b, p. 7-45):

1. The non-use study pertains to a comparable commodity and environmental change (i.e., potential increases in fish populations that are similar to those relevant at BFN); and

2. The non-use study pertains to a comparable site (i.e., the site is sufficiently similar to the Tennessee River).

We conducted a systematic review of existing literature to identify studies that had the potential to serve as a valid basis for benefit transfer. This review relied on electronic databases included in Google and Google Scholar, and included the following search terms: "non-use benefit valuation,"

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"bequest value," "existence value," "altruistic value," "non-market value," "stated preference survey," "contingent valuation," and "willingness-to-pay." In terms of geographic criteria, we searched for studies pertaining to rivers in the East.

3. Summary of Information on Non-Use Studies Reviewed

Table 6 summarizes the studies uncovered in our literature search and our evaluations of their appropriateness for benefits transfer based upon the two benefit transfer criteria provided above. Table 7 provides specifics regarding each study and our reasons for concluding that each is not appropriate for benefit transfer to non-use benefits for the CWIS alternatives at BFN.

Table 6: Summary of Appropriateness of Benefit Transfer for Studies Reviewed in Literature Search

Study	Adequately Similar Environmental Change	Adequately Similar Study Site
Huang et al. (1997)	No	No
Kotchen et al. (1999)	No	No
Farber et al. (2000)	No	No
Holmes et al. (2004)	No	Yes
Collins et al. (2005)	No	Yes
Whitehead (2005)	No	Yes
Foster (2008)	No	No
Kenney et al. (2012)	No	No
Zhao et al. (2013)	No	No
Lewis et al. (2017)	No	Yes
Burch et al. (2020)	No	Yes

Source: NERA.

Table 7: Evaluation of Appropriateness of Benefit Transfer for Studies Reviewed in Literature Search

Study	Summary of Study	Appropriateness for Benefits Transfer
Huang et al. (1997)	Huang et al.'s (1997) analysis uses stated and revelated preferences to develop willingness-to-pay estimates for use and non-use values for the Albemarle and Pamlico Sounds in North Carolina.	The study does not distinguish between ecological benefits and thus focuses on too broad an environmental change (i.e., it is not adequately similar to the benefits from increase in fish population from the entrainment technology alternatives at BFN). Additionally, the sites under consideration are too dissimilar from the Tennessee river for use in a benefits transfer. Therefore, the study is not appropriate for benefits transfer at BFN.

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Kotchen et al. (1999)	Kotchen et al. (1999) explores the relationships among environmental attitudes, nonuse values for endangered species, and underlying motivations for contingent valuation (CV) responses using the New Ecological Paradigm (NEP) scale and a CV survey for peregrine falcons and shortnose sturgeons in Maine.	While the study provides WTP estimates for individual fish species, the species under consideration (i.e., shortnose sturgeon and peregrine falcon) are not part of the fish population for which we assess benefits. Therefore, the study is not appropriate for benefits transfer at BFN.
Farber et al. (2000)	Farber et al. (2000) uses a conjoint analysis of survey results to develop willingness-to-pay estimates for water quality improvements in the Layola Creek and Conemaugh River in western Pennsylvania.	The study does not distinguish between ecological benefits and thus focuses on too broad an environmental change (i.e., it is not adequately similar to the benefits from increase in fish population from the two CWIS alternatives at BFN). Additionally, the sites under consideration are too dissimilar from the Tennessee river for use in a benefits transfer. Therefore, the study is not appropriate for benefits transfer at BFN.
Holmes et al. (2004)	Holmes et al. (2004) use a computerized contingent valuation survey instrument to develop the total economic value of restoration along the Little Tennessee River in western North Carolina for the following attributes: abundance of game fish, water clarity, wildlife habitat, allowable water uses, and ecosystem naturalness	The WTP estimates do not distinguish between ecological benefits and thus focuses on too broad an environmental change (i.e., it is not adequately similar to the benefits from increase in fish population from the two CWIS alternatives at BFN). Therefore, the study is not appropriate for benefits transfer at BFN.
Collins et al. (2005)	Colins et al. (2005) uses a contingent valuation approach to estimate the economic value of restoring Deckers Creek in Monongalia and Preston counties of West Virginia for three attributes: aquatic life, swimming, and scenic quality.	The WTP estimates do not distinguish between ecological benefits and thus focuses on too broad an environmental change (i.e., it is not adequately similar to the benefits from increase in fish population from the two CWIS alternatives at BFN). Therefore, the study is not appropriate for benefits transfer at BFN.
Whitehead (2005)	Whitehead (2005) uses a contingent valuation survey to estimate the willingness-to-pay for water quality improvements in the Neuse River basin in North Carolina.	The study does not distinguish between ecological benefits and thus focuses on too broad an environmental change (i.e., it is not adequately similar to the benefits from increase in fish population from the two CWIS alternatives at BFN). Additionally, the sites under consideration are too dissimilar from the Tennessee river for use in a benefits transfer. Therefore, the study is not appropriate for benefits transfer at BFN.
Foster (2008)	Foster (2008) uses a contingent valuation survey to determine the willingness-to-pay for improved water quality (as determined by nitrate-N reductions) in the Ichetucknee Springs and River for residents of Columbia County, Florida.	The study does not distinguish between ecological benefits and thus focuses on too broad an environmental change (i.e., it is not adequately similar to the benefits from increase in fish population from the two CWIS alternatives at BFN). Therefore, the study is not appropriate for benefits transfer at BFN.

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Kenney et al. (2012)	Kenney et al. (2012) uses a contingent valuation survey to quantify the dollar value of improvements to streams in urban areas (Maryland), in particular changes to the aesthetic and recreation attributes of the streams.	The WTP estimates do not distinguish between ecological benefits and thus focuses on too broad an environmental change (i.e., it is not adequately similar to the benefits from increase in fish population from the two CWIS alternatives at BFN). Additionally, the sites under consideration are too dissimilar from the Tennessee river for use in a benefits transfer. Therefore, the study is not appropriate for benefits transfer at BFN.
Zhao et al. (2013)	Zhao et al. (2013) uses a choice experiment to estimate the willingness-to-pay for the restoration of migratory fish passage in the Pawtuxet watershed of Rhode Island, using various indirect and direct benefit measures including the abundance of migratory fish.	Though the study provides estimates of WTP for changes in fish abundance and viability, both the watershed and species of this study are not comparable to the Tennessee River. Therefore, the study is not appropriate for benefits transfer at BFN.
Lewis et al. (2017)	Lewis et al. (2017) studies the willingness-to-pay for riparian zones in the Ozark watershed of northwest Arkansas. A mail survey was conducted using contingent valuation methods to elicit local willingness to pay for riparian zones.	The study does not distinguish between ecological benefits and thus focuses on too broad an environmental change (i.e., it is not adequately similar to the benefits from increase in fish population from the two CWIS alternatives at BFN). Therefore, the study is not appropriate for benefits transfer at BFN.
Burch et al. (2020)	Burch et al. (2020) used a contingent valuation survey to develop willingness-to-pay estimates for use and non-use values for the ecosystem services of the Kiamichi River in southeastern Oklahoma, including the following attributes: Freshwater provision, Water regulation, Habitat for species, Air quality, Water quality, Recreation, Cultural heritage, Local identity.	The WTP estimates do not distinguish between ecological benefits and thus focuses on too broad an environmental change (i.e., it is not adequately similar to the benefits from increase in fish population from the two CWIS alternatives at BFN).Therefore, the study is not appropriate for benefits transfer at BFN.

Source: NERA.

4. Conclusions Regarding Applicability of Existing Non-use Benefit Studies

Our literature survey did not uncover any non-use study that provided an acceptable basis for benefits transfer to the two CWIS alternatives at BFN. We thus conclude that no studies are appropriate to use as the basis for benefits transfer to develop non-use values for the CWIS alternatives.

D. Economic Criteria for Likely Significance of Non-Use Benefits

The economics literature on non-use valuation provides guidance on situations in which non-use values are likely to be significant. We use this literature to structure an assessment of the likely significance of non-use benefits due to the installation of the CWIS alternatives at BFN.

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In his text on measuring environmental and resource values, Freeman (2003) reviews the literature on non-use values, considering the situations in which non-use values are likely to be important:

> Another important question is, when are non-use values likely to be important? The long literature on non-use values emphasizes the *uniqueness or specialness of the resource in question* and the *irreversibility of loss or injury*. For example, economists have suggested that there are important non-use values in preserving the Grand Canyon in its natural state and in preventing the global or local extinction of species and the destruction of unique ecological communities. In contrast, resources such as ordinary streams and lakes or a subpopulation of a widely dispersed wildlife species are not likely to generate significant non-use values because of the availability of close substitutes. Moreover, the literature does not suggest that non-use values are likely to be important where recovery from an injury is quick and complete, either through natural processes or restoration (Freeman 2003, pp. 156-157, emphasis added).

Thus, Freeman's (2003) review of this literature suggests two operative criteria for evaluating whether non-use value for fish protection is likely to be important:

1. The resource effect is unique, in contrast to effects on a widely dispersed wildlife species; and

2. The loss would be irreversible or subject to a long recovery period.

Freeman (2003) recognizes that there is no generally accepted method of determining whether a resource is sufficiently unique, or a resource change is of sufficient duration to generate important non-use values (Freeman 2003, p. 157). But he suggests that unless the two criteria mentioned above are met, non-use values are unlikely to be important. Freeman also notes that stated preference methods should be used cautiously, as it is extremely difficult to perform such studies well (Freeman 2003, p. 183).

E. Implications for Potential Significance of Non-use Benefits

The Freeman criteria described above can be used to evaluate the potential significance of non-use benefits from the installation of the two CWIS alternatives at BFN. We consider the two factors (uniqueness and irreversibility) in terms of a quantitative assessment of changes in threatened and endangered ("T&E") species and other species.

1. Threatened and Endangered Species

Normandeau provides a discussion of potential T&E species at BFN (see Normandeau Report, Section 6.1). A complete evaluation of impacts to T&E species includes an assessment of both the direct benefits to such species as well as the potential indirect benefits due to impacts to critical habitat.

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a. Benefits to Threatened and Endangered Species

The Normandeau Report notes that Alabama provides ranks for species of concern in the state, three of which have been observed in the vicinity of BFN in electrofishing and gill net data since 1993. The Paddlefish, identified as "state protected," and the Bigeye Chub, identified as "state vulnerable," were each identified only once in the samples over that time. The Silver Redhorse, identified as "imperiled," was observed in 17 of 21 years of this sampling but has not appeared in the BFN entrainment samples. Normandeau notes that the Silver Redhorse "is not expected to be impacted by cooling water withdrawal" (Normandeau Report, Section 6.1).

Based upon consideration of this information, the Normandeau Report concludes that "no or negligible non-use benefits are expected from protecting threatened and endangered species by entrainment reduction technologies" (Normandeau Report, Section 6.1).

b. Conclusions on Threatened and Endangered Species

The biological information provided in the Normandeau Report indicates that the installation of the CWIS alternatives at BFN would not lead to protection of a unique resource, based upon impacts on T&E species. If there were no such effects, there would be no effect on long-term sustainability of T&E species. Thus, using the two operative criteria indicated by Freeman (2003), non-use benefits of the CWIS alternatives would not likely be significant as judged by impacts on T&E species.

2. Species Other Than Threatened and Endangered Species

Normandeau also assessed the potential effects of BFN entrainment on the viability of species other than T&E, and we rely upon these assessments (see Section 6.2 of Normandeau Report). Normandeau used total fish harvest and total fish catch in the Wheeler Reservoir, the relevant fishery in the vicinity of BFN, as measures of the total populations that might be affected by changes at BFN, as estimates of the total abundance were not available. Though data specific to individual species in the Wheeler Reservoir were limited, Normandeau developed inferences of the effects of BFN on Blue Catfish and Channel Catfish in the Wheeler Reservoir on the Tennessee River. Table 8 summarizes the estimates in the Normandeau report, which show the total gains in mortality for Blue Catfish and Channel Catfish due to the two CWIS alternatives at BFN as percentages of total recreational harvest and of total recreational catch in the Wheeler Reservoir. The results indicate that both CWIS alternatives would have very small effects on the Wheeler Reservoir population of these two species, based either on total harvest or total catch. Indeed, both measures represent conservative proxies for the mortality losses measured as a percentage of the Wheeler Reservoir populations for these species. For example, the reduction in mortality losses from CCRS represents just 4.1% of total annual harvest and just 1.6% of total annual catch and so would represent an even smaller percentage of the species population in the reservoir.

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Table 8: Reductions in Mortality of Blue Catfish and Channel Catfish as Percentages of Recreational Harvest and Recreational Catch

	Harvest Population			Catch Population		
Technology	Annual Combined Blue and Channel Catfish Mortality Reductions	Annual Combined Blue and Channel Catfish Harvest	Mortality / Harvest Population (%)	Annual Combined Blue and Channel Catfish Mortality Reductions	Annual Combined Blue and Channel Catfish Catch	Mortality / Catch Population (%)
0.5-mm Fine-Mesh Screen	1,126	43,626	2.6%	1,126	112,600	1.0%
Closed-Cyle Recirculating System	1,778	43,626	4.1%	1,778	111,125	1.6%

Source: Normandeau Report, Section 6.2.

Normandeau also considered the effects of the CWIS entrainment of fish eggs and larvae. Of the populations for these early life stages that are transported past the plant, 6.4% of eggs and 10.6% of larvae were entrained (Normandeau Report, p. 91). These percentages overstate the impacts on relevant eggs and larvae, however, because they do not account for eggs and larvae that grow to non-planktonic life stages (i.e., grow out of eggs and larvae) upstream of the plant nor for eggs and larvae that spawn downstream of the plant.

In summary, the Normandeau Report concludes: "Considering the available data, the entrainment losses at BFN without implementing a CCRS or FMS would not cause irreversible or long-lasting impacts to the fish populations or the recreational fishery in the Wheeler Reservoir. Therefore, no significant effects on the sustainability of non-threatened and endangered species would be expected from implementing entrainment reduction technologies" (Normandeau Report, p. 91).

These quantitative results and qualitative conclusions indicate that the benefits of the CWIS alternatives at BFN would not constitute a "unique" resource based upon the framework in Freeman (2003). Instead, the potential gains would be to a "subpopulation of a widely dispersed wildlife species," which Freeman notes would not be likely to generate significant non-use values. Moreover, if impacts would cease at the point at which BFN would discontinue operation, then any adverse effects of BFN would be reversible.

In summary, based upon the biological information provided in the Normandeau Report, the gains due to CWIS alternatives at BFN do not constitute unique resources and, indeed, any damage from not implementing the CWIS alternatives would not be irreversible. Thus, using the economic criteria in Freeman (2003), we conclude that non-use benefits of the CWIS alternatives at BFN would not likely be significant as judged by impacts on non-T&E species.

3. Appropriateness of Developing a Stated Preference Study to Monetize Non-Use Benefits

In principle, a well-designed stated preference study could be used to measure the potential non-use benefits associated with reduced entrainment at BFN due to the two CWIS alternatives. As noted in the EPA *Guidelines* (EPA 2014b, p. 7-35), however, stated preference studies are costly and obtaining reliable results from a stated preference study is challenging. Indeed, we are not aware of any instance in which non-use benefits have been estimated for changes in entrainment in the context of a site-specific 316(b) benefits valuation study.

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Accounting for the substantial costs and difficulty of developing a site-specific assessment of non-use benefits, as well as the conclusion that non-use benefits are not likely to be significant in this situation, we conclude that it is not appropriate to develop a stated preference study to assess non-use benefits from the CWIS alternatives. This conclusion is consistent with the EPA *Guidelines* (2014b, e.g., See C.7).

F. Conclusions Regarding Potential Non-Use Benefits

Based upon the available relevant biological information, the absence of an existing study of non-use values directly related to entrainment at BFN, the absence of a study that could be used appropriately as the basis for benefit transfer, and the overall cost and difficulty of developing an independent study of non-use benefits, we conclude that it is appropriate to provide a non-monetary evaluation of potential non-use benefits from the two CWIS alternatives. Based on the economic criteria outlined above and the biological information and conclusions related to T&E species and non-T&E species provided in the Normandeau Report and summarized above, we conclude that the non-use benefits are not likely to be significant for the two CWIS alternatives at BFN.

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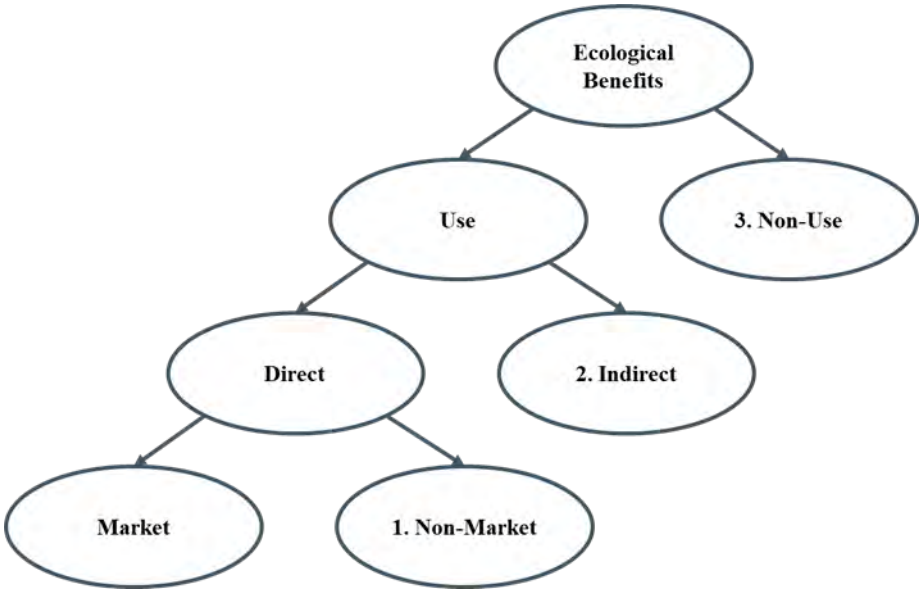
VII. Conclusions on Social Benefits

The following is a summary of our conclusions regarding the social benefits of the two CWIS alternatives at BFN.

A. Overview of Potential Social Benefit Categories

We use an economic framework for evaluating the potential social benefits of CWIS alternatives at BFN. The following diagram illustrates the potential benefit categories and the three categories we evaluate at BFN. There are no biological gains to commercial fishermen, the only potentially significant category of market use benefits, and thus we do not estimate direct market use benefits.

Figure 2: Summary of Benefit Classification Scheme from EPA 2000 Guidelines



Source: EPA (2000, p. 70); see also EPA (2014d, p. 7-9).

B. Monetized Recreational Benefits

As Table 9 indicates, the present values of total monetized benefits for 0.5 mm fine-mesh screens are about $0.65 million using a 3 percent discount rate and about $0.46 million using a 7 percent discount rate. The equivalent present values of total monetized benefits for CCRS are about $1.63 million using a 3 percent discount rate and about $1.08 million using a 7 percent discount rate.

Table 9 provides our estimates of the present values of the benefits of the two CWIS alternatives at BFN over the study period as of January 1, 2022, using annual discount rates of 3 percent and 7 percent. Values are presented in 2018 dollars to be consistent with the cost estimates. These values include direct use benefits as well as indirect use benefits based upon additional gains from additional forage due to the two CWIS alternatives.

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As Table 9 indicates, the present values of total monetized benefits for 0.5 mm fine-mesh screens are about $0.65 million using a 3 percent discount rate and about $0.46 million using a 7 percent discount rate. The equivalent present values of total monetized benefits for CCRS are about $1.63 million using a 3 percent discount rate and about $1.08 million using a 7 percent discount rate.

Table 9: Present Values of Total Monetized Social Benefits, 2022 – 2036 (2018$)

	Discount Rate	
Technology	**3%**	**7%**
0.5-mm Fine-Mesh Screens	$651,231	$460,414
Closed-Cycle Recirculating System	$1,630,354	$1,080,139

Note: All dollar values are in 2018 dollars. Present values are calculated as of January 1, 2022 for benefits accrued from 2022 to 2036. Benefits are assumed to occur annually in each year in which the plant operates. Note that this assumption may overstate benefits from 2033-2036, years in which one or more units may cease operation following permit expiration. For the purposes of present value calculations, the benefits are assumed to occur at the start of each year.

Source: NERA calculations as explained in text.

C. Potential Indirect Benefits

In addition to indirect benefits in the form of gains from additional recreational fish catch due to additional forage included in the monetized benefits estimates above, we also assessed potential market indirect use benefits (e.g., increases in fishing equipment sales) and potential non-market indirect use benefits (e.g., increases in value of boating or bird-watching). Consistent with EPA's benefit assessment in the Final 316(b) Rule, we did not develop monetary values for either category of potential indirect benefits.

For potential market indirect benefits, we rely on principles from the economic literature to conclude that secondary effects of changes in recreational fishing on the relevant markets would not lead to additional social benefits. Potential non-market indirect use benefits due to the CWIS alternatives were evaluated using biological information relevant to the economic evaluation. Based on the quantitative biological information and the conclusions in the Normandeau Report, we concluded that indirect benefits are not likely to be significant for the CWIS alternatives.

D. Potential Non-Use Benefits

After reviewing the relevant studies, we concluded that none was appropriate for use of benefit transfer to estimate the monetary value of non-use benefits of the two CWIS alternatives at BFN. The potential significance of non-use benefits due to the CWIS alternatives were evaluated based upon economic criteria for the likely significance of non-use benefits and quantitative biological information relevant to the economic criteria. Based on the quantitative biological information and economic criteria for significance, we concluded that non-use benefits are not likely to be significant for the two CWIS alternatives at BFN.

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Tennessee Valley Authority

Browns Ferry Nuclear Power Plant

National Pollutant Discharge Elimination System (NPDES) Permit No. AL0022080

Updated Final §316(b) Rule Information

40 CFR 122.21(r)(12) Submittal



Prepared for:
Tennessee Valley Authority

January 2022

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List of Acronyms and Abbreviations

Acronym/Abbreviation	Term/Phrase/Name
ºF	Degrees Fahrenheit
§	Section
ADEM	Alabama Department of Environmental Management
BMP	Best management practices
BFN	Browns Ferry Nuclear
CCRS	Closed cycle recirculating system
cfs	cubic feet per second
CoC	cycles of concentration
CWA	Clean Water Act
CWC	Cold Water Channel
CWIS	Cooling Water Intake Structure
dBA	A-weighted decibels
EA	Environmental Assessment
EECW	Emergency Equipment Cooling Water
EPA	U.S. Environmental Protection Agency
ft	feet
FHRS	Fish handling and return system
FICON	Federal Interagency Committee on Noise
FMS	Fine mesh traveling screens
gpm	Gallons per minute
kWh	Kilowatt hour
Ldn	Day-night average sound level
Leq	Equivalent sound level
MDCT	Mechanical draft cooling tower
MSL	Mean sea level
MWe	Megawatt electric
MWh	Megawatt hour
NAAQS	National Ambient Air Quality Standards
NPDES	National Pollutant Discharge Elimination System
NRC	United States Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NWP	Nationwide Permit
PM	Particulate matter
PM_{10}	Particulate matter with a diameter less than 10 microns
$PM_{2.5}$	Particulate matter with a diameter less than 2.5 microns
RBI	Reservoir Benthic Index
RFAI	Reservoir Fish Assemblage Index
RHRSW	Residual heat removal service water
SHPO	State Historic Preservation Officer
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority
UHS	Ultimate heat sink
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
WMA	Wildlife management area
WWC	Warm Water Channel

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1 Introduction

In accordance with the Clean Water Act (CWA) Final §316(b) Rule for Existing Facilities, 40 CFR Parts 122 and 125 (79 Fed. Reg. 48300-439) (August,15 2014) (Final 316(b) Rule or Rule), Tennessee Valley Authority (TVA) has prepared this document to address the Final §316(b) Rule information requirements specified in 40 CFR §122.21(r)(12). Section 122.21(r)(12) of the Rule requires applicants to prepare a non-water quality environmental and other impacts study, which includes the following information:

i. *estimates of changes to energy consumption, including but not limited to auxiliary power consumption and turbine backpressure energy penalty;*

ii. *estimates of air pollutant emissions and of the human health and environmental impacts associated with such emissions;*

iii. *estimates of changes in noise;*

iv. *a discussion of impacts to safety, including documentation of the potential for plumes, icing, and availability of emergency cooling water;*

v. *a discussion of facility reliability, including but not limited to facility availability, production of steam, impacts to production based on process unit heating or cooling, and reliability due to cooling water availability;*

vi. *a discussion of significant changes in consumption of water, including a facility-specific comparison of the evaporative losses of both once-through cooling and closed-cycle recirculating systems, and documentation of impacts attributable to changes in water consumption; and*

vii. *a discussion of all reasonable attempts to mitigate each of these factors.*

Pursuant to Section 122.21(r)(12) of the Rule, this report evaluates the non-water quality environmental and other impacts for the following two candidate technologies for entrainment reduction considered in the Comprehensive Technical Feasibility and Cost Evaluation Study for Browns Ferry Nuclear Power Plant (BFN):

- closed-cycle recirculating system
- dual-flow fine mesh traveling screens

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2 Environmental Setting

BFN is a three-unit, boiling water reactor nuclear power plant located on an 840-acre tract located in an unincorporated area of Limestone County, Alabama, approximately 10 miles northwest of Decatur, Alabama, and 10 miles southwest of Athens, Alabama (TVA 2010).

BFN lies on the north shore of Wheeler Reservoir. BFN utilizes a once-through condenser circulating water system to dissipate waste heat from steam turbines. The water is withdrawn from the Wheeler Reservoir /Tennessee River by an intake structure at approximate Tennessee River Mile (TRM) 294.3 into the intake forebay and returned to the river through submerged diffusers located on the bottom of the river at approximate TRM 294.0 (TVA 2020a). BFN operates its cooling water system under National Pollutant Discharge Elimination System (NPDES) Permit No. AL0022080 issued in 2018.

In addition to the three reactors, the site has seven mechanical draft cooling towers (MDCTs) and related cooling water system channels, turbine building, switchyards, numerous support buildings including a training center, lined sedimentation ponds and wastewater lagoons (TVA 2003), parking lots, roads, and open grassy areas and small wooded areas. Figure 2-1 shows the approximate landward property boundary for BFN, the plant structures, and the surrounding area. Figure 2-2 shows the major features of BFN's existing cooling water system.

Sources of non-radiological air pollutants at BFN include the MDCTs, the auxiliary steam generators, the emergency diesel generators, and miscellaneous other sources such as fuel storage facilities. BFN operates as a minor source under air quality permit No. 708-0003-X005 issued in June 2017. Emissions include carbon monoxide, carbon dioxide, particulate matter, nitrogen oxides, sulfur oxides, and volatile organic compounds. (TVA 2020a)

2.1 Land Use

As shown on Figure 2-1 which uses 2020 imagery, the surrounding area is primarily farmland with residential pockets. Residential areas border the BFN site on the north, Paradise Shores, and west, Point Westmoreland. Across Wheeler Reservoir from BFN, is the residential development of Lakeview. Limestone County does not have land-use zoning applicable to unincorporated portions of the county (Limestone County 2021). Based on 2018 Limestone County, Alabama, Flood Insurance Rate Maps 01083C0235F and 01083C0255F, BFN is located in areas of minimal flood hazard (FEMA 2018).

Also, across Wheeler Reservoir from BFN is the Mallard-Fox Creek Wildlife Management Area (WMA). Mallard-Fox Creek WMA is 1,742 acres offering waterfowl and small game hunting. A second WMA is Swan Creek WMA located on the north shore of Wheeler Reservoir approximately 3 miles upstream from BNF. Swan Creek is 8,870 acres, and also offers waterfowl and small game hunting. (ADCNR 2021)

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Figure 2-1. BFN and surrounding area. (Map data courtesy of Google© 2021)

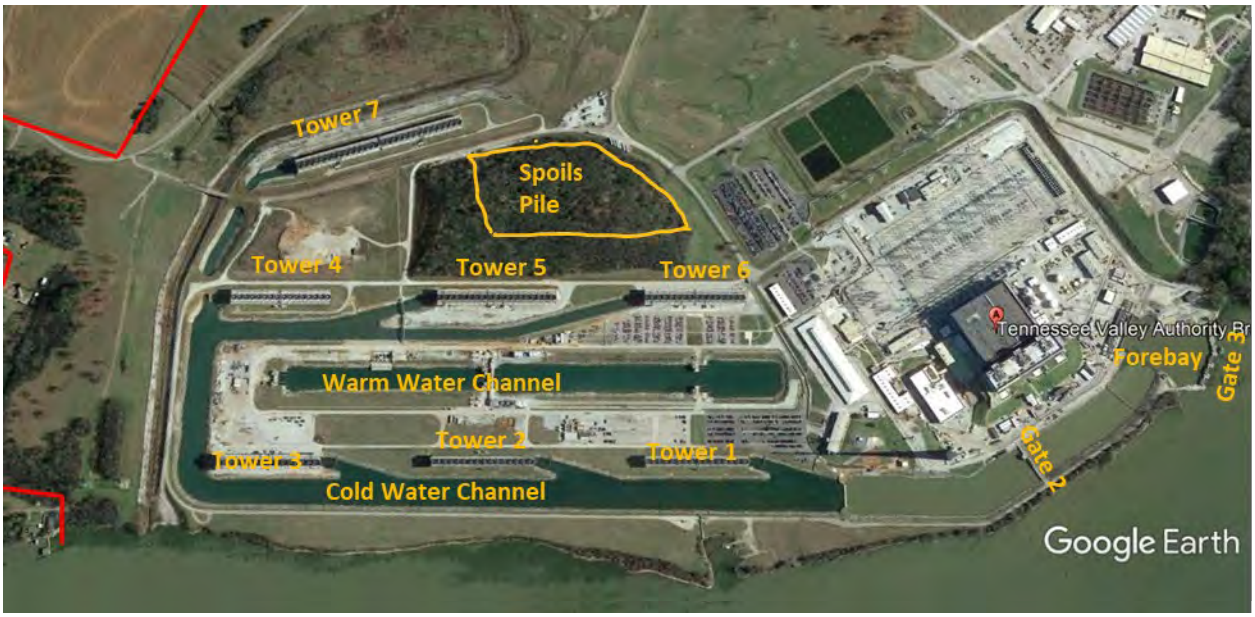


Figure 2-2. BFN Cooling Water System Features and 2018 spoils disposal site (Map data courtesy of Google© 2021)

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A desktop review was completed using United States Fish and Wildlife Service (USFWS) National Wetland Inventory data. Figure 2-3 shows that outside of the cooling water system, the BFN site has some freshwater forested/scrub wetland areas located well away from the developed areas (USFWS 2021a). Small, scattered areas of wetland vegetation (*Typha latifolia*) are located along the margins of the cooling tower cells; however, these areas are associated with the cooling water system at the BFN and are not considered jurisdictional wetlands subject to CWA Section 404 permitting (TVA 2020a).

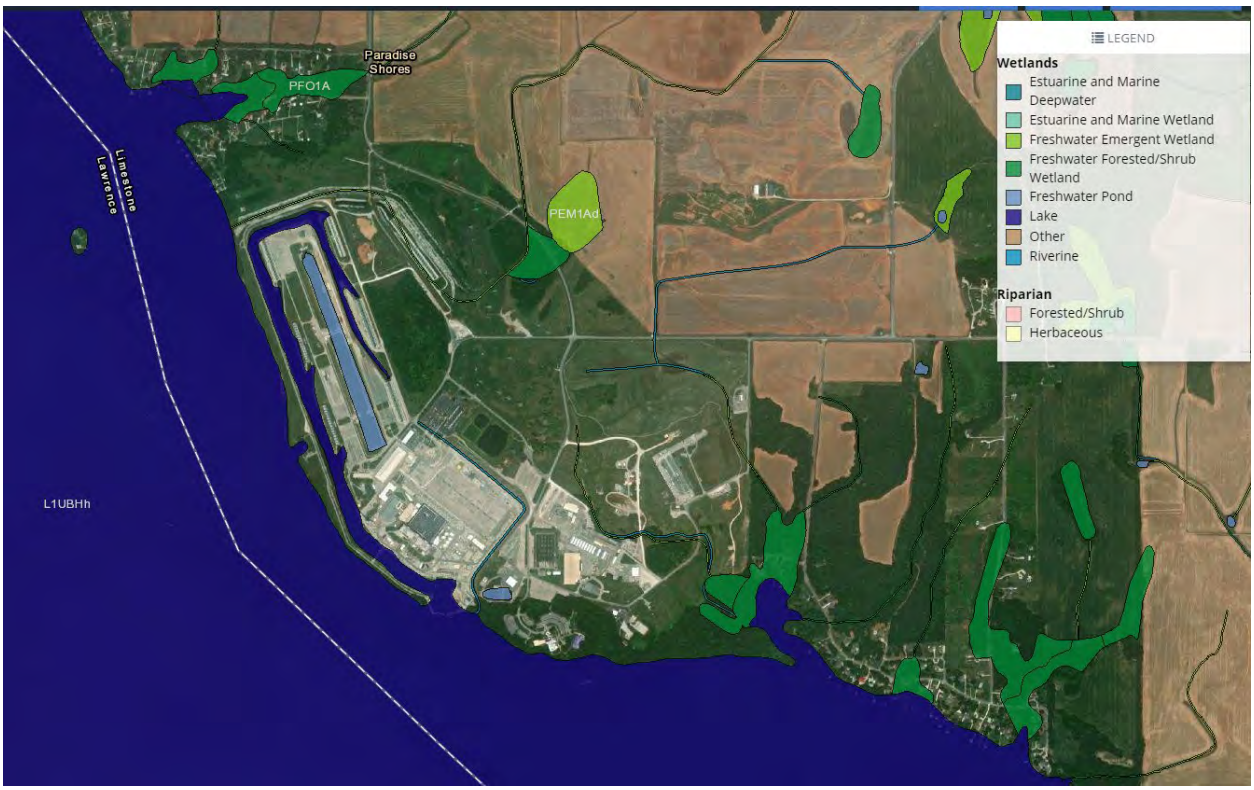


Figure 2-3. Results from National Wetlands Inventory for Browns Ferry Nuclear Plan and surrounding area (USFWS 2021a).

2.2 Aquatic Ecology

As mentioned above, BFN lies on the north shore of Wheeler Reservoir. The Reservoir is an impoundment on the Tennessee River. Flow of the Tennessee River at BFN is controlled primarily by releases from Guntersville Dam upstream and Wheeler Dam downstream. Flow past the plant is highly variable, ranging from an annual daily average of 20,000 to 80,000 cubic feet per second (cfs) (1977-2020). (TVA 2021a)

TVA monitors the health of the aquatic community in Wheeler Reservoir. TVA's multi-metric Reservoir Fish Assemblage Index (RFAI) attempts to address characteristics of a balanced indigenous population in a holistic manner by measuring 12 population "metrics", scoring the metrics based on expectations of healthy populations in the region, and summing the scores to arrive at an overall RFAI score and subsequent rating. The maximum RFAI score attainable is 60.

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Ecological health ratings are then applied to the scoring ranges: 12-21 “Very Poor”, 22-31 “Poor”, 32-40 “Fair”, 41-50 “Good”, or 51-60 “Excellent”. It has generally been accepted that an RFAI rating of “Fair” or better in the thermally affected area can be considered demonstration of a balanced indigenous population, particularly where RFAI scores for unaffected upstream areas are similar. RFAI scores for autumn 2020 were rated “46-Good” for the downstream site and “49-Good” for the thermally unaffected site upstream of BFN. Average RFAI scores for the period of 2000 through 2019 were “41-Good” at the downstream site and “42-Good” at the upstream site. (TVA 2021a)

TVA also uses its monitoring program to develop a Reservoir Benthic Index (RBI) of biotic integrity of the Wheeler Reservoir. TVA’s RBI is similarly calculated as the RFAI except that it uses seven metrics specific to the macroinvertebrate assemblage. The maximum RBI score is 35. Ecological health ratings are then applied to scoring ranges: 7-12 “Very Poor”, 13-18 “Poor”, 19-23 “Fair”, 24-29 “Good”, or 30-35 “Excellent.” The RBI score for autumn 2020 for upstream was 31 and the RBI scores for the two downstream monitoring sites were 31 and 33 (TVA 2021a).

Table 2-1 provides a list of federal or state protected aquatic species known within a 10-mile radius of BFN based on a query of TVA’s Natural Heritage Database. One fish species—spring pygmy sunfish—is listed under federal protection, and eight species of fish are under state protection or tracked within Alabama: bigeye chub, flame chub, paddlefish, redline darter, silver redhorse, southern cavefish, stargazing minnow, and Tuscumbia darter. The spring pygmy sunfish is considered extirpated within the vicinity of BFN, and no spring pygmy sunfish have been collected by TVA from 1993 to 2020 in the vicinity of BFN. Silver redhorse is the only of these protected species collected during TVA’s reservoir monitoring since 1993 and was done so during eight sample years with the most recent being in 2019 and 2020. (TVA 2021a)

A query of the USFWS Information for Planning and Consultation database (USFWS 2021b) for the approximate 10-mile radius of BFN, yielded three additional federally listed species -- the threatened fish species, the slackwater darter (*Etheostoma boschungi*) and two endangered mussel species, the sheepnose mussel (*Plethobasus cyphyus*) and the snuffbox mussel (*Epioblasma triquetra*).

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Table 2-1. Federal and state-listed aquatic animal species known within a 10-mile radius of Browns Ferry Nuclear Plant (TRM 294)[1]

Scientific Name	Common Name	Federal Status[2]	State Status[3]
FISH			
Hybopsis amblops	Bigeye Chub		TRKD
Hemitremia flammea	Flame Chub		TRKD
Polyodon spathula	Paddlefish		PROT
Etheostoma rufilineatum	Redline Darter		TRKD
Moxostoma anisurum	Silver Redhorse		TRKD
Typhlichthys subterraneus	Southern Cavefish		PROT
Elassoma alabamae	Spring Pygmy Sunfish	LT	PROT
Phenacobius uranops	Stargazing Minnow		TRKD
Etheostoma tuscumbia	Tuscumbia Darter		PROT
AMPHIBIANS			
Cryptobranchus alleganiensis	Eastern Hellbender	PS	PROT
MUSSELS			
Epioblasma haysiana	Acornshell		EXTI
Lemiox rimosus	Birdwing Pearlymussel	LE	PROT
Hemistena lata	Cracking Pearlymussel	LE	PROT
Epioblasma brevidens	Cumberlandian Combshell	LE	PROT
Dromus dromas	Dromedary Pearlymussel	LE	PROT
Ptychobranchus subtentum	Fluted Kidneyshell	LE	PROT
Toxolasma parvum	Lilliput		TRKD
Pleurobema cordatum	Ohio Pigtoe		TRKD
Lampsilis abrupta	Pink Mucket	LE	PROT
Potamilus ohiensis	Pink Papershell		TRKD
Toxolasma lividus	Purple Lilliput		TRKD
Obovaria retusa	Ring Pink	LE	PROT
Pleurobema plenum	Rough Pigtoe	LE	PROT
Cumberlandia monodonta	Spectaclecase	LE	PROT
Epioblasma torulosa torulosa	Tuberculed Blossom Pearlymussel	LE	PROT
Lasmigona complanata	White Heelsplitter		TRKD
SNAILS			
Elimia nassula	Round-rib Elimia		TRKD
Pleurocera pyrenella	Skirted Hornsnail		TRKD
Lithasia lima	Warty Rocksnail		HIST
Campeloma decampi	Slender Campeloma	LE	PROT

[1] Source: TVA Natural Heritage Database, queried on 03/25/2021 (TVA 2021a)
[2] Federal Status Codes: LE = Listed Endangered; LT = Listed Threatened; PS=Partial status (Missouri distinct population segment is listed);
[3] State Status Codes: PROT=State Protected; TRKD=Not protected by State, but tracked; EXTI=Extirpated; HIST=Historical record

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2.3 Terrestrial Ecology

The BFN site is a heavily disturbed area and provides limited wildlife habitat. Due to the lack of features that provide high-quality wildlife habitats, such as streams, springs, caves, rock bluffs, and moist forested habitats, the overall diversity of wildlife at BFN is not uncommon from a local, state, or regional perspective. Terrestrial wildlife species found among upland habitats on the BFN site are generally common and have widespread distributions. No uncommon wildlife communities or important terrestrial habitats, such as caves, occur within 3 miles of BFN (TVA 2020a). As mentioned above, two WMAs offering wildlife habitat are within 3 miles of BFN.

Review of the USFWS Information for Planning and Consultation database (USFWS 2021b) identified nine migratory birds of conservation concern (blue-winged warbler (*Vermivora cyanoptera*), Kentucky warbler (*Geothlypis formosa*), Le Conte's sparrow (*Ammodramus leconteii*), lesser yellowlegs (*Tringa flavipes*), prairie warbler (*Setophaga discolor*), red-headed woodpecker (*Melanerpes erythrocephalus*), rusty blackbird (*Euphagus carolinus*), semipalmated sandpiper (*Calidris pusilla*), and wood thrush (*Hylocichla mustelina*) that have the potential to occur within about 10-miles of BFN. In addition, the bald eagle (*Haliaeetus leucocephalus*) and golden eagle (*Aquila chrysaetos*) both protected under the Bald and Golden Eagle Protection Act were identified by the USFWS as having the potential to occur within about 10 miles of BFN. The nearest bald eagle record is a nest that is approximately 6.0 miles from BFN (TVA 2020a). Suitable foraging habitat for bald eagle exists in the Warm Water Channel (WWC) and the Cold Water channel (CWC). Additional foraging habitat for bald eagle exists in the Wheeler Reservoir.

A review of threatened and endangered terrestrial species records in the TVA Regional Natural Heritage Database in February 2020 identified one state-listed species (osprey [*Pandion haliaetus]*) and one federally listed species (gray bat [*Myotis grisescens*]) within 3.0 miles of the onsite cooling tower area shown Figure 2-2. An osprey nest has been recorded as occurring approximately 930 feet from the onsite area hosting the CTs. However, this nest was not found during a February 2020 field review. (TVA 2020a) Suitable foraging habitat for osprey exists in and above the WWC and CWC. Additional foraging habitat for osprey exists in and above the Wheeler Reservoir. Two other protected bat species were identified by USFWS (2021b) as having the potential to occur in Limestone County, Alabama, the federally listed Indiana bat (*Myotis sodalis*) and northern long-eared bat (*Myotis septentrionalis*).

Table 2-2 presents the protected terrestrial species applicable to the BFN site identified in the TVA Regional Natural Heritage Database and the USFWS Information for Planning and Consultation database.

The BFN site was extensively disturbed during BFN construction with only an approximately 4-acre wooded area within the 840-acre BFN site containing intact soils and sediments remaining (TVA 2015). TVA has conducted several archaeological surveys within BFN for various projects. TVA assessed the area that hosts the cooling towers as the Area of Potential Effect for Environmental Assessments (EAs) in 2010 and 2020, concluding for both that the projects would have no adverse effect on cultural resources (TVA 2010 and TVA 2020).

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Table 2-2. Federal and State-Listed Terrestrial Species for approximate 10-mile radius of BFN[1]

Scientific Name	Common Name	Federal Status[2]	State Status[2]
BIRDS			
Haliaeetus leucocephalus	Bald eagle	BGEPA	PROT
Pandion haliaetus	Osprey		PROT
MAMMALS			
Myotis grisescens	Gray bat	LE	PROT
Myotis sodalis	Indiana bat	LE	PROT
Myotis septentrionalis	Northern long-eared bat	LT	PROT
PLANTS			
Leavenworthia crassa	Fleshy-fruit gladecress[3]	LE	PROT

[1] Source: and USFWS 2021b for all species except Osprey which was identified in TVA 2020a
[2] Status Codes: LE = Listed Endangered; LT = Listed Threatened; BGEPA = protected under the Bald and Golden Eagle Protection Act, PROT=State Protected.
[3] USFWS 2021c identifies range within the 10-mile radius as Lawrence County on the opposite side of Wheeler Reservoir and TVA 2020a did not identify this species as being recorded within 3-miles of BFN

2.4 Cultural Resources

BFN meets minimum age criteria (a property achieving significance within the past 50 years) for inclusion in the National Register of Historic Places (NRHP), therefore BFN is potentially eligible for inclusion in the NRHP. However, no formal determination of eligibility has been made for BFN. BFN is considered by TVA to be eligible for listing in the NRHP under Criterion A (association with events that have made a significant contribution to the broad patterns of our history), based on an in-house assessment. (TVA 2020a)

To support the 2015 extended power uprate license amendment request, TVA researched current historic property records for aboveground resources at the Alabama Historical Commission, and identified all previously identified above-ground properties within a 6-mile radius of BFN. No architectural resources included or eligible for inclusion in the NRHP have been recorded within 3 miles of BFN. The nearest such resource is the Burt Cemetery, located approximately 3.5 miles southeast of the plant on the opposite side of the Tennessee River. (TVA 2015) A review of the Alabama Historical Commission's online interactive map of recorded sites and the National Park Service's listing of NRHPs did not identify any additional properties within approximately 3 miles (AHC 2021 and NPS 2021).

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3 Closed-cycle Cooling

BFN currently has seven linear mechanical draft cooling towers with a total of 127 cells. Under a separate, previous project, TVA is, in 2021, replacing and upgrading Towers 1 and 2 which are past their service life span. This project also includes replacement of the associated lift pumps. After the modifications to Towers 1 and 2, BFN will have a total of 139 tower cells. The implementation of a closed-cycle recirculating system (CCRS) consistent with the definition found in 40 CFR 125.92(c) at BFN would utilize BFN's existing cooling towers with the Tower 1 and 2 replacements, lift pump upgrades, and additional modifications. For implementation of the CCRS at BFN additional modifications are required as follows:

Additional cooling tower replacements and upgrades

- upgrade/replacement of the lift pumps and discharge valves for Towers 3, 4, 5, and 6,
- refurbishment or replacement of Tower 4,
- upgrade of Tower 7's flow distribution system to allow the flow capacity of all four lift pumps,
- 2 new vacuum tanks, pumps, and piping,
- new control building and electrical equipment enclosures located in the cooling tower area,

Modifications to the forebay and water channels:

- installation of a new gate structure (New Gate 2) downstream from existing Gate 2,
- partial removal of existing Gate 2,
- installation of spillways in the CWC and WWC,
- installation of bypass lines for each cooling tower from their lift pump discharge header into and along the length of the CWC,
- maintenance dredging in the forebay, and

Chemical Treatment:

- year-round chemical treatment

3.1 Construction-related Impacts

In 2020, TVA assessed the environmental impacts of various cooling tower upgrades to be constructed/installed at BFN (TVA 2020a). The 2020 EA considered the impacts of replacement/expansion of Towers 1 and 2, replacement/upgrade of the associated four lift pumps, installation of a flow distribution system upgrade for Tower 7, installation of a vacuum priming system, modification of Gate 1 within the CWC, and installation of chlorination systems for each cooling tower lift pump at an onsite project area of 224 acres shown in Figure 3-1. The Tower 7 flow and vacuum prime systems overlap with the cooling tower replacement and upgrades listed in Section 3. The replacement of Towers 1 and 2 and associated lift pumps would be similar in scope to replacement of Tower 4 and lift pump upgrades. With the exception of construction of a new Gate 2 and partial removal of the existing Gate 2, the modifications required for CCRS would take place within the 224-acre project area considered in TVA's 2020 EA and construction

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techniques and the construction equipment used would be similar. TVA determined in the 2020 EA that the construction impacts to air, surface water and groundwater resources, terrestrial ecology, and waste management would be minor, temporary, and localized and no impact to wetlands, floodplains, cultural resources, or aquatic ecology (TVA 2020a). TVA issued a Finding of No Significant Impact for the project (TVA 2020b).

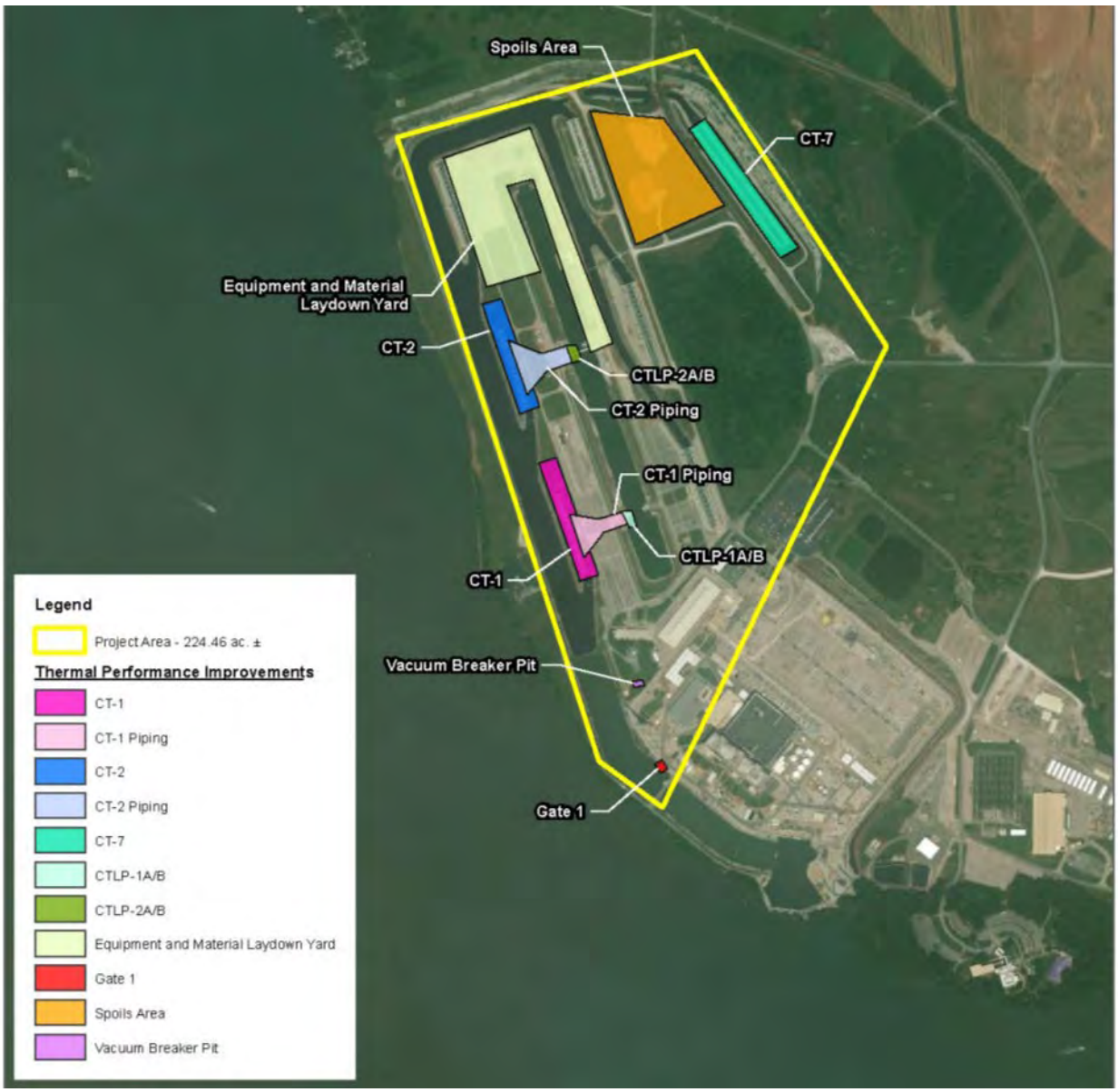


Figure 3-1. Project area and components assessed in BFN Thermal Performance Program Cooling Tower Capacity Improvements Enviornmental Assessment
(Figure reproduced from TVA 2020a)

As part of the CCRS, a new Gate 2 would be constructed downstream from the existing Gate 2, in the approximate location indicated by the blue marker in the Figure 3-2. The structure would consist of a dam extending into the CWC, with a reinforced concrete center with a built-in gate.

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This reinforced concrete center structure would be similar in size and width to the existing Gate 2, but the size of the openings would be sufficient to accommodate the cooling water flow of all three units.

Installation of this structure would require a sheet pile cofferdam to install the reinforced concrete portion of the dam. The earthen portion of the dam would be supported with the use of sheet pile cofferdams backfilled internally with structural fill and externally protected by rip rap. Once installation of the new Gate 2 is complete, the existing Gate 2 would undergo partial demolition. Cofferdams would remain in place as appropriate during construction of the new Gate 2 and demolition of the existing Gate 2 to minimize sedimentation and turbidity impacts to the CWC.



Figure 3-2: New Gate 2 Location (Map data courtesy of Google© 2021)

To mitigate the potential for uncontrolled flooding under certain operating scenarios, the CCRS candidate technology includes the construction of two spillways. The WWC spillway would be implemented across the berm separating the WWC and the CWC, spilling into the CWC as far upstream as practical (e.g., between Towers 4 and 5). The CWC spillway would be implemented across the dike separating the CWC from the reservoir upstream of Gate 2. The approximate locations of the spillways are indicated by the yellow markers in the Figure 3-3. The spillways would be constructed by excavation and backfill with crushed stone topped with riprap conforming to the sloping requirements for seismic qualification.

The CWC spillway would involve the dike separating the CWC from Wheeler Reservoir. The normal water level of the Wheeler Reservoir ranges from 550 ft to 556 ft mean sea level (MSL).

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The top elevation of the dike between the CWC and the Wheeler Reservoir is 565 ft MSL. The spillway would have an elevation between 557 and 562 ft MSL. This dike work would require a CWA Section 404 permit issued by the USACE, either a Nationwide Permit (NWP) (e.g., NWP 3, Maintenance or NWP18, Minor Discharges) or an Individual Permit. Because this project includes additional project components including potentially conducting maintenance dredging in the forebay, it could require an USACE Individual Permit. If the project does not qualify for NWP authorization, a joint permit application to the USACE (Nashville District) and the Alabama Department of Environmental Management (ADEM) would be required. The permitting process would require consultations with the USFWS and the Alabama Department of Conservation and Natural Resources regarding the potential for affects to protected species. The permit would establish conditions to protect water quality and the Wheeler Reservoir aquatic community. The permitting process would also require consultation with the State Historic Preservation Officer regarding the potential for affects to cultural resources.



Figure 3-3: Spillway Locations (Map data courtesy of Google© 2021)

As mentioned above, implementation of the CCRS would also require dredging in the forebay. The dredging could be covered under NWP 3 as the dredging within the forebay in 2018 was covered. The CCRS flow path would pass over the undredged area, which is approximately 175,000 ft^2. This portion of the forebay bottom would be evaluated for excessive levels of sediment deposition and restored to its original depth as necessary via dredging. Assuming an equivalent dredged volume per square foot of area as experienced with the 2018 dredging, approximately 6,000 cubic yards of dredging would be required in the remainder of the forebay. It is assumed that dredging spoils would be added to the spoils pile shown on Figure 2-2 which was used for the 2018 dredge spoils disposal. TVA would submit a preconstruction notification for coverage under NWP 3 for the dredging or seek an Individual Permit.

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3.1.1 Terrestrial Ecology Impacts

As presented in Section 2, the BFN site is a heavily disturbed area with limited wildlife habitat, none of which is high-quality wildlife habitat. Construction activities would take place within the plant's industrialized area, consisting primarily of existing buildings and structures, parking areas, roads, cooling water channels, and maintained grasses. Scattered trees are located throughout the area surrounding the cooling towers and channels and a small, forested area is located adjacent to Towers 5 and 6 and east of the dredge spoils pile used for the 2018 dredging (Figure 2-2). Common mammals, birds, and reptiles have been observed using parts of buildings abandoned or used infrequently by humans. Species of bats commonly found in this region may roost in abandoned, dark, or quiet areas of structures. Migratory birds may also roost in buildings or infrequently used areas of buildings. (TVA 2020a)

Table 2-2 lists the protected terrestrial species for an approximate 10-mile radius of BFN. These are bird and bat species and a plant species. Foraging habitat for protected bird and bat species exists in and above the cooling water channels as well as above and along the forested area adjacent to Towers 5 and 6. Additional foraging habitat for these species exists adjacent to BFN in and above the Wheeler Reservoir. The small, forested area adjacent to Towers 5 and 6 may also provide roosting and maternity habitat for the northern long-eared bat and Indiana bat. The range for the plant species, Fleshy-fruit gladecress (*Leavenworthia crassa*) does not include Limestone County, Alabama.

Construction activities may result in direct impacts to immobile species and in the displacement of common wildlife species using the cooling tower area, including nesting birds. Project activities will be performed in accordance with the Migratory Bird Treaty Act (e.g., construction timing restrictions or nest surveys) to avoid impacts to avian species. TVA would also follow USFWS guidance to avoid take of the bald eagle. Depending on timing, construction could adversely affect threatened or endangered species. Construction during the northern long-eared bat pup season could potentially adversely affect this listed species. If tree removal occurred during spring/summer, this could be considered an adverse impact to the Indiana bat. As part of its bat strategy, TVA completed an Endangered Species Act programmatic consultation in 2018 for endangered or threatened bats in the TVA Region (gray bat, Indiana bat, northern long-eared bat, and the Virginia big-eared bat (TVA 2021b). The consultation is effective for 20 years (TVA 2021b). TVA would follow its bat strategy procedure to assess the potential for impacts and implement the conservation measures described in the Programmatic Biological Opinion as appropriate. Due to the minimal amount of suitable wildlife habitat present, impacts to species are anticipated to be minor, temporary, and localized. TVA would implement guidelines and strategies to avoid adverse impacts to protected species (i.e., may affect, but not likely to affect listed species).

3.1.2 Surface Water and Aquatic Ecology Impacts

Construction activities resulting in land disturbance of one acre or greater must apply for a stormwater permit coverage under the Alabama Construction General Permit, ALR100000 2021 (ADEM 2021). The General Permit requires erosion and sediment controls and a best management practice (BMP) plan that would serve to minimize impacts to surface waters. Also, as mentioned above, construction of the spillway along the dike separating the CWC from Wheeler

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Reservoir would require a CWA Section 404 permit either an NWP or an Individual Permit. Section 2 discusses the aquatic resources in BFN's environmental setting. With in-water work confined within the CWC, compliance with USACE and ADEM permits, and implementation of BMPs, only minor impacts to water quality and aquatic resources are expected. In addition, compliance with permit requirements and use of BMPs to minimize dust, emissions, and prevent spills as discussed below would further minimize the potential for impact to aquatic species.

Table 2-1 lists the federal or state protected aquatic species with potential to occur in the Wheeler Reservoir within a 10-mile radius of BFN. Of the fish species listed in Table 2-1, only the silver redhorse has been collected during TVA's reservoir monitoring since 1993 and was done so during eight sample years with the most recent being in 2019 and 2020. The in-water work would be confined to the cooling water channels utilizing cofferdams. The WWC discharges into the CWC and the CWC discharges into the forebay. The forebay is separated from the Wheeler Reservoir by Gate 3. Gate 3 is open to Wheeler Reservoir to ensure the ability to sustain a minimum water level because the forebay and Wheeler Reservoir serve as BFN's ultimate heat sink (UHS). Use of cofferdams and the configuration of the cooling water system would reduce the potential for water quality impacts to Wheeler Reservoir, with any water quality impacts likely localized to the cooling water channels and the forebay. TVA (2018) assessed the potential for impacts to protected aquatic species including mussels and snails from dredging extending from the forebay into Wheeler Reservoir to approximately 900 feet from Gate 3. TVA determined that the federally endangered slender campeloma snail would not be affected and the dredge area is not likely to provide suitable habitat for the three other snails identified in Table 2-1. TVA's review of the distribution of rare mussels indicated that almost all recent records of federally listed mussels do not occur between TRM 305 (Decatur) and Wheeler Dam - presumably due to impoundment conditions that are unsuitable for most freshwater mussel species. TVA determined that impacts from dredging would be no effect for the federally listed pink mucket, rough pigtoe, and snuffbox and impacts to state-listed mussel species would be insignificant to the overall populations and habitat availability in the vicinity of the dredged area in the Tennessee River. (TVA 2018)

3.1.3 Groundwater Impacts

TVA assessed the potential for groundwater impacts from cooling tower upgrades in the 2020 EA (TVA 2020a). Groundwater use was not proposed for the cooling tower upgrades assessed in the 2020 EA (TVA 2020a). TVA assessed the impacts from demolition of existing foundations and basins, construction of new foundations and basins, and modifications and upgrades to underground piping. These same activities would be expected for replacement of Tower 4 and the other upgrades listed in Section 3. TVA (2020a) determined that ground disturbance would be minor, temporary, and localized and would not be at depths that would intersect public groundwater supplies (typically 50 to 150 feet beneath the land surface or result in significant impacts to geologic and groundwater resources. Additionally, TVA (2020a) determined construction activities would not impact seeps or springs as none have been identified in the Project Area (see Figure 3-1). The cooling tower replacement and upgrades associated with CCRS would be similar and would take place within the 224-acre project area considered in TVA's 2020 EA. The construction activities in the cooling water channels and the forebay would also not involve depths to intersect drinking water supplies. Moreover, there are no groundwater wells onsite or within 2-miles of the site that are used as a source of drinking water (TVA 2021c). Given TVA's previous assessment and that

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groundwater supplies are at greater depths with no drinking water wells are within 2 miles, no significant groundwater impacts would be expected.

TVA also has a Groundwater Protection Program using onsite monitoring wells to detect inadvertent radiological releases to groundwater. BFN has been monitoring a legacy tritium plume in the vicinity of a groundwater well (Dewat-A) located adjacent to the Reactor Building (TVA 2021c). No other plant related radionuclides were detected in any groundwater well in 2020 (TVA 2021c). Given TVA's Groundwater Protection Program monitors for inadvertent radioactive releases and the extent of legacy plumes, TVA would be aware of groundwater plumes that would need to be avoided by construction activities or mitigation measures implemented.

3.1.4 Air Quality Impacts

Much of the construction activities would be in-water work, presenting little or no opportunity to generate fugitive dust. Fugitive dust and fine particulate matter would be generated during earthmoving activities, material-handling activities, wind erosion, and other general construction activities. TVA would manage construction activities in accordance with regulatory requirements and application of BMPs (e.g., paving or stabilizing disturbed areas, water suppression, reduced material handling) to minimize fugitive dust and fine particulate matter.

In addition, there would be emissions from construction equipment. Some additional vehicle-related air emissions can be expected from workforce personnel vehicles and over-the-road project construction vehicles, as well as delivery of equipment and supplies. Overall, air quality impacts would be expected to be minor, temporary, and localized to the BFN site.

3.1.5 Noise Impacts

Construction-related noise impacts would include the operation of vehicles, earthmoving equipment, and other equipment such as generators and compressors. These noises would be intermittent and last for the duration of construction activities. The construction activities listed in Section 3 are estimated to take approximately years. Some construction noise would be noticeable above background levels at times, but construction would occur during normal work hours over a relatively limited period. BFN is located in a rural area, approximately 10 miles from Athens, Alabama and 10 miles from Decatur, Alabama. The nearest sensitive receptors are residents of Paradise Shores with the nearest residence being approximately 0.1 miles away from the western side of the cooling tower area. Other sensitive noise receptors such as hospitals, daycares, and schools are located in Athens and Decatur. The most significant noise levels during construction would be from demolition, site preparation, and foundation work required for replacement of Tower 4 and pile driving associated with installation of the cofferdams for the cooling channel construction activities. Based on the construction schedule considered for the replacement of Towers 1 and 2 (TVA 2020a), replacement of Tower 4 would take approximately eight months. Because the noise levels generated by construction activities would be intermittent and temporary in nature, typically conducted during daytime hours, and applicable BMPs would be implemented, noise impacts resulting from construction would be minor, temporary, and localized. Construction activities are not expected to raise the noise levels to such a degree as to jeopardize the health and welfare of nearby residents. Wildlife may disperse to adjacent habitats due to noise associated with construction activities.

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3.1.6 Visual Impacts

Construction activities would be visible from the surrounding areas including the Paradise Shores residential community and Wheeler Reservoir but would not be out of character with the view of the plant's industrialized area. Therefore, the visual impact would be minimal.

3.1.7 Waste Management Impacts

Construction would create municipal solid waste, non-hazardous and small amounts of hazardous industrial wastes. These wastes will be properly managed onsite and disposed at an approved offsite treatment or disposal facility. The impact of construction wastes would be minimal.

TVA also has procedures for the management of chemicals and response to spills. All chemicals brought on site must be reviewed and approved under the site chemical traffic control process, and must be handled, used, stored, and disposed of in accordance with the Nuclear Chemical Traffic Control Program, NPG-SPP- 05.4. Any chemical and petroleum spills are to be reported to the Shift Manager and contained immediately. The Integrated Pollution Prevention Plan (BFN-RWI-007 Rev 0023) contains guidance regarding spill management. (TVA 2020a)

3.1.8 Cultural Resources Impacts

As presented in Section 2, no architectural resources included or eligible for inclusion in the NRHP have been recorded within 3 miles of BFN with the nearest being approximately 3.5 miles away. The visual intrusion of construction activities at the BFN site nor construction noise or vibration would be expected to impact the cultural sites at this distance.

3.1.9 Environmental Justice Impacts

Potential impacts on minority and low-income populations from construction would primarily be associated with socioeconomic effects. These impacts would consist of the short-term increase in worker expenditures at local businesses and potential rental housing shortages during the construction phase of the project. The increase in traffic on roads would likely be spread across the three plant access roads and their connecting roads and would not be expected to result in significant impacts to traffic that could affect local minority and low-income populations. Environmental impacts to these populations would be minor and likely would result in no disproportionate adverse impacts to minority and low-income populations.

3.2 Operational-related Impacts

BFN utilizes its cooling towers during the warmer months. Their use is in the helper mode in which the cooling water is not recirculated but discharged to Wheeler Reservoir. Under the CWRS compliance method, BFN's cooling towers would be operated in a closed-cycle cooling configuration. In closed-cycle cooling, flow will be drawn from the intake forebay by the CCW pumps and travel through the condensers before being routed to the WWC. The lift pumps transfer the water to the cooling towers and the cooled flow discharges into the CWC. Finally, the flow travels over the discharge control structure and through Gate 2 back to the intake forebay, where it would be drawn back into the intake pumping station. Due to loss of CCW to evaporation and drift in the towers as well as blowdown, some flow still needs to be drawn in from Wheeler Reservoir

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through the intake channel that passes underneath Gate 3, which separates the intake forebay from the Wheeler Reservoir.

The continual use of the cooling towers may lead to an increased magnitude in the impacts over what BFN normally experiences with intermittent usage. Closed-cycle cooling would result in air emissions, noise, water consumption, wastewater discharge, and has the potential for visual impacts. These effects from operations could also result in impacts to terrestrial and aquatic ecological resources. MDCT operations would not likely result in solid waste except for the typical types of solid waste generated during maintenance activities. In addition, CCRS would reduce BFN's generating capacity and further reduce net electricity output by consuming energy for its operation. Details are discussed in the following sections.

3.2.1 Air Quality and Atmospheric Impacts

MDCTs provide a transfer of system heat load to the atmosphere. Cooling towers are designed to promote close contact between air and water within the fill to improve heat transfer, and ultimately, the performance of the cooling tower. As a byproduct of this facet of their design, small water droplets become entrained in the air stream leaving the tower, i.e., drift.

Cooling tower drift is defined as the circulating water that is lost from a cooling tower as liquid droplets become entrained in the exhaust air stream. Drift that leaves the top of the tower will reflect the same water chemistry as that of the cooling water system. Drift results in five effects of environmental concern listed below. Installation and use of drift eliminators would reduce these effects.

- Drift results in water consumption (see Section 3.2.3)
- Larger entrained water droplets can settle out of the air quickly and cause wetting, fogging, and during freezing temperatures icing in the immediate area surrounding the cooling tower which can damage equipment and cause occupational safety hazards (see Section 3.2.6).
- Very small water droplets in the saturated water vapor condense out of the air due to a drop in temperature forming atmospheric plumes.
- Once the water droplets evaporate, it leaves behind the solids that were once dissolved introducing fine particulate matter into the atmosphere.
- The solids that were once dissolved would eventually be deposited on the surrounding land/water.

The cooling towers are currently only operated for several days during warmer months. During cooling tower operation, a plume is often visible in the early morning and evening, but it usually becomes invisible as the temperature rises during the day (TVA 2003). A concern with the formation of plumes is its ability to travel away from BFN and effect the surrounding area. As discussed in the 40 CFR §122.21(r)(10) report, a study conducted for the plant license in the early 1970s of meteorological conditions indicates the potential for plume-induced icing. Data indicate that this could occur on 55 days per year from November to March. The directions with the maximum frequency of plume travel during icing conditions are south and southeast over the reservoir. These conditions would extend to more than 4 miles less than 2% of the time. On these occasions, some light-to-moderate icing could be encountered by river traffic. A second direction

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of potential light-to-moderate icing is north-northeast of the plant out to approximately 3.5 miles. Such icing might occur up to five days per year with a possible hazard to road traffic on local roads. Some icing on structures in the immediate plant area and on adjacent transmission towers and lines might also be expected. The effects of the plume would need to be examined more closely prior to a more detailed design.

The BFN closed-cycle cooling system would concentrate the dissolved solids in the makeup water (i.e., Wheeler Reservoir) as a result of the cycles of concentration (CoC). BFN's assumed CoC for closed cycle cooling is three; thus, the drift would contain three times the levels of dissolved solids than that of Wheeler Reservoir. When the water droplets in the drift evaporate, the solids that were once dissolved are left behind. This has the effect of introducing fine particulate matter into the atmosphere. Particles with a mean aerodynamic diameter of less than or equal to 10 microns or 2.5 microns are classified within the National Ambient Air Quality Standards (NAAQS) as PM_{10} or $PM_{2.5}$, respectively. (40 CFR § 50.6, § 50.7, § 50.13, § 50.18). Alabama incorporated the NAAQS standards into the Code of Alabama Chapter 335-3-1-.03.

The magnitude of drift related PM_{10} and $PM_{2.5}$ emissions from wet towers (e.g., MDCTs) depends on several conditions and parameters, such as the makeup water composition, concentrations of total dissolved solids (organic matter, biocides, corrosion inhibitors, sodium chloride), steam condenser flow rate, design and number of cooling towers/cells, and annual hours of operation. NRC's comparison of the impacts of using seawater versus freshwater included consideration that drift emissions from cooling tower systems using seawater are over seven times greater than those from systems supplied with freshwater makeup feeds if everything else is held constant. NRC determined that operation of wet towers at nuclear power plants for salt or freshwater sources would be result in small impacts on air quality provided the plant operated within their state-issued air permit. NRC defines small impacts as "Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource." (NRC 2013).

Because BFN's makeup water does not have a high salt content or mineral content, modeling to estimate PM_{10} emissions have not been conducted. Because BFN's makeup water does not have a high salt content or mineral content and BFN's existing cooling towers would have to operate in compliance with an ADEM-issued air permit, air quality impacts and causal human health effects from the drift from closed cycle cooling are not expected to be significant.

Once the drift related solids fall out of the air, they deposit on the surrounding land and water. This salt deposition could damage structures and vegetation and make freshwater bodies acidic. However, because BFN's makeup water does not have a high salt content or mineral content, the surrounding land, structures, freshwater, and wetlands are not expected to experience significant impacts. When assessing the impacts of salt deposition from cooling tower operations at nuclear power plants with a range of makeup water sources and decades of operation, NRC determined the impacts to be small (i.e., effects that are not detectable or minor) (NRC 2013)

3.2.2 Noise Impacts

There are no applicable federal, state, or local municipal noise standards, regulations, or ordinances. TVA uses, as a guideline, the equivalent sound level (L_{eq}) of 60 A-weighted decibels

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(dBA) at the property line (TVA 2020a). In addition, TVA uses the Federal Interagency Committee on Noise (FICON 1992) recommendation that a three decibel increase in day-night average sound level L_{dn} indicates possible impact and the need for further analysis when the background L_{dn} is 60 dBA or less (TVA 2020a).

The primary sources of noise from MDCTs are from pumps and fans, and “fill” noises. The nearest sensitive noise receptors to the cooling towers are residences in the Paradise Shores community approximately 0.1 miles away. A noise study was performed in 2012 at the location of the nearest residence in the Paradise Shores Community found that background noise levels without cooling tower operation was 59.7 dBA, and that the noise levels with operation of six of the seven cooling towers was 61.9 dBA, an increase of 2.2 dBA (TVA 2020a).

As a follow-on mitigation measure in the 2020 EA (TVA 2020A) concerning cooling tower upgrades, TVA indicated that an additional environmental sound pressure level assessment following completion of the CT replacements would be conducted. The 2020 EA (TVA 2020a) further stated that if TVA finds that the resulting noise levels exceed the FICON guidelines, TVA would develop and implement additional acoustical mitigation, such as modifications to fans and motors or the installation of barriers. With TVA’s intent to mitigate noise levels within applicable guidelines, impacts to the residents of Paradise Shores would be small from implementation of a CCRS at BFN.

As presented in Section 2, the BFN site is a heavily disturbed area with limited wildlife habitat. The addition of sound from operation of the MDCTs could cause wildlife to distance themselves and relocate to wildlife habitat areas where the sound levels have further attenuated. However, any wildlife occurring near the cooling towers would be tolerate of the noise levels of the operating BFN and noise impacts on wildlife would be minor.

3.2.3 Water Consumption and Wastewater Discharge Impacts

In a closed-cycle cooling system, intake flow is required for makeup only. The makeup flow is required to offset water losses that occur by three primary mechanisms: evaporation, drift, and blowdown. As presented in the 40 CFR 122.21(r)(10) report, the amount of makeup flow withdrawn from the river would be approximately 160,000 gpm with a blowdown flow rate of approximately 115,000 gpm. The remainder would be the amount consumed due to evaporation and drift, approximately 45,000 gpm. As reported in BFN’s 40 CFR 122.21(r)(2) data, historical daily flows in Wheeler Reservoir at BFN averaged across all months is roughly 48,000 cfs (about 22 million gpm). BFN’s consumption would be approximately 0.2 percent of the daily flow in Wheeler Reservoir.

As presented in the 40 CFR 122.21(r)(10) report, the circulating cooling water pump flow rate of all three units in the once-through cooling mode is 2,100,000 gpm. Nearly all of this intake flow would be returned; however, assuming a 0.4 percent consumption rate, BFN's consumption would be approximately 9,100 gpm for the three units. This consumption rate is based on the National Energy Technology Laboratory’s analysis of data reported by US plants to the U.S. Energy Information Administration which presents the national average withdrawal factor for freshwater, once-through nuclear power plants to be 31.497 gal/kWh and the consumption rate to be 0.137 gal/kWh (NETL 2010). The consumption rate for CCRS would be four times the once-though cooling rate, which is the current primary mode of operation for BFN.

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Operation of the CCRS would result in water returned to the Wheeler Reservoir as blowdown. The discharge would be subject to the plant's NPDES permit. As presented in the 40 CFR 122.21(r)(10) report, currently, CCW is treated to maintain the condenser tubes, which are susceptible to biological growth when forebay temperatures exceed approximately 60°F (about half of the year). Closed-cycle operation would result in temperatures in excess of the threshold for biological growth year-round, and that year-round chemical treatment would be necessary. Any treatment and wastewater discharge levels would have to be in accordance with the NPDES permit as amended for the CCRS. The discharge limits imposed by the NPDES permit would be protective of aquatic organisms and therefore, given compliance with the NPDES permit, minimal impact on aquatic ecology would be expected.

Under normal operations blowdown would be discharged to Wheeler Reservoir through the existing discharge diffusers. The volume of the discharge would be less than the existing discharge and it is expected that any physical impacts localized at around the diffuser ports such as scouring of the bottom would be less with the closed-cycle cooling system than the existing once-through cooling system.

The NPDES permit addresses upset and bypass conditions where exceptions to the discharge point through the diffusers and discharge limits are not prohibited. Such circumstances could arise during certain off normal conditions (e.g., loss of power).

3.2.4 Visual Impacts and Obstruction Impacts

Implementation of the CCRS candidate technology would not require that more cooling towers be added. The land-based modifications would be buried piping, equipment within existing buildings, or addition of buildings in close proximity of existing structures. The modifications of the cooling water channels would have a lower profile or would not be visible from offsite due to the existing embankments and Gate 3. The continuous operation of the cooling towers would increase the frequency of plume formation.

As discussed in Section 3.2.1, a concern with the formation of plumes is its ability to travel away from BFN. Plumes can affect the surrounding area with lowered visibility due to fogging and light scatter at night. TVA assessed the impacts of continuous use of six MDCTs during plant licensure. Local atmospheric conditions indicate that dense, naturally occurring fogs (visibility less than 1,000 feet) can be expected about 25 days per year with highest frequency from late fall through the winter and during early morning hours in the vicinity of BFN (TVA 1971). Use of the MDCTs would increase fogging with the predominate direction of plume travel being north of the plant. The area north of the plant would experience plume-induced fogging approximately 54 days a year (TVA 1971). The residential community, Paradise Shores lies north, northwest of the cooling towers and would be the offsite area most affected by plume-induced fogging. These generally localized conditions of fogging and lowered visibility during portions of the day and primarily during the colder months of the year would be experienced mostly on local roadways and the nearby residential community, Paradise Shores. The effects of the plume would need to be examined more closely prior to a more detailed design.

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No impacts to the viewshed from structures; however, the viewshed would be impacted from plumes from the seven cooling towers continuous operation. Impacts due to fogging and lowered visibility would be localized and intermittent.

3.2.5 Energy Consumption and Net Reduction in Energy Output

The conversion to closed-cycle cooling would lead to a reduction in gross generating capacity because the thermal efficiency of the plant would be reduced by the increased circulating water temperature. The reduced capacity would vary as the ambient temperature and water temperature vary with the seasons. The thermal performance of the CCW system was evaluated assuming three cycles of concentration (CoC) and other assumptions as detailed in the §122.21(r)(10) report. The average monthly operational power difference for the three units combined would range from -30 MWe in July to 47 MWe in April with an average annual loss of approximately 17 MWe.

In addition to the reduced gross generating capacity due to operational losses, the conversion of BFN to a closed-cycle cooling system would also cause the station to consume more electric power as a result of the additional equipment required. An additional annual average 52 MWe of parasitic losses is estimated. Therefore, the total reduction in net generating capacity is the sum of the operational losses and the total parasitic losses. As presented in the §122.21(r)(10) report, the total annual average reduction in net generating capacity would be 69 MWe or an annual energy penalty of approximately 544,000 MWh at a 90% utilization factor.

Alternate sources of power would be required to replace this lost power on a continual basis. If replacement power was sourced from fossil fuel-fired sources, emissions of criteria air pollutants would result. Replacement of the annual average loss of 69 MWe by a hypothetical natural gas combined cycle generating plant assumed to operate with water injection and SCR emission control technologies was used to estimate additional air emissions. Based on U.S. EPA AP-42 emission factors (EPA 2000), the annual air emission estimates are approximately 34 tons of nitrogen oxide, 8.0 tons of nitrous oxide, 80 tons of carbon monoxide, 290,000 tons of carbon dioxide, 18 tons of PM_{10}, 9 tons of sulfur dioxide, and 5.6 tons of volatile organic compounds.

3.2.6 Safety and Reliability Impacts

The CCRS would increase the water temperature in the forebay which, in conjunction with the Wheeler Reservoir, serves as the plant's UHS. As discussed in 40 CFR 122.21(r)(10) report, the CCRS design addresses the two scenarios when the UHS temperature limit of 92.5°F could be challenged. The inclusion of the two spillways in the CCRS design prevents an uncontrolled flooding event.

Safety impacts such as fogging, low visibility, and icing could be posed by cooling tower operation when weather conditions favor fog, rain, or snow. Also, the thermal discharge into the cooling water system channels and the forebay could have the potential for creating significant fogging during winter months. These conditions could pose safety concerns (reduced visibility, slip and fall hazards from wet and moist surfaces) for BFN staff conducting activities in and near the cooling towers and forebay area or possibly result in security concerns due to fogging of security cameras and reduced image clarity.

Operation of towers in the winter will introduce the possibility of settled plume and drift deposits on nearby equipment which could result in corrosion and rusting, which could have long-term reliability

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and maintenance impacts from corrosion. As presented 40 CFR 122.21(r)(10) report, another plant with a similar climate did not observe equipment reliability issues or increase in maintenance requirements after its closed-cycle cooling retrofit, even with the towers being sited near the switchyard. It should be noted that the other plant's closed-cycle cooling retrofit utilized plume-abated MDCTs which typically result in a more buoyant plume with less ground impacts. While the BFN towers are not plume abated, plume development is not expected to cause a reliability impact on surrounding equipment.

3.3 Summary

Conversion to closed-cycle cooling would result in temporary, localized construction impacts from upgrades and modifications to BFN's existing cooling water system. Construction would have temporary impacts to air quality, noise, and water quality. In addition, depending on the timing of construction have the potential to affect listed species; however, TVA would implement guidelines and strategies to avoid adverse impacts to protected species (i.e., may affect, but not likely to affect listed species).

Continuous operation of the MDCTs would result in air emissions and noise. Because BFN operates using a freshwater intake source, the drift from the MDCTs would not be expected to contain high levels of dissolved solids, introducing fine particulate matter into the atmosphere. CCRS would increase noise levels on a continuous basis in the surrounding area with sound levels decreasing with distance. Increased noise levels could be experienced at the nearby Paradise Shores residential community. Paradise Shores and local roadways would also experience intermittent lowered visibility from fogging and nighttime light scatter from ground level plumes from cooling tower operation. Plume-induced icing during freezing conditions would also occur.

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4 Fine Mesh Screens

This method of compliance would involve installing a new circulating water intake structure (CWIS) housing fine mesh screens (FMS). The existing CWIS, as well as the existing intake pumping station, would remain in service to supplement the new screening structure and support the safety bypass. As shown on Figure 4-1, the new CWIS would span the forebay between the existing CWIS and Gate 3. The new CWIS would be 334 ft in length, 65 ft in width, and 52 ft in height (same elevation of the existing CWIS). The new CWIS would house 22 new dual-flow fine-mesh screens with 0.5 mm openings. Extending out from the screening structure, along the embankment, reinforced concrete wingwalls would also be provided to support the embankment and dredged areas. These wing walls would be similar in concept to the wing walls supporting the current pumping station on site. Electrical equipment supporting the new CWIS would be located on previously developed land on the east bank of the forebay.

The new CWIS would include a fish handling and return system (FHRS) to safely return collected organisms to the Wheeler Reservoir. The new FHRS would be merged with the existing FHRS trough on the plant side of the dike separating the forebay from Wheeler Reservoir. The new CWIS design also includes a separate debris collection trough. the debris trough would carry debris to the end of the screening structure where it would be collected in trash baskets for removal.

The new CWIS would also have safety-related and “normal” bypasses. An 8 ft diameter steel safety bypass pipe would be installed at either end of the structure below the minimum water level resulting from a downstream dam failure, 529 ft above mean sea level, and would be permanently open. There would be 22 normal bypasses (one per screen), with each normal bypass running through the “nose” of a screen to mitigate the potential impacts of high debris load events. The normal bypasses would each feature a normally closed manual gate valve.

The environmental setting, construction-related activities, and operational effects and emissions of the FMS were considered to assess the potential non-water quality environmental impacts as required by 40 CFR 122.21(r)(12). As discussed in the following sections, addition of FMS would have construction impacts due to dredging within the forebay for installation and during operations for maintenance. Dredging would result in temporary water quality impacts and dredge spoils would be disposed of onsite. Construction activities would have minor air quality and noise impacts. Operation of the FMS would not have air emissions and only slight increases in water intake levels. The following sections discuss the construction and operational impacts in detail.

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Figure 4-1: Conceptual Design of the Fine Mesh Screens Circulating Water Intake Structure (Map data courtesy of Google© 2021)

4.1 Construction-related Impacts

Impacts would result from construction and dredging activities within the forebay and and dredge spoils disposal. Construction of the new CWIS would require a permit from the USACE that would include conditions designed to minimize environmental permits. Alterations to an intake and/or fish collection system may be authorized under NWP 7, which covers activities related to the construction or modification of outfall structures and associated intake structures subject to CWA Section 404. However, because this project includes additional project components including the construction of a FHRS, it will likely require an USACE Individual Permit. If the project does not qualify for NWP authorization, a joint permit application to the USACE (Nashville District) and the ADEM would be required. The permitting process would require consultations with the USFWS and the Alabama Department of Conservation and Natural Resources regarding the potential for affects to protected species. The permitting process would also require consultation with the State Historic Preservation Officer regarding the potential for affects to cultural resources.

Construction is estimated to require 3.5 years. Most of the construction activities would take place within the forebay and along the adjacent landward sides. Dredging of approximately 40,000 yd^3 of banked earth from the intake forebay would be required prior to construction of the mud mat and bottom slab of the new screening structure. Dredge spoils would be disposed of onsite in the existing spoils pile shown in Figure 4-2. The new CWIS would be constructed in two phases, approximately one half of the structure at a time. Cofferdams would be used in the construction of all parts of the structure submerged underwater in order to limit water ingress and allow dry space for concrete work. Cofferdams would be installed across the appropriate half of the forebay to allow excavation of the construction area. The land on the east and west sides of the forebay would be

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used for equipment and material staging as construction proceeds on each half of the new CWIS. As shown in Figure 4-3, the land along the east side of the forebay is larger and would have more space to accommodate staging. The existing FLEX deployment pad located along the water line on the east side would be also moved farther away from the forebay water line by approximately 50 feet to accommodate construction. If additional area is needed for staging construction equipment and materials, TVA would utilize available previously developed land onsite. As shown in Figure 4-3, there are open concrete areas north and east of the sedimentation ponds that potentially could be used. Following construction of the CWIS, a 40 ft by 50 ft concrete slab on grade and prefabricated buildings would be installed on this eastern side of the forebay to house electrical equipment to support the new CWIS. Also, as shown on Figure 4-1, a FHRS would be installed on the east side of the new CWIS and extend above the WWC to merge with the existing FHRS along the WWC embankment.



Figure 4-2: Dredging Spoils Disposal (Map data courtesy of Google© 2021)

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Figure 4-3. BFN forebay and surrounding area. (Map data courtesy of Google© 2021)

As mentioned above, construction would require a permit issued by the USACE, either an NWP or more likely, an Individual Permit. Either permit type is a CWA Section 404 permit that would govern the required dredging activities and disposal of the dredged material. The permit would establish conditions for dredging to protect water quality and the Wheeler Reservoir aquatic community. Construction activities resulting in land disturbance of one acre or more must apply for a stormwater permit coverage under the Alabama Construction General Permit, ALR100000 2021 (ADEM 2021). The General Permit requires erosion and sediment controls and a BMP plan that would serve to minimize impacts to surface waters. To minimize impacts on plant operation from increased turbidity, dredging precautions such as the use of specialized siltation curtains or reductions in dredging rate could be used.

4.1.1 Terrestrial Ecology Impacts

As mentioned above, the land on the east and west sides of the forebay would be used for equipment and material staging and installation of building to house electrical equipment. As shown in Figure 4-3, these areas are previously developed and do not provide terrestrial habitat. Thus, construction activities would be restricted to previously developed land/water with the exception of spoils disposal.

Spoils would be disposed of in BFN's existing spoils disposal area and if a geotechnical study determines the need for additional dredging beyond the capacity of the existing spoils disposal area, additional onsite acreage would be available for spoils disposal. The dredge spoils would be managed in accordance with the dredge permit and state stormwater regulations. It is expected that the dredged material would not be suitable for use as backfill in follow-on construction activities due to its composition. The dredged earth could be added to the existing spoils pile on site, which

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features an area of approximately 50,000 square yards where the ground is below the peak elevation as shown in Figure 4-2. The spoils would be spread so that the height would not exceed three feet above the natural ground surface. The surface would be seeded daily throughout the spoils deposition process. A geotechnical study would be required during detailed design to determine if additional dredging, or if piles are required to support the structure, or address potential soil liquification concerns based on existing soil conditions.

As presented in Section 2, the BFN site is a heavily disturbed area, with limited wildlife habitat none of which is high-quality wildlife habitat and the terrestrial species found on the site are common to the area. Impacts to upland terrestrial habitat from construction activities would be minor. Further, to avoid the unlikely take of the northern long-eared bat, Indiana bat, and the bald eagle during preparation of spoils disposal areas, TVA would follow USFWS guidance on tree removal and TVA's bat strategy discussed in Section 3.1.1.

4.1.2 Aquatic Ecology Impacts

Section 2 discusses the aquatic resources in BFN's environmental setting. With permit compliance and implementation of BMPs designed to minimize water quality impacts, the impact to the aquatic community would also be minimized and localized to the forebay. For any turbidity that extends into the Wheeler Reservoir, motile species can move away from any increased, temporary turbidity.

The intake channel within the Wheeler Reservoir and the BFN forebay is subject to periodic maintenance dredging to maintain a minimum depth for operation in compliance with the plant's U.S. Nuclear Regulatory Commission license. The most recent dredging occurred in 2018 under a USACE NWP 3 and extended 900 feet into the Wheeler Reservoir from Gate 3 which separates the forebay from the Wheeler Reservoir (TVA 2018). TVA evaluated the dredging as discussed in Section 3.1.2. TVA issued a NEPA Categorical Exclusion for the dredging (TVA 2018), indicating no significant environmental impacts were expected.

Table 2-1 lists the federal or state protected aquatic species with potential to occur in the Wheeler Reservoir within a 10-mile radius of BFN. Of the fish species listed in Table 2-1, only the silver redhorse has been collected during TVA's reservoir monitoring since 1993 and was done so during eight sample years with the most recent being in 2019 and 2020. The CWA 404 permit process includes consultation with the USFWS and the ADEM regarding the potential to impact protected species and mitigation measures would be included in permit conditions as appropriate.

Overall, with in-water work confined with the forebay and the CWC, compliance with USACE and ADEM permits and implementation of BMPs, only minor impacts to water quality and aquatic resources are expected. In addition, compliance with permit requirements and use of BMPs to minimize dust, emissions, and prevent spills as discussed below would further minimize the potential for impact to aquatic species.

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4.1.3 Groundwater Impacts

The construction activities in the forebay would require excavation. The bottom slab of the new CWIS has a depth of three feet and would be cast on top of a concrete mud mat. The top elevation of the bottom slab would be 517 ft MSL. The average elevation of the forebay floor is 533 ft MSL. As mentioned in Section 3.1, the normal water level of the Wheeler Reservoir ranges from 550 ft to 556 ft MSL. The excavation at the bottom of the forebay would approach the depth of drinking water supplies in the BFN area, typically 50 to 150 feet beneath the land surface (TVA 2020a). However, there are no groundwater wells onsite or within 2-miles of the site that are used as a source of drinking water (TVA 2021c). Given there are no drinking water wells are within 2 miles, no significant groundwater impacts would be expected. Groundwater movement onsite is toward the Wheeler Reservoir, so any groundwater plumes from BFN operations would first be intersected by the forebay.

4.1.4 Air Quality Impacts

Much of the construction activities would be in-water work, presenting little or no opportunity to generate fugitive dust. Fugitive dust and fine particulate matter would be generated during earthmoving activities for preparation of the spoils disposal area, material-handling activities, wind erosion, and other general construction activities. TVA would manage construction activities in accordance with regulatory requirements and application of BMPs (e.g., paving or stabilizing disturbed areas, water suppression, reduced material handling) to minimize fugitive dust and fine particulate matter.

In addition, there would be emissions from equipment associated with construction of the new CWIS, mechanical dredging equipment, and other equipment such as generators and compressors used in the onshore and in-water construction activities. Some additional vehicle-related air emissions can be expected from workforce personnel vehicles and over-the-road project construction vehicles, as well as delivery of equipment and supplies. Overall, air quality impacts would be expected to be minor, temporary, and localized to the BFN site.

4.1.5 Noise Impacts

Construction-related noise impacts would include the operation of vehicles, earthmoving equipment, mechanical dredging equipment, and other equipment such as generators and compressors used in the onshore and in water construction activities. These noises would be intermittent and last for the duration of construction activities, which is estimated to be 3.5 years. The BFN site is in a rural location with limited noise receptors. As presented in Section 2, the BFN site is bordered by residential areas. However, the construction activities would not take place along property borders with these residential communities. Construction activities would not be expected to raise the noise levels to such a degree to jeopardize the health and welfare of nearby residents. As mentioned above, the BFN site provides limited wildlife habitat, and the construction work would be in close proximity to BFN operational areas. Any wildlife residing on the BFN site would be used to industrial noise; therefore, the additional, intermittent construction noise would be expected to have minor impacts to wildlife.

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4.1.6 Visual Impacts

Construction activities, with the exception of work at the dredge spoils disposal site, would be visible from Wheeler Reservoir but would not be out of character with the existing view of BFN. Therefore, the visual impact would be minimal.

4.1.7 Waste Management Impacts

Construction would create municipal solid waste, non-hazardous, and potentially small amounts of hazardous industrial wastes. These wastes will be properly managed onsite and disposed at an approved offsite treatment or disposal facility. The impact of construction wastes would be minimal.

TVA also has procedures for the management of chemicals and response to spills. All chemicals brought on site must be reviewed and approved under the site chemical traffic control process, and must be handled, used, stored, and disposed of in accordance with the Nuclear Chemical Traffic Control Program, NPG-SPP- 05.4. Any chemical and petroleum spills are to be reported to the Shift Manager and contained immediately. The Integrated Pollution Prevention Plan (BFN-RWI-007 Rev 0023) contains guidance regarding spill management. (TVA 2020a)

4.1.8 Cultural Resources Impacts

As presented in Section 2, no architectural resources included or eligible for inclusion in the NRHP have been recorded within 3 miles of BFN with the nearest being approximately 3.5 miles away. The visual intrusion of construction activities at the BFN site nor construction noise or vibration would be expected to impact the cultural sites at this distance.

In addition to the existing, dredge spoils area, the BFN site has other available land that could be used for spoils disposal. TVA assessed three potential spoils areas to support a previously proposed cooling tower capacity expansion. The three potential spoils areas are about 200 acres each. A Phase I survey was conducted at the three disposal site/spoil pile locations. The survey identified two historic properties. TVA consulted with the Alabama SHPO who agreed that disposal activities would have no effect on significant cultural resources provided that the two cultural sites were avoided (TVA 2003).

4.1.9 Environmental Justice Impacts

Potential impacts on minority and low-income populations from construction would primarily be associated with socioeconomic effects. These impacts would consist of the short-term increase in worker expenditures at local businesses and potential rental housing shortages during the construction phase of the project. The increase in traffic on roads would likely be spread across the three plant access roads and their connecting roads and would not be expected to result in significant impacts to traffic that could affect local minority and low-income populations. Environmental impacts to these populations would be minor and likely would result in no disproportionate adverse impacts to minority and low-income populations.

4.2 Operational-related Impacts

Once operational, implementation of the FMS compliance method would not result in additional air emissions from operation of the FMS-related equipment, alterations of the existing wastewater discharge, or alterations in water consumption and only a slight increase in water withdrawal

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quantity. TVA would continue to comply with existing and future air regulations and NPDES permits. The use of FMS would reduce net electricity output by consuming energy for its operation. New equipment would minimally add to noise levels onsite. Details are discussed in the following sections.

Additionally, periodic dredging (approximately every 10 years) of the intake forebay in the vicinity of the two sets of safety-related bypass piping would be required to assure availability of the UHS under all design basis events.

As with the construction dredging, a dredge permit would be required, and dredge spoils would be managed in compliance with state regulations. In compliance with federal and state dredge permits, NPDES permits would be used during maintenance dredging to mitigate the impacts to water quality and aquatic ecological resources. To minimize impacts on plant operation from increased turbidity, dredging precautions such as the use of specialized siltation curtains or reductions in dredging rate could be used. These measures would also minimize impacts to water quality and aquatic ecological resources.

4.2.1 Air Quality and Atmospheric Impacts

Operation of the cooling system with the FMS would not result in additional air emissions and thus there would be no impact on air quality. There would likewise be no atmospheric impacts.

4.2.2 Noise

The retrofit to FMS would have new noise sources from motors, the speed reduction or power transmission units, and various pumps. These noise sources would be located inside structures or in close proximity to existing structures and sound sources including wind and waves at the Wheeler Reservoir shoreline. These locations would dampen or mask the additional noise from the motors' operation. Noise levels at the site boundary are expected to be largely unchanged following installation of the FMS and have no impact to offsite receptors. In addition, the WMAs would be distant enough from the new noise sources and separated by existing structures and vegetation to attenuate noise levels. Therefore, impacts to terrestrial habitats are not expected.

4.2.3 Water Consumption and Wastewater Discharge Impacts

The retrofitting of BFN with FMS would not alter the existing configuration of how BFN draws water from Wheeler Reservoir and discharges it back to the Reservoir. Water withdrawals would increase slightly due to operation of the screen wash and FHRS pumps. The water from the screen wash and FHRS pumps would be discharged upstream of the cooling water pumps, or be returned to Wheeler Reservoir via the FHRS, resulting in no net increase in water consumption.

Incorporating FMS into the existing cooling water system would not alter the plant's wastewater discharge volume and discharge configuration, thus no new physical impacts (e.g., scouring) are expected.

4.2.4 Visual Impacts

Implementation of the FMS compliance method would require the construction of new CWIS that spans the forebay behind the existing Gate 3 structure. The CWIS design is 334 feet in length, 65 feet in width, and 52 feet in height. The top deck elevation would be the same as the current CWIS

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and a railing would be provided around the perimeter of the top deck. The top deck would be reinforced concrete. Major components on the top deck include two trash raked, dual-flow FMS housings, screen wash pumps, FHRS equipment, and maintenance vehicles. Extending out from the CWIS, along the embankment, would be concrete wing walls similar those at the existing CWIS current pumping station.

On the western side of the new CWIS, the FHRS piping from the CWIS along the dike separating the WWC from the Wheeler Reservoir would likely be visible, though its use of the existing

FHRS discharge piping would cause little change to the current view.

On the land on the eastern side of the new CWIS would be three new structures housing electrical equipment and a new electrical substation. This location is already developed and has existing structures.

The new CWIS and the land-based structures would be visible from the Wheeler Reservoir and the opposite shoreline. These new structures would have a similar appearance to existing BFN structures and blend in with the existing viewshed. Therefore, the addition of these structures will have a minimal effect on the viewshed.

4.2.5 Energy Consumption and Net Reduction in Energy Output

The lost net generating capacity for the plant would be due to parasitic losses. Parasitic losses are defined as power consumption necessary to operate the plant, which therefore reduces the net generating capacity of the plant. Parasitic losses would result from the energy required for motors to operate the dual-flow traveling water screens, FHRS and debris trough pumps, and intermittent operation of the trash rake system. The exact power consumption values would be based on detailed design, final equipment selection, and the manner in which the equipment is operated. The parasitic losses are estimated at 0.802 MWe, resulting in an annual loss in electricity supplied to the grid of 6,330 MWhr at a 90% utilization factor.

Alternate sources of power would be required to replace this lost power on a continual basis. If replacement power was sourced from fossil fuel-fired sources, emissions of criteria air pollutants would result. Replacement of the annual average loss of 0.802 MWe by a hypothetical natural gas combined cycle generating plant assumed to operate with water injection and SCR emission control technologies was used to estimate additional air emissions. Based on U.S. EPA AP-42 emission factors (EPA 2000), the air emission estimates are approximately 0.4 tons of nitrogen oxide, 0.09 tons of nitrous oxide, 0.9 tons of carbon monoxide, 3,400 tons of carbon dioxide, 0.2 tons of PM_{10}, 0.1 tons of sulfur dioxide, and 0.06 tons of volatile organic compounds.

4.2.6 Safety and Reliability Impacts

BFN’s emergency equipment cooling water (EECW) system is supplied by the residual heat removal service water (RHRSW) system pumps. The FMS retrofit includes two safety bypass pipes installed below the minimal water level in front of the new CWIS. The new CWIS would also be designed to Seismic Category I to ensure that the structure would not crumble and fill the intake channel, which could obstruct the passage for water from the Wheeler Reservoir to the intake structure at the minimum water level. The safety bypass pipes would be continuously open. Therefore, the two safety bypass pipes would ensure that any debris loading, or screen collapse

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would not affect the EECW or RHRSW's ability to operate. Additionally, the implementation of fine-mesh screens would not impact the UHS water temperature, which would remain a function of the ambient water temperature of Wheeler Reservoir.

The fire water pump is housed in the existing CWIS and its operation would be affected by a reduction in cooling water availably due to screen blockage. As discussed below, the blockage/failure of any one screen would be compensated by the remaining screens and the design of the new CWIS includes redundancy and robustness to mitigate screen blockage.

Furthermore, the FMS modification would be reviewed using the criteria in 10 CFR 50.59 to determine if prior NRC approval of some or all aspects of modification are required. The new safety related bypass and seismic screening structure are the most likely issues to require NRC review to ensure that any modification would not impact the plant's ability to perform a safe shutdown.

A plant reliability impact associated with the implementation of FMS is the increased potential for the screens to foul or collapse. Due to the lower percent open area and opening width, fine mesh screens are at increased risk for fouling, debris stapling, and increasing differential pressure. If large-scale screen blockage occurred, it could result in a partial reduction of flow to the Units' cooling water systems (as well as the EECW and RHRSW systems), potentially leading to a derate. The risk of screen blockage is mitigated by redundancy and robustness in the fine-mesh screening structure design as detailed in the §122.21(r)(10) report. The failure of one fine-mesh screen is compensated by the remaining 21 screens.

As mentioned in Section 4.2, periodic dredging of the intake forebay in the vicinity of the emergency bypass pipe would be required to assure availability of the plant's UHS. Dredging precautions, such as the use of specialized siltation curtains or reductions in dredging rate, would be used during maintenance dredging to mitigate potential impacts to plant operation.

4.3 Summary

Implementation of the FMS would result in temporary construction-related impacts primarily from dredging within the forebay and construction of the new CWIS. Construction of the new CWIS in the forebay would require dredging of the forebay. Dredging would temporarily impact water quality. Dredging would be conducted in compliance with federal and state permits, which would establish conditions to minimize impacts to water quality and protected species. Construction equipment would also result in air emissions and noise that could have localized impacts but would not be expected to impact offsite receptors.

Once operational, implementation of the FMS compliance method would not result in additional air emissions, alterations of the existing wastewater discharge, or alterations in water consumption and a slight increase in water withdrawal. The use of FMS would reduce net electricity output by consuming energy for its operation. Periodic dredging in the vicinity of the safety bypass pipes would be needed and would require a dredge permit. Dredging would be confined to the forebay and have temporary water quality impacts.

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TVA 2015. Browns Ferry Nuclear Plant License Amendment Request for an Extended Power Uprate Supplemental Environmental Report. 2015.

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TVA 2018. Browns Ferry Nuclear Plant (BFN) Plant Intake Maintenance Dredging – File No. LRN-0-4116100 – Permit Modification. October 11, 2018.

TVA 2020a. Browns Ferry Nuclear Plant Thermal Performance Program Cooling Tower Capacity Improvements Environmental Assessment. June 2020.

TVA 2020b. Finding of No Significant Impact Tennessee Valley Authority Browns Ferry Nuclear Plant Thermal Performance Program Cooling Tower Capacity Improvements

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Browns Ferry Nuclear Power Plant

National Pollutant Discharge Elimination System (NPDES) Permit No. AL0022080

Updated Final §316(b) Rule Information

40 CFR 122.21(r)(13) Submittal



Prepared for:
Tennessee Valley Authority

January 2022

Prepared by:
Enercon Services, Inc.

ENERCON
Excellence—Every project. Every day.

500 TownPark Lane
Kennesaw, GA 30144

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1 Introduction

Tennessee Valley Authority (TVA) has undertaken a peer review of reports prepared pursuant to 40 CFR §122.21(r)(10-13) for the Browns Ferry Nuclear Power Plant (BFN) located on the Tennessee River in Limestone County, Alabama. As required by (r)(13), the review process included:

- Selection of expert peer reviewers independent of those preparing the §122.21(r)(10-12) reports and having the appropriate credentials and expertise (see Appendix A);
- Pre-Approval of the expert reviewers by the Alabama Department of Environmental Management (ADEM) in August 2021 (see Appendix A);
- Instructions and charge questions/forms provided to the experts (see Appendix B);
- Expert review of the §122.21(r)(10-12) reports (see Appendix B);
- Independent review of the peer review comments (see Appendix B); and
- Production of a comprehensive peer review report that:
    - Compiles the experts' comments and responses by the authors, and
    - Demonstrates, based on peer review that the §122.21(r)(10-12) report conclusions are supported by the technical information and analyses provided.

This §122.21(r)(13) peer review report summarizes and documents the peer review process performed for BFN.

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2 Peer Review Approach

The peer review approach was based on the requirements of § 122.21(r)(13) as well as guidance from the U.S. Environmental Protection Agency (EPA), the Electric Power Research Institute (EPRI), and various peer-reviewed literature. The 316(b) Rule (Rule) at §122.21(r)(13) provides a description of the peer review requirements for the §122.21(r)(10-12) information:

> *(r)(13) Peer Review. If the applicant is required to submit studies under paragraphs (r)(10) through (12) of this section, the applicant must conduct an external peer review of each report to be submitted with the permit application. The applicant must select peer reviewers and notify the Director in advance of the peer review. The Director may disapprove of a peer reviewer or require additional peer reviewers. The Director may confer with EPA, Federal, State and Tribal fish and wildlife management agencies with responsibility for fish and wildlife potentially affected by the cooling water intake structure, independent system operators, and state public utility regulatory agencies, to determine which peer review comments must be addressed. The applicant must provide an explanation for any significant reviewer comments not accepted. Peer reviewers must have appropriate qualifications and their names and credentials must be included in the peer review report.*

The EPA Handbook, referenced in the Rule preamble, was developed by the EPA for peer review of the technical research used to support new environmental regulation and/or policy.

> *"Peer review is a documented process for enhancing a scientific or technical work product so that the decision or position taken by the Agency, based on that product, has a sound, credible basis…. It is conducted by qualified individuals (or organizations) who are independent of those who performed the work and who are collectively equivalent in technical expertise to those who performed the original work (i.e., peers). Peer review is conducted to ensure that activities are technically defensible, competently performed, properly documented and consistent with established quality criteria. Peer review is an in-depth assessment of the assumptions, calculations, extrapolations, alternate interpretations, methodology, acceptance criteria and conclusions pertaining to the scientific or technical work product, and of the documentation that supports them."*

Since the Handbook was not specifically designed to help permittees with NPDES permit compliance, EPRI developed a peer review process to support the Rule using basic concepts from EPA and incorporating §122.21(r)(13) requirements to address specific attributes of the Rule: specifically, whether the conclusions drawn are technically sound, adequate in terms of the Rule's requirements, and supported by the information provided. The review process described here also recognizes that permittees are subject to strict regulatory schedules for submittal of the peer reviewed information.

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3 Peer Review Qualifications and Peer Review Process

The EPA has required third-party peer review of the §122.21(r)(10-12) studies by qualified experts to reduce the burden on the permitting authority as diversity of technical information spanning the disciplines of engineering, biology, and resource economics must be included. TVA selected reviewers based on their relevant technical expertise and experience on the subject matters requiring review. The Peer Review team consisted of experts in the biological discipline (private consultant), engineering discipline (from Kleinschmidt Associates), and resource economics (from Industrial Economics, Inc.). TVA submitted the qualifications of the selected reviewers to ADEM and received a letter dated August 20, 2021 approving the selected experts as peer reviewers (see Appendix B). The resumes of the selected experts describing their qualifications are provided in Appendix B.

The peer review for BFN incorporated guidance discussed above and proceeded as follows:

- Technical expertise required for this site and set of (r) reports was carefully considered prior to the search for qualified peer reviewers.
- Potential peer reviewers were identified and provided an opportunity to respond to a Request for Proposal (RFP).
- Bids were reviewed, and candidates were screened for appropriate qualifications and conflicts of interest.
- Qualifications of the peer reviewers were evaluated and approved by ADEM.
- Charge questions were developed to guide experts and ensure the information required in §122.21(r)(10-12) was addressed and that reviewers had the opportunity to provide insights based on their experience.
- A peer review package was forwarded to the expert reviewers. The package included the (r) reports and charge questions/comment form (see Appendix B).
- The peer review experts submitted written comments.
- Peer review comments were forwarded to the report authors to either address in their documents or explain why no change is necessary (see Appendix B).
- And finally, each peer reviewer was asked to review the responses and indicate their satisfaction with how the authors addressed their comments. Peer reviewer acceptance letters are provided in Appendix C.

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Appendix A. Peer Review Team Resumes and ADEM Approval Letter

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TENNESSEE VALLEY AUTHORITY

1101 Market Street, BR 2C, Chattanooga, Tennessee 37402

Sent Via Electronic Transmittal

August 5, 2021

Mr. Theo Pinson (tpinson@adem.alabama.gov)
Industrial Section
Industrial/Municipal Branch
Water Division
Alabama Department of Environmental Management
Post Office Box 301463
Montgomery, Alabama 36130-1463

Dear Mr. Pinson:

TENNESSEE VALLEY AUTHORITY (TVA) – BROWNS FERRY NUCLEAR PLANT (BFN) – NPDES PERMIT NUMBER AL0022080 – CLEAN WATER ACT SECTION 316(b) § 122.21(r)(13) – NOTIFICATION OF PEER REVIEWERS AND QUALIFICATIONS

TVA is submitting peer reviewer information and qualifications for your consideration for the BFN as required by 40 CFR 122.21(r)(13). Given that the BFN is subject to the Existing Facilities Rule[1] and must submit studies pertaining to candidate entrainment control technologies under paragraphs (r)(10) through (12), § 122.21(r)(13) requires TVA to notify the Director of selected peer reviewers for the § 122.21(r)(10) through (12) reports prior to the peer review. Therefore, TVA has identified the following candidate peer reviewers:

Peer Reviewer	Affiliation	Discipline
Charles Coutant, Ph.D.	Private consultant	Biology
Robert Unsworth	Industrial Economics, Incorporated	Economics
Harold Thompson, P.E.	Kleinschmidt Associates	Engineering

Per U.S. Environmental Protection Agency recommendations, the candidate reviewers have provided Conflict of Interest assessments based on the U.S. EPA (2015) Peer Review Handbook questionnaire. These assessments are enclosed, along with each reviewer's resume.

TVA's Contractor is in the process of preparing the § 122.21(r)(10), (11), and (12) reports, and we anticipate submitting them to ADEM by March 4, 2023 with the station's NPDES permit

[1] National Pollutant Discharge Elimination System—Final Regulations To Establish Requirements for Cooling Water Intake Structures at Existing Facilities and Amend Requirements at Phase I Facilities; Final Rule (79 FR 48300, August 15, 2014)

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renewal application. Therefore, we would appreciate your review and concurrence on the candidate peer reviewers by September 4, 2022.

If you have questions, please feel free to contact Chad Reed at chreed@tva.gov or by phone at 423-751-3948.

Sincerely,



Paul Pearman
Senior Manager
Water Permits, Compliance, and Monitoring

Enclosures

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CHR:SMF
Enclosures
cc (Electronic Distribution w/ Enclosures):
S. W. Keenum, NAB 1G-BFN
D. E. McGee, TSC 1A-HNA
W. K. Nesmith, LP 2A-C
G. P. Shaffer, WT 11D-K
M. B. Stiefel, BR 2C-C
ECM, ENVrecords

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BRIEF RESUME

Charles C. Coutant, Ph. D.
Fellow, American Association for the Advancement of Science
Fellow, American Institute of Fishery Research Biologists
Fellow, American Fisheries Society
Retired Distinguished Research Ecologist, Environmental Sciences Division
Oak Ridge National Laboratory, Oak Ridge, Tennessee
Personal Consultancy in Aquatic Ecology
120 Miramar Circle, Oak Ridge, TN 37830
(865) 483-5976 (h); 865-566-2754 (c); ccoutant3@comcast.net

Education: BA 1960 (Lehigh University, Bethlehem, Pennsylvania); MS 1962 (Lehigh); PhD 1965 (Lehigh).

Positions: (1) Battelle-Pacific Northwest Laboratories, Richland, Washington (1965-70): Research Scientist, Columbia River Thermal Effects Studies; (2) Environmental Sciences Division, Oak Ridge National Laboratory (1970-2005): Manager Cooling Systems Program (1970-79), Leader Multimedia Modeling Project (1979-82); Manager DOE Global Carbon Cycle Program (1985-86); Manager ORNL Exploratory Studies Program (1989-1991); Senior Research Staff (1982-85, 1986-88, 1992-2004); Distinguished Research Staff (2004-2005); (3) Private consultant (2005-present).

Professional Affiliations (positions currently or previously held): American Association for the Advancement of Science (Fellow); American Institute of Fishery Research Biologists (Fellow); American Fisheries Society (AFS; Presidents of Water Quality Section, Tennessee Chapter, Southern Division, and full Society; Co-Editor of journal *Transactions of the American Fisheries Society*; Fellow); American Society of Limnology and Oceanography, lapsed; American Society for Testing and Materials (Chair Environmental Fate Models Task Group; lapsed); Ecological Society of America (Vice Chair Applied Ecology Section); Sigma Xi (Southeast Regional Lecturer, President Oak Ridge Chapter); Water Pollution Control Federation (Literature Review Committee-Thermal Effects; lapsed).

Honors: Darbaker Prize in Microbiology, Pennsylvania Academy of Science; Director's Award, Battelle-Northwest; Excellence in Fisheries, TN Chapter AFS; Outstanding Publication, Martin Marietta Energy Systems (then operator of ORNL); Distinguished Publication, American Society for Information Science; Distinguished Service Award, AFS; Outstanding Achievement Award, Southern Division, AFS; 2002 ORNL Distinguished Scientist of the Year; 2013 Career Achievement Award by Bioengineering Section AFS.

Publications: Refereed articles in journals-51; non-refereed articles in journals-22; book chapters-41, symposium articles-37; laboratory or agency reports-169; book reviews, news articles, editorials-21; contributions to Environmental Impact Statements-9; Book editor/co-editor-2. Total=352. [Updated September 2017; Does not include proprietary reports from consulting]

Synopsis of Significant Technical Contributions: Field study of thermal discharge effects on invertebrates of Delaware River; Laboratory and field studies of thermal effects of Hanford reactors on Columbia River salmonids and other aquatic life; annual reviews of thermal-effects publications 1968-1980; evaluation of aquatic thermal-effects information to provide national

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water temperature criteria recommendations by the National Academy of Sciences; participation in development of EPA guidelines for Clean Water Act §316(a) thermal studies of power stations; development of biological data and criteria for environmental impact assessments of steam electric power plants; participant in the establishment of the Electric Power Research Institute and member of its national Advisory Council; development of electronic temperature telemetry of fishes as a research tool for thermal behavior studies; lead role in developing guidance for thermal power plant impact assessment for UNESCO and International Atomic Energy Agency; advisor on project evaluation to Bonneville Power Administration (BPA) Fish and Wildlife Program and member of Scientific Review Group; member of Northwest Power Planning Council's (NPPC) Independent Scientific Group; member National Marine Fisheries Service and NPPC's Independent Scientific Advisory Board for Pacific salmon restoration; member NPPC's Independent Scientific Review Panel for review of projects for BPA's Fish and Wildlife Program; elucidation of the thermal ecology of striped bass through laboratory and field research and its application to management of the species in fresh water and estuaries; evaluation of impacts of hydropower on aquatic systems; review and evaluation of Clean Water Act §316(a and b) study plans, studies, and documents for power companies; new concepts for behavioral guidance of salmon smolts; book editor, *Behavioral Technologies for Fish Guidance* (2001); book co-editor, *Biology and Management of Inland Striped Bass and Hybrid Striped Bass* (2103); evaluation of an entrainment-free power station water intake.

Synopsis of Management Experience: Leader of several research teams up to about 15 people; manager of Department of Energy intra- and extramural carbon dioxide research program ($4 million/yr); manager of ORNL internal funding program ($6-10 million/yr).

Synopsis of Power Plant-related Advisory Roles: Co-author of EPA's 316(a) guidelines (1977); Co-chair of Technical Advisory Committee for Virginia Power Company's North Anna Power Station 316(a) studies (1980s); Co-chair of Technical Advisory Committee for Commonwealth Edison Co. 316(a, b) studies on Upper Illinois waterway (1991-1996); Technical Advisor to Electricity Corp of New Zealand for thermal discharge permitting patterned after 316(a) (1991-1994); Third-party advisor for Georgia Power Co. and the State of Georgia for Plant Branch 316(a) demonstration (1993-1999); Advisor for 316(a) demonstration studies for Carolina Power and Light Co.'s H. B. Robinson Steam Plant (1994-1996); Advisor for 316(a) demonstration by Public Service Electric and Gas Co. for Hudson Station (1995-1998), Mercer Station (1998-2001) and Salem Nuclear Station (1998-2000; 2006); Advisor for siting a power plant in Portugal (1997); Review of Brayton Point Plant 316(a) studies for USEPA (1997-1998 and 2003); Review and expert testimony on Diablo Canyon thermal effects monitoring for Pacific Gas and Electric (1999-2000); Review and white paper preparation on fish population status and trends for Hudson River Utilities (2001-2002); Advised Dynegy Northeast on Danskammer and Roseton power plant relicensing issues (2002-2005); Served on Fishery Panel for City of Newport News water intake (2004); Consultant to Dominion North Anna regarding biological aspects of NRC Early Site Permit for additional units at North Anna Nuclear Station (2005-2007); Advisor to Natural Solutions for implementation of a Flow Velocity Enhancement System for fish guidance and debris management at intakes (2005-present); Member of University of Tennessee team for 316(a) biological assessment of thermal discharge from Blue Ridge Paper Products paper mill (2005-2006), related litigation (2009-2011; expert witness), permit renewal studies (2012-2013) and permit modification support (2016-2017 and 2020); Technical advisor to a stakeholder group evaluating revision of Colorado temperature standards (2006-2007; expert witness); Participant in EPRI study of effectiveness of strobe lights for reducing impingement at power plant intakes

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(2006-2007); Advisor for Millstone Nuclear Power Plant (Connecticut) NPDES re-permitting (2006-2009; expert witness); Expert witness for Vermont Yankee Atomic Power Plant NPDES re-licensing (2007); Advisor and expert witness for resolving aquatic environmental impacts for NRC Early Site Permit for expansion of the Vogtle nuclear power plant, Georgia (2006-2009); Advisor of the Utility Water Act Group (UWAG) for developing consistent national approaches for 316(a) implementation (2007-2010); Consultant and expert witness for Environment Canada for thermal discharge from a pulp mill (2008-2009); Consultant to Utility Water Act Group (2006-2009); Consultant to Dominion Manchester for planning biological studies for a 316(a) Demonstration for the Manchester Street Station, Providence, RI (2009-2010); Consultant to Arcadis, Inc. for thermal-effects analyses of two Florida power stations (2010); Consultant to Idaho Power Co. for application for a site-specific temperature standard for the Snake River (2010-2014); Consultant to Tennessee Valley Authority for entrainment and impingement studies leading to NRC permit for Watts Bar Nuclear 2 (2010-2011); Consultant to Duke Energy for post-event analysis of a water-intake incident at McGuire Nuclear Station, North Carolina (2011); Consultant to ASA Analysis and Communication for review of 316(a) documents (2012); Participant in EPRI-funded study by Natural Solutions of debris and fish-impingement management at the water intake of Dairyland Cooperative's Genoa Station on the Mississippi River (2012); Consultant to Dominion Virginia Power for approaches to meeting West Virginia water temperature standards (2012-present); Consultant to Energy Northwest, Inc. for analysis of existing cooling-water intake structure for NPDES re-permitting and development of a 316(b) study plan and reports for the Columbia (nuclear) Generating Station (2013-present); Consultant to Alden Research Laboratories for design of studies of American eel guidance (2014-2015); Reviewer for EPRI of 316(b) entrainment characterization study plans for seven power plants on the Ohio River (Cardinal, Clifty Creek, F. B. Culley, Kyger Creek, Mill Creek, Sammis, and Stuart)(2014); Reviewer for entrainment study plans for BC Hydro's "Site C" new hydropower plant on behalf of the Natural Sciences and Engineering Research Council of Canada (2015); Consultant to Consumers Energy for FERC re-licensing of the Ludington Pumped Storage Project on Lake Michigan (2015-2017). Reviewer (2015-2018) of entrainment study plans or 316(b) documents for Sutton Power Station (Duke Energy/HDR), Summer Nuclear Station and Urquhart Station (SCANA), Waiau Power Station (Hawaiian Electric Co.), Madgett Power Station site (Dairyland Cooperative), Labadie Energy Center (Ameren Missouri/ASAAC), Robinson Nuclear Station (Duke Energy/HDR), Oconee Nuclear Station (Duke Energy/HDR), Brunswick Nuclear Station (Duke Energy/HDR), Nebraska City Station (Omaha Public Power District), North Omaha Station (Omaha Public Power District), Eddystone Generating Station (Exelon Generation), Sequoyah Nuclear Station (TVA), Waiau Generating Station and Kahe Generating Station (Hawaiian Electric Co.), Phillips 66 Bayway Refinery (2017). Review of 316(a) thermal demonstration for Cumberland Generating Station (TVA, 2017). Review panel for Bruce Power Co. Environmental Risk Assessments for Bruce Generating Station, Ontario (2017), Review of results of thermal discharge study, 316(a) demonstration, and expert testimony for Ameren's Labadie Station (2017-2019); Review of 316(b) reports for Tennessee Valley Authority's Sequoyah Nuclear Station (2018); Review of 316(b) documents for Tennessee Eastman's chemical plant (2018); Review of 316(b) reports for First Energy Generation's Bay Shore and Sammis stations (2018); Review of EPRI 316(b) documents for the Ohio Valley Electric Corporation's Kyger Creek Generating Station (2018), Southern Indiana Gas & Electric Company's Culley Station (2019), Indiana-Kentucky Electric Corp.'s Clifty Creek Station (2019), and American Electric Power/Buckeye's Cardinal Station (2019); Review of 316(a) documents for Dairyland Cooperative's Madgett Station; Review of 316(b) reports for Omaha Public Power's Nebraska City Station and North Omaha Station (2019); Review of 316(b)

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documents for Exelon Generation's Eddystone Station (2019); Review of 316(b) reports for Duke Energy Indiana's Cayuga Station (2019) and Oconee Station (2020).

February 2021

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Peer Reviewer Potential Conflict of Interest Evaluation

The following questions are taken directly from USEPA's 2015 Peer Review Handbook, 4th Edition, Appendix J. For the purposes of this questionnaire, the "subject topic" is the Clean Water Act §122.21(r)(10), (11), or (12) reports prepared by **ENERCON** for **Tennessee Valley Authority** (TVA) Browns Ferry Nuclear Plant that you will be reviewing . If answering 'yes' to any question, please explain.

a. To the best of your knowledge and belief, is there any connection between the subject topic and any of your and/or your spouse's compensated or uncompensated employment, including government service, during the past 24 months? No.

b. To the best of your knowledge and belief, is there any connection between the subject topic and any of your and/or your spouse's research support and project funding, including from any government source, during the past 24 months? No.

c. To the best of your knowledge and belief, is there any connection between the subject topic and any consulting by you and/or your spouse, during the past 24 months? No.

d. To the best of your knowledge and belief, is there any connection between the subject topic and any expert witness activity by you and/or your spouse, during the past 24 months? No

e. To the best of your knowledge and belief, have you, your spouse, or dependent child, held in the past 24 months, any financial holdings (excluding well-diversified mutual funds and holdings, with a value less than $15,000) with any connection to the subject topic? No

f. Have you made any public statements or taken positions on or closely related to the subject topic under review? No

g. Have you had previous involvement with the development of the document (or review materials) you have been asked to review? No

h. To the best of your knowledge and belief, is there any other information that might reasonably raise a question about an actual or potential personal conflict of interest or bias? I have consulted with TVA in previous projects not related to the subject topic.

i. To the best of your knowledge and belief, is there any financial benefit that might be gained by you or your spouse as a result of the outcome of this review? No. Only my received fee, regardless of outcome.

I hereby certify that I have read the above statements and, to the best of my knowledge and belief, no conflict of interest exists that may diminish my capacity to provide an impartial, technically sound, objective review of the subject matter or otherwise result in a biased opinion.

Charles C. Contant, Ph.D.

(Name – please print)

Charles C. Contant

(Signature)

August 4, 2021

(Date)

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Harold L. Thompson, P.E.

Project Role: **Senior Engineer Consultant**

Harold Thompson specializes in thermo/fluid system design, piping design, and fluid system performance as well as hydropower facilities design. He has engineering design experience with architectural/engineering firms designing power generation facilities. He has experience with Northeast Utilities and Dominion Nuclear Connecticut. For these utilities, Harold performed engineering design, plant startup (Millstone Unit 3), and system engineering (Millstone Unit 2 and Unit 3). His technical and leadership experience includes supervisory and leadership positions during the performance of configuration management reviews, planned outages, and design modifications.

Position with Firm
Senior Engineering Consultant

Key Expertise
- Thermo/Fluid System Design
- Piping Design
- Fluid System Performance
- Powerhouse Design
- Hydro Due Diligence
- Hydro Unit and Plant Control Systems
- Technical Assistance for Turbine Generator Equipment Selection and Procurement

Professional Registration
Professional Engineer, MA and CT

Certification/Training
U.S. Navy Nuclear Power School and Prototype Training

Education
M.S. Management, Rensselaer Polytechnic Institute, 1987

B.S. Mechanical Engineering, Northeastern University, 1978

Years of Experience
With Kleinschmidt: 11
Total: 52

Relevant Project Experience

316(b) Peer Review, §122.21 (r)(12) Vistra Energy
Lead peer reviewer for engineering-related contents of the Non-Water Quality Environmental and Other Impacts Assessment report (§122.21 (r)(12)) prepared for compliance with 316(b) regulations. This included several plants such as Kincaid Power Station, Edwards Power Station, Dresden Power Station (Exelon Nuclear), Joppa Power Station and Newton Power Station.

316(b) Peer Review, §122.21 (r)(12) Sequoyah Nuclear Plant
Tennessee Valley Authority, Soddy-Daisy, TN
Lead peer reviewer for engineering-related contents of the Non-Water Quality Environmental and Other Impacts Assessment report (§122.21 (r)(12)) prepared for compliance with 316(b) regulations.

316(b) Peer Review, §122.21 (r)(10-12) Brunner Island Steam Electric Station
Talen Energy, York Haven, PA
Served as Lead Peer Reviewer for engineering-related contents of the three reports prepared for compliance with 316(b) regulations.

316(b) Peer Review, §122.21 (r)(10-12) Peach Bottom Nuclear Power Station
Exelon Generation Company, Delta, PA
Served as Lead Peer Reviewer for engineering-related contents of the three reports prepared for compliance with 316(b) regulations.

316(b) Peer Review, §122.21 (r)(10-12) High Bridge Combined Cycle Power Plant
Xcel Energy, St. Paul, MN
Served as Lead Peer Reviewer for engineering-related content of the three reports prepared for compliance with 316(b) regulations.

316(b) Compliance Activities, Bridgeport Energy Facility
Bridgeport Energy, LLC, Bridgeport, CT
Served as Lead Engineer for identifying alternative options for compliance with Environmental Protection Agency's impingement mortality and entrainment reduction standards. Work included reviewing plant operating data and previous analyses to determine an effective solution that minimizes impacts to both operations and the local environment. Work also included providing supplemental information as required by §122.21(r)(10-12) of the 316(b) rule.

316(b) Peer Review, Various Nuclear Generating Stations
Exelon Generation Company
Senior Engineer for performing peer review of engineering contents of reports required by 40 CFR 122.21(r)(2-13) for Exelon's entire nuclear fleet.

Technical Assistance, Millstone Power Station
Dominion Nuclear CT, Waterford, CT
Subject Matter Expert (SME) to Millstone Station supporting improvements in the operation and reliability of significant safety systems and safety related equipment at Millstone Station. This effort has included supporting System Engineering trouble shooting efforts, identifying and implementing

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corrective actions and the interfacing with the NRC and Nuclear Industry performance monitoring teams (INPO).

316(b) Compliance Activities, BTA Assessment, Windsor Locks Co-Gen Station
Algonquin Power Windsor Locks, LLC, Windsor Locks, CT

Senior Engineer for conducting an assessment of Best Technology Available (BTA) for reducing adverse effects associated with the use of the station's cooling water intake structure as required by National Pollutant Discharge Elimination System permit. The assessment of technologies/operational measures was performed and allowed for identification of the preferred alternative of modifying current operations to achieve compliance with permit stipulations.

316(b) Compliance Activities, BTA Assessment, Montville Generating Station
NRG Energy, Inc., Montville, CT

Senior Engineer for performing assessment of Best Technology Available (BTA) for reducing adverse environmental impacts due to the design, operation, and location of the Montville Generating Station cooling water intake structure on the Thames River. The assessment of each option included a description of the design and operation, installation feasibility, and estimation of capital and operational costs.

316(b) Compliance Activities, Evaluation of Alternative CWIS Technologies
Pfizer, Inc., Groton, CT

Senior Engineer in assessment of available technologies/operational measures for reducing impingement and entrainment impacts at Pfizer's cooling water intake structure. The assessment of each option included a description of the design and operation, feasibility of installation, and estimation of capital and operational costs.

Evaluation of Alternative Cooling Water Intake Structure Technologies
Pfizer, Inc., Groton, CT

Senior Engineer responsible for providing engineering assessment of available technologies/operational measures available for reducing cooling water consumption at Pfizer's global research campus in Groton, Connecticut. The assessment of each option included a description of the design, operation, and possible installation barriers, and estimated capital costs for the identified potential options.

316(b) Compliance Activities, Mt. Tom Generating Station
FirstLight Power Resources, LLC., Holyoke, MA

Senior Engineer in evaluation of technologies/operational measures for reducing 316(b) impacts at the station's cooling water intake structure. The assessment of each option included a description of the design and operation, identification of installation feasibility, and estimation of capital and operational costs.

Mechanical Systems Design and Material Selection, Holtwood Hydroelectric Expansion Project, PPL Holtwood, Holtwood, PA

Senior Engineer responsible for preparing and reviewing specifications for mechanical systems and components including but not limited to valves, pumps, piping, insulation, and instrumentation. Reviewed material selection for various components including pumps, piping, and valves.

Technical Assistance, Rocky River Penstock Replacement
FirstLight Power Resources (GDF Suez, NA), New Milford, CT

Senior Engineer responsible for performing hydraulic review of penstock to determine most efficient penstock diameter to support plant configuration. Reviewed available material and made material selection recommendations. Prepared purchase and installation specifications and reviewed technical submittals.

Cooling Water Evaluation, Algonquin Co-Generation Station
Algonquin Power Systems, Windsor Locks, CT

Senior Engineer responsible for evaluating plant systems and water usage in an effort to provide recommendations for the reduction in water usage at the facility. This included a review of equipment cooling water demands and normal plant operating characteristics. This review resulted in potential plant operational changes that would minimize cooling water usage, especially during critical periods of spring and late summer that would minimize impingement and entrainment of small fish and fish larvae.

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Peer Reviewer Potential Conflict of Interest Evaluation

The following questions are taken directly from USEPA's 2015 Peer Review Handbook, 4th Edition, Appendix J. For the purposes of this questionnaire, the "subject topic" is the Clean Water Act §122.21(r)(10), (11), or (12) reports prepared by **ENERCON** for **Tennessee Valley Authority** (TVA) Browns Ferry Nuclear Plant that you will be reviewing . If answering 'yes' to any question, please explain.

a. To the best of your knowledge and belief, is there any connection between the subject topic and any of your and/or your spouse's compensated or uncompensated employment, including government service, during the past 24 months? **No**

b. To the best of your knowledge and belief, is there any connection between the subject topic and any of your and/or your spouse's research support and project funding, including from any government source, during the past 24 months? **No**

c. To the best of your knowledge and belief, is there any connection between the subject topic and any consulting by you and/or your spouse, during the past 24 months? **No**

d. To the best of your knowledge and belief, is there any connection between the subject topic and any expert witness activity by you and/or your spouse, during the past 24 months? **No**

e. To the best of your knowledge and belief, have you, your spouse, or dependent child, held in the past 24 months, any financial holdings (excluding well-diversified mutual funds and holdings, with a value less than $15,000) with any connection to the subject topic? **No**

f. Have you made any public statements or taken positions on or closely related to the subject topic under review? **No**

g. Have you had previous involvement with the development of the document (or review materials) you have been asked to review? **No**

h. To the best of your knowledge and belief, is there any other information that might reasonably raise a question about an actual or potential personal conflict of interest or bias? **No**

i. To the best of your knowledge and belief, is there any financial benefit that might be gained by you or your spouse as a result of the outcome of this review? **No**

I hereby certify that I have read the above statements and, to the best of my knowledge and belief, no conflict of interest exists that may diminish my capacity to provide an impartial, technically sound, objective review of the subject matter or otherwise result in a biased opinion.

Harold Thompson

(Name – please print)

Harold Thompson

(Signature)

8/4/2021

(Date)

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IEc

ROBERT E. UNSWORTH **PRINCIPAL**

Overview

Mr. Unsworth specializes in the fields of environmental and natural resource economics, environmental benefits assessment, and environmental policy analysis. His work is conducted in the context of environmental and natural resource policy development, regulatory analysis, and litigation. Mr. Unsworth served as IEc's Chief Operating Officer and President from 2001-2011, and was a member of the Board of Directors from 1998 to 2018.

Mr. Unsworth has testified in the context of environmental litigation and before state commissions. He has served as a member of several expert panels, including the National Research Council, Transportation Safety Board, Committee to Evaluate Alternative Tanker Designs; the Atlantic States Marine Fisheries Commission, Horseshoe Crab and Tautog Management Committees; and U.S. Environmental Protection Agency panels on approaches to estimate the economic benefits of the Clean Water Act.

Summary of Qualifications

Examples of Mr. Unsworth's applied work and expert testimony in the context of water economics, fisheries economics, ecosystem valuation, and expert peer review include:

- Completing economics peer reviews for 316(b) methodologies and reports, for facilities operated by **VISTRA ENERGY** (multiple generating facilities), **EXELON NUCLEAR, EXELON CORPORATION** (multiple generating facilities), **TALEN ENERGY** (Brunner Island), and **DAIRYLAND POWER COOPERATIVE** (Genoa and JPM generating stations), and **ARCELORMITTAL BURNS HARBOR**.
- For **DOMINION** he completed an evaluation of an existing peer review. In this role he has reviewed draft benefit analyses and study plans to address economic impacts associated with the environmental effects of once-through cooling.
- For **EXELON NUCLEAR**, prepared an economic benefits analysis of a fish handling and return system for the James A. Fitzpatrick Nuclear Power Plant.
- For the **CALIFORNIA ENERGY COMMISSION**, defined best practices for monetizing the ecological impacts associated with once-through cooling at electricity generating facilities along the California coast. Testified before the Commission on the results of this effort and served as primary author of several sections of the final report. Topics addressed included review of the state-of-the-science on monetization of once-through cooling impacts; possible use of equivalency analysis; best practices (e.g., how to treat baseline conditions, discounting); review of the strengths and weaknesses of methods used in past efforts; and review of U.S. Environmental Protection Agency guidance on this topic.
- For the **LOS ANGELES DEPARTMENT OF WATER AND POWER**, Assessed potential changes in ecological and human use services provided by an urbanized bay system in California resulting from changes in one-through cooling technology at two large electricity generating facilities. This report was used to support decisions regarding alternative cooling technologies. Considered impacts under a range of scenarios, and addressed significant baseline water quality and habitat issues.
- For the **ATLANTA REGIONAL COMMISSION** (through the **KING AND SPALDING** law firm), Mr. Unsworth directed an effort to model the economic and environmental implications of changes in dam operations at the the Corps of Engineers' Buford Project, which controls the flow of water from Lake Lanier to the Chattahoochee River in northwest Georgia. Considered were water

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quality, ecosystem services, water supply, transportation, and recreation impacts, as well as impacts on water use, water rates, and values in the Atlanta region.

- Served as an expert witness on the valuation of changes in commercial and recreational fisheries, including the Long Island Sound Lobster fishery and the Allen Harbor clam fishery (Rhode Island). Assessed the regional economic and social welfare values of the Monomoy, Cape Cod shellfish fishery and the Atlantic coast striped bass fishery.
- For a range of clients, he has testified on proper methods for valuing changes in natural resources, addressing a range of ecosystem services. This includes testimony before State Commissions, in State and Federal Court, and for the International Court of Justice in The Hague.
- He has conducted and managed a large number of studies of recreational impacts associated with changes in environmental quality. For example, for the **U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE**, managed the development of a meta-analysis of 150 contingent valuation and travel cost-based sport fishing valuation studies in order to provide an analytic tool for recreational valuation to be used in damage assessment and policy analyses.
- Mr. Unsworth is recognized as an expert in the field of applied environmental economics, having authored guidance for Federal and State agencies on the use of environmental impact and valuation approaches. For example, assisted the **U.S. ENVIRONMENTAL PROTECTION AGENCY** in the development of guidelines for preparing economic analyses of environmental regulations; the **U.S. DEPARTMENT OF THE INTERIOR** in guidelines for assessment of the economic impacts associated with critical habitat designation and the conduct of natural resource and cultural damage assessment; and the **U.S. DEPARTMENT OF TRANSPORTATION**, Office of Pipeline Safety guidance for cost-benefit analysis.
- Provided guidance to **U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE** on the legal requirements for, and appropriate economic approach to, analyses of the ecological and human use impacts of relicensing proposals for hydropower projects.
- Served as a peer reviewer on the topic of environmental economics. For example, he has peer reviewed methods for assessing economic damages under the **EUROPEAN UNION**'s Environmental Liability Directive, and has served in the role of peer reviewer for several site specific environmental damage assessments.

Education

Master of Forest Science, Yale University.
Bachelor of Science *magna cum laude* in Forestry, State University of New York.

Selected Reports and Publications

"Economic Costs of Once-Through Cooling Impacts" In: Issues and Environmental Impacts Associated with Once-Through Cooling at California's Coastal Power Plants. Staff Report, California Energy Commission. CEC-700-2005-013-AP-A. June 2005.

Genova, Leslie, Robert E. Unsworth, and David S. Brookshire. 2012 "Impacts of Endangered Species Protection on Water Management, Allocation and Use in New Mexico." In: Water Policy in New Mexico: Addressing the Challenge of an Uncertain Future. Resources for the Future Press, Washington, DC.

"The Economic Value of Natural Resource Services Potentially Impacted by a Change in Cooling Regime at the

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Haynes and Alamitos Generating Stations." Consulting Report Prepared for: Haynes Generating Station, Los Angeles Department of Water and Power. 2005.

"Environmental Performance of Tanker Designs in Collision and Grounding: Method for Comparison," Committee for Evaluation Double-Hull Tanker Design Alternatives, Marine Board, Transportation Research Board, The National Academies. Washington, DC. 2001.

Bishop, Richard and Robert Unsworth, 1994, "Assessing Natural Resource Damages Using Environmental Annuities," *Ecological Economics* 11:35-41.

Mendelsohn, Robert, Daniel Hellerstein, Michael Huguenin, Richard Brazee, and R. Unsworth, 1992, "Measuring Hazardous Waste Damages with Panel Models," *Journal of Environmental Economics and Management* 22:259-271.

Selected Testimony

Mr. Unsworth testified before the California Energy Commission on methods for placing economic values on the environmental impacts of once-through cooling systems.

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Peer Reviewer Potential Conflict of Interest Evaluation

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a. To the best of your knowledge and belief, is there any connection between the subject topic and any of your and/or your spouse's compensated or uncompensated employment, including government service, during the past 24 months? **No**.

b. To the best of your knowledge and belief, is there any connection between the subject topic and any of your and/or your spouse's research support and project funding, including from any government source, during the past 24 months? **No.**

c. To the best of your knowledge and belief, is there any connection between the subject topic and any consulting by you and/or your spouse, during the past 24 months? **Mr. Unsworth has conducted other economic peer review assignments under Clean Water Act 316(b) at other facilities, but has not done any work related to this facility.**

d. To the best of your knowledge and belief, is there any connection between the subject topic and any expert witness activity by you and/or your spouse, during the past 24 months? **No.**

e. To the best of your knowledge and belief, have you, your spouse, or dependent child, held in the past 24 months, any financial holdings (excluding well-diversified mutual funds and holdings, with a value less than $15,000) with any connection to the subject topic? **No.**

f. Have you made any public statements or taken positions on or closely related to the subject topic under review? **Mr. Unsworth has completed other peer reviews under Clean Water Act 316(b), some of which are public, and has testified on approaches to measure benefits before the California Energy Commission (generally and not with respect to any specific facility), but has not done work related to this facility.**

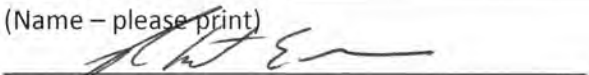
g. Have you had previous involvement with the development of the document (or review materials) you have been asked to review? **No.**

h. To the best of your knowledge and belief, is there any other information that might reasonably raise a question about an actual or potential personal conflict of interest or bias? **No.**

i. To the best of your knowledge and belief, is there any financial benefit that might be gained by you or your spouse as a result of the outcome of this review? **No.**

I hereby certify that I have read the above statements and, to the best of my knowledge and belief, no conflict of interest exists that may diminish my capacity to provide an impartial, technically sound, objective review of the subject matter or otherwise result in a biased opinion.

____Robert E. Unsworth_____
(Name – please print)



(Signature)

____8.4.21_____
(Date)

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LANCE R. LEFLEUR
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KAY IVEY
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AUGUST 20, 2021

MR PAUL PEARMAN
SENIOR MANAGER
WATER PERMITS COMPLIANCE AND MONITORING
TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT
1101 MARKET STREET BR 2C
CHATTANOOGA TENNESSEE 37402

RE: NOTIFICATION OF PEER REVIEWERS AND QUALIFICATIONS
NPDES PERMIT NUMBER AL0022080

Dear Mr. Pearman:

The Department has reviewed the qualifications and information submitted in your August 5, 2021 letter for the proposed candidate peer reviewers for the Clean Water Act Section 316(b) reports described in §122.21(r)(10) through (12). The Department has no comment at this time. If you have any questions, please contact Theo Pinson by e-mail at **tpinson@adem.alabama.gov** or by phone at **(334) 274-4202.**

Sincerely,

Scott Ramsey, Chief
Industrial Section
Industrial/Municipal Branch
Water Division

Birmingham Branch
110 Vulcan Road
Birmingham, AL 35209-4702
(205) 942-6168
(205) 941-1603 (FAX)

Decatur Branch
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Decatur, AL 35603-1333
(256) 353-1713
(256) 340-9359 (FAX)

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(251) 450-3400
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Mobile-Coastal
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Mobile, AL 36608
(251) 304-1176
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Appendix B. Charge Questions and Comment Forms

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Browns Ferry Nuclear Power Plant
Peer Review
Biologist Charge Questions

Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
§122.21(r)(10)	Closed-cycle recirculation system (CCRS)	Was the discussion of factors other than cost that may make a candidate technology impractical or infeasible for further evaluation reasonable and adequate for this level of study?	Yes (Finding)	No response required
§122.21(r)(10)	CCRS	Please provide additional relevant comments or suggestions not covered by the charge questions.	The following comment relates to the existing cooling-water system as background for evaluating the CCRS. (Finding) Figure 1. This figure diagramming the present cooling-water system at BFN is essential for understanding the rest of the report, and it took me considerable study to decipher it. I believe it would be easier to understand if a few things were done: - I suggest that the “cold water channel” would be better understood if it is called the *cooled* water channel (in text, too) since the water in the forebay is the initial “cold water” for the circuit and what is labeled “cold“ is better understood as cooling-tower cooled. - The meaning of the colors used for the flows could use explanation in the text or legend, such as blue for cold water inlet to condenser, red for warmed water, and black for optional interties, assuming I figured it our correctly. - The text refers to a “discharge control structure” that isn’t labeled as such on the figure. Is it what is labeled “Overflow weir”? A subsequent paragraph states that there are actually two structures, the discharge control structure and the overflow weir. Perhaps the figure label could be Discharge Structure/Overflow Weir since they appear to be close according to the text. - Since the text refers to a blowdown outlet it would be helpful to show a discharge to the river at the overflow weir. - The red squares are not labeled, although they might be intended to indicate screen structures, and could be identified in the legend. Unclear why one of those for Cooling Tower 7 is green. - The figure shows “RCW” coming off the CCW pumps, but there’s no indication of the acronym in the text or list of abbreviations. It looks like it could be Raw Cooling Water but going where? The actual raw cooling water is shown going to the condensers.	Please note that this is a simplified diagram of the CCW system, as stated in the text. The intent is to convey just the main components of the CCW system. The figure is quite “busy” as is, and we do not want to make it any more cluttered. - The term “cold water channel” is consistent with the BFN NPDES permit application. We suggest keeping as is. - There are arrows from the cooling tower lift pumps to the cooling towers. We can add arrows from the cooling towers into the cold water channel to complete the loop. Immediately above the CCW Pumps is the word “Forebay” as well as “Tennessee River”. The warm water channel is already labeled accordingly. - Agreed, the figure label will be changed to “Discharge Structure/Overflow Weir” - This does not seem material to the depiction of the CCW system and would only “clutter” an already “busy” schematic. - We will remove the squares, they are not material to the figure. - The reviewer is correct, RCW is the Raw Cooling Water. As discussed in Section 3.9, the RCW system removes heat from the equipment located in and adjacent to the turbine building. The RCW system pumps are supplied with water from the CCW conduits of each unit. We will add RCW to list of acronyms.

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	In your opinion, was the selected mesh size(s) used (which the Rule says may not exceed 2.0 mm) for the evaluation reasonable and adequate given the design constraints and considerations of the species and life stages identified in the Entrainment Characterization Study?	Yes (Finding)	No response required
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	For fine-mesh traveling screens, discuss whether or not the proposed conceptual design(s) for the fish return system was reasonable and adequate for the source waterbody location where the fish would be returned?	The location downstream of the intake's zone of influence is reasonable, as is the use of an existing outlet. This assumes there is no eddy flow in the reservoir that would bring the water back to the intake (a detail that likely would not influence the conclusion for this technology). (Finding)	No response required
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	Was the discussion of factors other than cost that may make a candidate technology impractical or infeasible for further evaluation reasonable and adequate for this level of study?	Yes (Finding)	No response required
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	Please provide additional relevant comments or suggestions not covered by the charge questions.	1. Figure 8 and related text, page 50. Since the purpose of the 316(b) analyses is to evaluate entrainment and impingement, it would be helpful if this figure, its legend and related text would specifically point out the e&i relevant features as well as the text mentioning debris collection (lack of carryover into the condenser). This would include identification (labeling) of screen wash sprays (not shown on the figure) and the collection troughs for the wash water, debris, and organisms (shown but not labeled). The different colors aren't given a purpose, but could indicate cooling-water flow (blue), elevation of impinged organisms to the spray washes (green), and transport of organisms and debris to the river in the spray wash ((yellow). A stock figure and description from the vendor often isn't sufficient for a 316(b) report. (Finding) 2. Section 11.1.2. Existing intake Pumping Station, page 53. It isn't clear why operation of the existing screens (mesh size not given) and their screen wash is needed when the CCW would already be screened by the new structure with fine-meshed screens. Is it compensation for the safety bypasses where aquatic life could pass the new structure (is this what you mean by "support the safety bypass")? (Question) 3. Section 11.1.3. New Screening structure, pages 54-55. It would be helpful to have the last paragraph on page 55 be the beginning of the section where it would introduce the features discussed in the rest of the section. The content is fine—just the order of presentation. (Finding)	1. Agreed, the figure should include labeling. This will be done. Additionally, the reader will be directed to Appendices E and F which show the FMS conceptual design in (greater) detail. 2. The reviewer is correct – the existing screens need to be retained in case the new screens require bypass. The text in the report will be modified to make this clearer. 3. We will move the last paragraph to the beginning of Section 11.1.3

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
			4. Figure 12, page 56. It may be assumed that the screen would be placed in the structure shown, but it would be helpful to show where the screen would be placed. Maybe the rectangles unconnected to the structure are supposed to show the screen units, but a reader shouldn't have to guess. Again, just using the company's stock figure doesn't necessarily serve the purpose of the 316(b) report. (Question) 5. Table 4, page 57. Since all the other data are in English units, it would be helpful for those not familiar with metric to parenthetically give the proposed mesh opening size in English units (0.02 inch). (Finding) 6. Debris issue, Page 58. This is a major drawback to the FMS option, regardless of the biological entrainment question (as is well discussed). But I would have expected the mention of screen clogging by the otherwise entrainable organisms such as fish eggs and larvae that 316(b) is supposed to protect (and high mortality of the impinged biota). Biological clogging was included in the r(11) evaluation, but it would be good to include a mention of it here. (Finding) 7. Section 11.1.4.1, New Screen Wash and Fish Spray System, page 58. The first paragraph says that "all the fish are washed into the fish trough." Experience has shown though, that most of the entrainment-vulnerable fish eggs and larvae that are impinged on the FMS aren't washed off alive. Larger fish would be. Some recognition of that seems needed here. Perhaps restating that the *goal* is to wash all fish off the screen, but that in reality most of the entrainment-vulnerable fish eggs and larvae that are impinged on the FMS aren't washed off alive. (Finding) 8. Section 15, Conclusions for Fine Mesh Screen, pages 81-82. Some 316(b) r(10) reports include the issue of biological effectiveness for protecting entrainable biota with FMS, concluding that FMSs don't work well. You haven't chosen to do that here, with the issue referred to r(11). But the poor viability of impinged eggs and larvae is a key liability of FMSs, so it seems like that point ought to be mentioned, at least, in the engineering assessment of the FMS option, with statement that it is covered in r(11) with a cross reference. (Finding)	4. We agree that Figure 12 can be confusing. It will be deleted. Figure 8 already shows the screen and the location of the screen within one of the bays; as indicated in response to Comment 1 above, the figure will be labeled to assist the reader in identifying the screen and bay features. Additionally, the reader will be directed to Appendices E and F which provide details of the FMS conceptual design. Note that Figure 12 is included in Appendix E (page 5 of 9 of the Appendix), so there is no real need to include it in the body of the report. 5. Mesh size 0.5 mm will be presented in English units also. 6. Clogging of the FMS is a significant concern for use of this technology at BFN. The FMS design includes separate bypass systems for the nuclear safety related intake water (check term used in report) and a bypass is included within the design of each screen. Given the availability of both systems to respond to a clogging event, clogging issues are addressed in terms of bypass and the associated loss of effectiveness. 7. Text will be revised as suggested to state that the goal is to wash all fish of the screen but that most of the entrainment-vulnerable fish eggs and larvae that are impinged would not survive the wash 8. Poor viability of impinged eggs and larvae as a key liability of FMS will be pointed out in r(10) and cross referenced to r(11)
§122.21(r)(11)	All evaluated	Provide your professional opinion as to whether or the not the method used to estimate the reduction in impingement mortality and entrainment losses for each of the technologies evaluated was reasonable and adequate.	The methods used to evaluate differential mortality reduction were detailed, appropriate for the science, well presented, and clearly reasonable and adequate. One qualification, though: the influence of the bypasses in the FMS option, where unscreened organisms pass unscreened by the FMS, doesn't seem to be covered, and probably should be. (Finding)	The end of the Section 3.4.1 of the Biological Benefit Evaluation (Appendix A of r11) was revised by adding the following: "Estimation of entrainment abundance and reduction if a 0.5-mm FMS was installed at BFN did not account for fish entrained through the existing traveling screens if the FMS were bypassed for safety-related reasons as

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
				described in the Comprehensive Technical Feasibility and Cost Evaluation Study. Rather than assuming the frequency, timing and duration of a safety-related bypass over the period of 2022–2036, the biological benefits of a 0.5-mm FMS were estimated assuming safety-related bypasses would not be required. However, the effectiveness of the 0.5-mm FMS at reducing entrainment would be less if a safety-related bypass was required during the entrainment season."
§122.21(r)(11)	All evaluated	Were the results of the Entrainment Characterization Study and Source Waterbody Biological Information appropriately considered as input to the benefit evaluation?	Yes (Finding)	No response required
§122.21(r)(11)	All evaluated	If changes in stock sizes or harvest levels of commercial or recreational species were estimated, discuss whether the methods used to estimate these changes were reasonable and adequate.	The methods for estimating changes in stock sizes or harvest levels of commercial (no commercial fisheries) or recreational species were also detailed, appropriate for the science, well presented, and clearly reasonable and adequate. (Finding)	No response required
§122.21(r)(11)	All evaluated	Was the selection of taxa or relevant species reasonable and adequate for the evaluation and did it include quantification of commercial, recreational, and forage species?	The taxa/species were those found in the Entrainment Characterization Study [r(9)] and thus reasonable and adequate. Quantification of multi-species data and aggregation of this information into the blue catfish as the example predator was also reasonable and adequate. (Finding)	No response required
§122.21(r)(11)	All evaluated	If applicable, did the evaluation consider benefits to federal or state protected species and their designated critical habitat and was evaluation of this topic reasonable and adequate?	This information was included and it was reasonable and adequate (Finding)	No response required
§122.21(r)(11)	All evaluated	If mitigation efforts prior to October 14, 2014 were implemented and included in the evaluation, was an appropriate method or methods used to quantify their benefits and was the discussion of results reasonable and adequate?	It was adequately reported that there were no specific mitigation efforts prior to October 14, 2014. (Finding)	No response required
§122.21(r)(11)	CCRS	For use of a CCRS, was the benefit of the reduction in the thermal discharge evaluated? And if so, was the discussion of the results reasonable and adequate?	The thermal discharge was evaluated and the discussion was reasonable and adequate. See additional comments for another perspective. (Finding)	No response required
§122.21(r)(11)	All evaluated	For each evaluated technology, please comment on the following. a. Were identified biological benefits to the environment or species (other than those impinged and entrained)	From a biological perspective, the prominent benefits would reasonably be to fish species and the social impacts on recreational fishing. Any other benefits would be negligible. The brief discussion of these topics was reasonable and adequate. (Finding)	No response required

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
		reasonable and were they adequately discussed? b. If quantified, was an appropriate method used and adequately described? c. Were significant biological environmental benefits or collateral losses omitted?		
§122.21(r)(11)	All evaluated	Please discuss whether the authors identified important assumptions and sufficiently considered their potential impact on the results.	There was no specific section critiquing assumptions and their impact, and this could be a useful addition to the report. Assumptions were described throughout, which may be adequate. (Finding)	While a separate section that discusses the impacts of the assumptions made in the biological estimates could be useful, assumptions were adequately described throughout in context of the calculations and methods. Since assumptions were described adequately and a separate section of assumptions and their impacts is not required under §122.21(r)(11), no revisions were made.
§122.21(r)(11)	All evaluated	Based on the Rule's requirements for this information, in your professional opinion, do you think the technical information provided is reasonable and adequate?	Yes. Detailed and well-presented biological information was synthesized into the biological benefits analysis and the information was appropriately used for the economic analysis. All reasonable and adequate from a biological perspective. (Finding)	No response required
§122.21(r)(11)	All evaluated	Please provide additional relevant comments or suggestions not covered by the charge questions.	Section 1: Introduction and Summary of Results. - The first paragraph doesn't say what the Benefits Valuation Study is of. Since some readers of the 316(b) documents may begin with the r(11) report, it would be essential to state that the study is to quantitatively compare alternative technologies and/or operations to reduce biological and social (monetary) effects of entrainment and impingement of aquatic life by the existing condenser cooling system (you could quote the relevant part of the Rule that precedes your list). (Finding) *The owner or operator of an existing facility that withdraws greater than 125 mgd AIF must develop for submission to the Director an evaluation of the benefits of the candidate entrainment reduction technologies and operational measures evaluated in paragraph (r)(10) of this section including using the Entrainment Characterization Study completed in paragraph (r)(9) of this section. Each category of benefits must be described narratively, and when possible, benefits should be quantified in physical or biological units and monetized using appropriate economic valuation methods. The benefits valuation study must include, but is not limited to, the following elements:* If not quoted, then precede the list of requirements with something like: For each technology/operations selected for analysis, the following are required by the Rule: … - The bottom paragraph of page 4 jumps directly to the economic analysis (elements *iii-vi*) without referring to the relevant biological benefits analysis (elements *i* and *ii*). I suggest adding something like:	The first paragraph will be revised to state that the Benefits Valuation Study quantitatively compares alternative technologies and/or operations to reduce biological and social effects of entrainment an impingement of aquatic life by the existing CCW system. Suggested text/paragraph will be incorporated into Section 1

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
			The candidate technologies were evaluated relative to performance of the existing CWIS, assuming 100% through-plant entrainment mortality. A recent Entrainment Characterization Study [r(9)] quantified the concentration of species and numbers of organisms capable of being entrained in the CCW (mostly fish eggs and larvae). The biological benefits evaluation combined this concentration with volumes of cooling water typically withdrawn (existing CWIS) and each candidate technology to quantify the technology's reduction in numbers and species assumed killed by entrainment. The withdrawn species and numbers of early life stages were then converted to numbers of socially-used life stages (catchable stock sizes and harvest levels; Appendix A). For entrainable species not normally harvested but providing food (forage) for harvestable species, change in their availability as food (production foregone) was estimated. [paragraph change here would be good to separate the biological benefits analysis from the monetary.] As discussed in this report and Appendices A & B, … (Finding) - This summary doesn't mention impingement, which is part of 316(b). If the impingement analysis is deferred to after resolution of entrainment (as is often the case), this should be mentioned. In most 316(b) reports, this caveat is stated at the outset of the report. (Finding) Section 3: Estimated Changes in Stock Size and Harvest Levels - Table 3-1, page 9: By "five-year (2016-2020) actual intake flow" do you mean five-year *average* flow? Best to say exactly what Appendix A (Section 3.1.2) says: "2016-2020 daily average AIF". Same for Tables 3-2, 3-3. (Question) - Tables 3-2 & 3-3, which give numbers of fish don't readily convey the relative changes. Not sure which is confusing, the legend or the numbers or both. Are the numbers the additional fish that would occur if each technology was implemented? If so, then the legend could be better worded, something like: Numbers of additional age-1 equivalents (or adults, as appropriate for each table) estimated to occur for species and life stages from reduced annual entrainment mortalities if a CCRS or… (Finding) Section 4: Impingement Mortality and Entrainment Benefits Monetization Basis - This heading includes impingement, but the foregoing doesn't mention any changes in impingement from the existing CWIS. Is it included in Appendix A? (Question) Section 7: Thermal Discharge Reduction Benefits. - What you have is good, but from a regulatory standpoint, if BFN has a discharge permit with a 316(a) variance or	As stated in the r(6) report, TVA is deferring the final decision of a chosen method of compliance with impingement mortality standard until after the BTA determination for entrainment. This will be added to the Summary Section3 Table captions will be changed to state "2016-2020 daily average AIF" as suggested. Section3 Tables 3-2 and 3-3 reflect the relative changes, age-1 and adult equivalents "saved" from annual entrainment mortality reductions. The table captions do state equivalent estimates correspond to annual entrainment mortality reductions. Section 4 The heading will be corrected to "Entrainment Benefits Monetization Basis". Section 7

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			other regulatory approval, then there are no benefits from implementing either CCRS or FMS. (Finding) Appendix A. Biological Benefit Evaluation (Normandeau Associates 2021) - This appendix may already be in final form, so it isn't clear how useful my comments would be. Nonetheless, I will make a few. - Section 3.1.2, page 3 ,and Table 3-3, page 13. Calculations of annual AIF make sense, but the table legend needs work to help understand it. It says AIF is in "gallons per day (MGD)" but MGD is *million* gallons per day. "Actual intake flow (AIF)" is actually an average for each date in January 2016-December 2020 corresponding to the dates sampled in 2018 or 2019, and extrapolated for the number of days represented by each sampling. The "total" is confusing since it is for the sampling period (the column) and the sum of the volumes on days sampled as expanded for the days in the sampling period (the bottom line). Applicable to tables 3-4 and 3-5, too. (Finding) - Section 4.4.1,page A-64. This shows a typical problem of calling out appendices of an appendix. This text is in Appendix A of the r(11) report. So calling out "Appendix A" here can be confusing as this *is* Appendix A. This confusion can be avoided by a footnote when the main Appendix A is cited (and hope a reader remembers it). (Finding) - Page 71, top paragraph, 3d line. Something seems missing after the "non". (Finding) - Page 71, Section 4.3.2, 3d line. I'm sure you mean production foregone reductions. (Finding) - Page 72, 3d full paragraph, line 11. I'm sure you mean equivalent fishery yield *saved*. (Finding) - Page 72, bottom paragraph. Again, I believe you are comparing estimated numbers saved by the technologies. (Finding) - Section 5.5, page 92, Thermal Discharge Reduction Benefits. From a regulatory standpoint, when BFN has an MPDES permit for the thermal discharge, whether by meeting standards or approved variance, the state has determined that there are no significant impacts from the thermal discharge and thus no benefits from a reduction. (Finding) - General comment. The fine-mesh screen option includes two types of bypasses around the screens, a big safety one and small ones at each screen nose. I don't recall the calculations of biological benefit including these bypasses, which would allow some entrainable organisms	Text will be revised to add: "The finding that BFN's thermal discharge under existing CWIS operations is not causing appreciable harm was substantiated by BFN being granted a §316(a) variance in their NPDES Permit". Section 3.1.2, page 3 was revised to: "Daily water withdrawal volumes were based on the January 2016–December 2020 daily average AIF at BFN provided by TVA that corresponds to the dates sampled in 2018 and 2019, and extrapolated by the number of days represented in each sample period ~~and summarized by sample period in (~~Table 3-3)." Appendix A, Tables 3-3 through 3-5 were revised with the following: 1. In table captions, inserted "million" (accidental omission) in front of "million gallons per day (MGD)" 2. Inserted "Mean" in column headers that now read "Mean AIF (MGD)" 3. For clarity, "Total" was inserted resulting in column headers that read "Total Volume (m3)" 4. Footnotes added to bottom row "Year[a]" a The mean AIF for the year is the 2016–2020 daily average (n=365) and the total volume for the year is the sum of the volumes withdrawn for the sample periods corresponding to the dates sampled in 2018 and 2019. Confusion with referencing "Appendix A" in the Biological Report titled "Biological Benefit Evaluation of Entrainment Reducing Technologies at Browns Ferry Nuclear Plant" that appears as Appendix A in the submittal document was resolved by renaming Appendix A of the Biological Evaluation Report to Appendix 1, and the in-text references, appendix tables (fish life history tables) and page numbers were revised accordingly. Page 71, top paragraph, "d" inserted after "release" and replaced "non" with "population" so the phrase now reads: "…based on the proportions of the catch harvested and released from the creel survey data for Blue Catfish, Channel Catfish, Sunfish, White Bass, Yellow Bass, Crappie and Sauger (Table 4 2) assuming these data are representative of the whole population for a typical year;…"

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			to pass through. I searched the r(11) document for the word "bypass" and didn't get a hit. It seems that any effect of the bypasses ought to be mentioned, even if it is trivial. (Finding) Appendix B. Social Benefits Evaluation (NERA Economic Consulting 2021). The detailed fisheries information was used appropriately by the economic analyses. (Finding)	Page 71, Section 4.3.2, 3d line: Changed to: "Using the production foregone model, both CCRS and FMS scenarios were used to estimate the biomass of forage fish corresponding to the annual entrainment mortality reductions based on both years of the entrainment data and the two-year average ~~mean annual entrainment~~." Page 72, 3d full paragraph, line 11. In lieu of inserting "saved" the statement was revised to: "Equivalent fishery yield from annual entrainment mortality reductions for the FMS was lower in comparison to the CCRS In same paragraph, the following sentence was corrected: "In 2019, the total value was 22,370 fish with the majority (10,433 fish) ~~was~~ represented by White Bass (Table 4-13)." In same paragraph, "from annual entrainment mortality reductions" were also inserted for clarity: ". The total equivalent fishery yield from annual entrainment reductions for the CCRS in 2018…" "Total equivalent catch values from annual entrainment reductions for both years of data and the mean for the CCRS" Section 4, last para: "…and the mean of both years produced an estimated fishery yield from annual entrainment reductions of 35,397 fish for the CCRS and 11,589 fish for the FMS (Table 4 16)." Concerning the two types of bypasses around the FMS, see previous response to the bypass comment in r11. Misspelling of "catfish" was corrected in footnotes to Table 4-2. Section 5.5, page 92. Normandeau agrees with the reviewer's comment that any plant with a valid NPDES Permit assumes no significant biological impact is present if the thermal discharge standards are met or a variance has been granted. To address §122.21(r)(11)(vi), any benefits resulting from reductions in thermal discharge from entrainment technologies were described. A misspelling of "extent" was corrected in this section:

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				"However, operation of a CCRS would expect to lead to a substantial reduction in spatial ~~extend~~ extent and magnitude of the thermal discharge." No response required for Appendix B
§122.21(r)(12)	CCRS	Did the evaluation compare changes in water consumption that would be realized by retrofitting a CCRS?	Yes (Finding)	No response required
§122.21(r)(12)	CCRS	Were the methods used to evaluate and quantify the differences in water consumption reasonable and adequate?	Yes (Finding)	No response required
§122.21(r)(12)	CCRS	Were the impacts of water consumption documented?	Yes, in the sense that the estimated CT water consumption was related to the flow of the water through Wheeler Reservoir/Tennessee River (~0.2%, believed to have trivial impact). (Finding)	No response required
§122.21(r)(12)	CCRS	Comment on whether the discussion of attempts to mitigate the impacts identified and evaluated was reasonable and adequate.	Most impacts were believed small, and not requiring much mitigation beyond normal plant maintenance. This seems reasonable and adequate. (Finding)	No response required
§122.21(r)(12)	CCRS	Please provide additional relevant comments or suggestions not covered by the charge questions.	1. Figure 2-2, page 6. As noted for review of r(10), the "cold water channel" would be better called the cooled water channel (cooled by the towers) to distinguish it from the cold water source at Gate 3. Also, the legend indicates the figure shows the spoils disposal site, but that is not labeled on the figure. (Finding) 2. Page 8, various table citations. These table citations are awkward, and may be confusing to readers. Some citations refer to tables in the cited documents (e.g., Table 1 in 1st paragraph and Table D-5 in 2nd paragraph) while the 3d paragraph cites a table in this report. I suggest for clarity citing the tables in other reports as: Table 1 in TVA 2021a and Table D-5 in TVA 2021a. Same for citations later (e.g., bottom paragraph of page 10). (Finding) 3. Section 3.1, 1st paragraph, line 8, life pumps should be lift pumps. (Finding)	1. The naming of the cold water channel is consistent with the BFN NDPES permit application discharge flow schematic. Figure 2-2 will be revised to identify the spoils disposal site. 2. The additional identification of specific locations/tables within the sources was provided for TVA reviewers and will be deleted in this version of the report. Citations throughout the document will be revised to just the source (e.g., TVA 2021a). 3. This correction will be made.
§122.21(r)(12)	Dual-flow, fine-mesh traveling screens	Comment on whether the evaluation and discussion of non-water quality environmental and other impacts of the other technologies (i.e., fine-mesh screens) were reasonable and adequate. Were the attempts to mitigate the impacts identified reasonable and adequate?	Reasonable and adequate (Finding)	No response required

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
§122.21(r)(12)	Dual-flow, fine-mesh traveling screens	Please provide additional relevant comments or suggestions not covered by the charge questions.	1. Section 4, page 26, 3d paragraph, 2nd sentence. Some words seem missing for this to make sense. I don't recall the r(11) evaluation including the passing of entrainable life stages through these bypasses (see comment on r(11), Appendix A). (Finding) 2. Figure 4-2, page 28. The spoils disposal area isn't labeled on the figure, and the reader shouldn't have to guess where it is. (Finding)	1. This is the same wording found in the R10 report page 52. The paragraph is provided to describe the fine mesh screens. 2. Figure 4-2 will be revised to identify the spoils disposal site.

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Browns Ferry Nuclear Power Plant
Peer Review
Economist Charge Questions

Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
§122.21(r)(10)	Closed-cycle recirculation system (CCRS)	Due to the high capital and O&M cost, a CCRS retrofit for less economically efficient units may not be economically viable for the owners unless it is identified as a "reliability must run" (RMR) unit so it can recover the compliance cost from ratepayers. If the owner determined it would not be economically practical to retrofit with a CCRS and would likely retire the facility, please address the following: • Discuss whether the information and justification provided to support a unit or facility retirement decision was reasonable and adequate. • Discuss whether or not the evaluation, estimation, and discussion of the social costs of a unit or facility retirement was reasonable and adequate.	No determination is made regarding economic practicality of BAT/facility retirement, and no analysis of the social costs of facility retirement is presented.	That is correct, no such analyses were performed and thus there are no economic analyses to evaluate.
§122.21(r)(10)	CCRS	If a CCRS was to be retrofitted, the social costs can vary depending on the nature and use of the land adjacent to the facility (i.e., urban, suburban, rural/agricultural, native vegetation or parkland). Note that the basis for most of the social costs provided in the §122.21(r)(10) report is likely to have come from the §122.21(r)(12) information. a. Was the list of social impacts considered reasonable? b. Were the methods used to quantify and/or monetize the social costs appropriate? c. Were the social costs (negative and positive) adequately quantified and monetized for the facility?	The report provides a reasonable list of social costs including capital costs of new facility construction; operation and maintenance costs; energy costs (i.e., electricity that would no longer be available for sale to consumers); and administrative costs (addressed qualitatively). The report notes that construction outages (i.e., plant shutdowns) are unlikely given the ability to take advantage of facility downtime. The methods used to monetize expected social costs are reasonable and well described, consistent with best practices, and the social costs of the two alternatives considered are adequately presented.	No response required
§122.21(r)(10)	CCRS	Were the social costs for CCRS retrofit presented as an annualized cost and net present value (NPV) and were the methods used to generate these estimates reasonable and adequate?	The 40 CFR 122.21(r)(11) report presents both annual and net present value social costs for each of the alternatives. The methods used are reasonable and adequate, and consistent with EPA's guidelines for Preparing Economic Analyses (2014). The sensitivity of the results to the real rate of social discount is shown by considering both 3% and 7% real rates of interest. Note that the authors correctly report annual social cost estimates using the 3% and 7% social discount rates and the	No response required

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			annual compliance cost estimates discounted at TVA's private discount rate (while TVA is a public entity, it is correct to consider their real rate of borrowing, which is defined as a private discount rate, not a social discount rate in these calculations). Note that the compliance cost calculations assume a rate of inflation for 2021 and 2022 that may be low given current conditions. Assuming inflation returns to recent historical levels in the near term (and bond rates for TVA debt do not dramatically change), changes in these factors will have a modest impact on the results that are presented.	
§122.21(r)(10)	CCRS	Discuss whether the authors identified important assumptions and uncertainties and sufficiently considered their potential impact on the results.	The authors clearly lay out all assumptions and discuss some sources of uncertainty. No formal uncertainty analysis is conducted (although reporting of results using 3% and 7% rates of social discounting are a form of sensitivity analysis). Other 316(b) reports have utilized more detailed and formal sensitivity analyses to allow the reader to understand the role of each significant assumption in the confidence we should have in the results. In this case, given the substantial difference between the social costs and social benefits of the two alternatives analyzed, such analysis would be interesting but would not change the conclusion.	No response required
§122.21(r)(10)	CCRS	Based on the Rule's requirements for this set of information, in your professional opinion, do you think the technical information provided is reasonable and adequate?	Yes. The information provided is reasonable, well-presented, and adequate for decision-making regarding the cost-benefit implications of the alternative technologies.	No response required
§122.21(r)(10)	CCRS	Please provide additional relevant comments or suggestions not covered by the charge questions.	Some additional discussion of the implications of the use of the wholesale price of electricity as the metric used to describe the social cost of reductions in efficiency and parasitic losses under the alternatives would be useful, including the appropriateness of this assumption in the context of this facility in the region's power supply (the report simply states that the change in total sales will be small and implies that this lost production will be made up for by other producers at the wholesale price). Use of the wholesale price is reasonable in this context, but more language supporting its use for social cost analysis at this facility would be appropriate (possibly described simply as a replacement cost from other generating sources, with no expected change in the wholesale price to consumers).	As recommended, NERA has provided some additional discussion of the appropriateness of the use of wholesale electricity prices to estimate the social cost of reductions in efficiency and parasitic losses under the alternatives.
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	For fine-mesh screens, discuss whether the list of potential social impact costs (negative and positive) considered is reasonable and adequate.	The report provides a reasonable list of social costs including capital costs of new facility construction; operation and maintenance costs; energy costs (i.e., energy that would no longer be available for use by consumers); and administrative costs (addressed qualitatively). The report notes that construction outages are unlikely given the ability to take advantage of facility downtime.	No response required

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			The methods used to monetize these costs are reasonable and well described, and these costs are adequately described.	
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	Discuss whether the methods used to quantify and monetize the social cost of fine-mesh screens were reasonable and adequate.	Yes, the methods used to monetize social costs of the fine-mesh screen alternative are reasonable and well-accepted. The write-up is clear.	No response required
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	Were the social costs for fine-mesh screens presented as an annualized cost and NPV?	The 40 CFR 122.21(r)(11) report presents both annual and net present value social costs for each of the alternatives. The methods used are reasonable and adequate, and consistent with EPA's guidelines for Preparing Economic Analyses (2014). The sensitivity of the results to the real rate of social discount is shown by considering both 3% and 7% real rates of interest. Note that the authors correctly report annual social cost estimates using the 3% and 7% social discount rates and the annual compliance cost estimates discounted at TVA's private discount rate (while TVA is a public entity, it is correct to consider their real rate of borrowing, which is a private, not social discount rate). Note that the compliance cost calculations assume a rate of inflation for 2021 and 2022 that may be low given current conditions. Assuming inflation returns to recent historical levels (and bond rates for TVA do not dramatically change), this factor will have a modest impact on the results that are presented.	No response required
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	Discuss whether the authors identified important assumptions and uncertainties and sufficiently considered their potential impact on the results.	The authors clearly lay out all assumptions and discuss some sources of uncertainty. No formal uncertainty analysis is conducted (although reporting of results using 3% and 7% rates of social discounting are a form of sensitivity analysis). Some other 316(b) reports have utilized more detailed sensitivity analyses to allow the reader to understand the role of each significant assumption in the results. In this case, given the substantial difference between the social costs and social benefits of the two alternatives analyzed, such analysis would be interesting but would not change the conclusion.	No response required
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	Based on the Rule's requirements for this set of information, in your professional opinion, do you think the technical information provided is reasonable and adequate?	Yes. The information provided is reasonable, well-described and adequate for decision-making regarding the cost-benefit implications of the alternative technologies.	No response required
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	Please provide additional relevant comments or suggestions not covered by the charge questions.	Some additional discussion of the implications of the use of the wholesale price of electricity as the metric used to describe the social cost of reductions in efficiency and parasitic losses under the alternatives would be useful, including the appropriateness of this assumption in the context of this facility in the region's power supply (the report simply states that the change in total sales will be small and implies that this lost production will be made up for by other producers at the wholesale price). Use of	As recommended, NERA has provided some additional discussion of the appropriateness of the use of wholesale electricity prices to estimate the social cost of reductions in efficiency and parasitic losses under the alternatives.

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
			the wholesale price is reasonable in this context, but more language supporting its use for social cost analysis at this facility would be appropriate.	
§122.21(r)(11)	All evaluated	Discuss if the methods, analysis, and assumptions used to monetize benefits were reasonable and adequate with respect to: a. direct use market benefits b. direct use non-market benefits c. indirect use benefits d. indirect non-use benefits	The social benefit analyses and interpretations of results are consistent with EPA's Guidelines as well as best practices in resource economics. The report considers a broad range of potential benefits of the evaluated technologies, including direct and indirect, and market and non-market. The methods used to monetize benefits are reasonable and adequate for the task at hand. In some cases, benefit categories (e.g., nonuse) were addressed qualitatively, which is appropriate given site-specific conditions. The results obtained and presented should be considered reliable and appropriate for decision-making purposes. The report assumes that gains in total biomass production in the fishery for non-target species associated with reduced entrainment will be expressed as a gain in recreational harvest of Blue Catfish. Since this species has a relatively low value per adult lost from harvest, it would be useful to provide details on why it was chosen for use in the benefit assessment. See Table 3: Recreational Catch Values by Species. The report notes that there is no commercial fishing in the study area, so correctly models this as a recreational fishery. It does this using benefit transfer of values for marginal increases in catch rates, which is appropriate in this context. The values are reasonable and drawn from reliable sources. Use of benefit transfer in this context is appropriate and consistent with best practices in the field of resource economics, and the analysis presented is transparent and easily understood. The cost of primary research (such as the development of a site-specific travel cost-based Random Utility Model, including the data required to support such a model) would not be justified by the increase in confidence in the benefit estimates. The qualities and characteristics of the aquatic resources at this site, as well as the modest expected changes in fish populations, support the author's conclusion that any changes in the nonuse values the public holds for the subject resources will be modest. The analysis does a good job describing the available approaches to place a monetized value on the ecological changes that would result from changes in technology installed at the facility and comes to a reasonable conclusion that these methods (i.e., applying a primary valuation study to understand the public's willingness-to-pay for small changes in the ecology of the study area) would not be justified.	No response required See Section 4.2.2 of Appendix A. "In this assessment, 100% of foregone production was assumed to be consumed by a single recreationally valuable predator species (age-3 Blue Catfish). Blue Catfish was selected because it is the most abundant predatory and highly targeted fish in the local recreational fishery, and was identified in the entrainment density data." No response required No response required

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
			If the ratio of costs to benefits were far narrower, or if the ecological impact of the facility far greater, nonuse values might be considered in more detail. This is not the case for this facility. The social benefit analyses are dependent on underlying biological data, assumptions, and analyses. Any significant changes in those analyses or assumptions could impact these results and thus the conclusions of the report regarding the relationship of social costs to social benefits.	
§122.21(r)(11)	All evaluated	Discuss if the method, analysis, and discussion of the monetization of the recreational and commercial fishery benefits for the evaluated technologies were reasonable and adequate.	The approach used to monetize recreational fishing benefits under the two alternatives assessed is reasonable and follows well-accepted practices in the field. As noted, there are no commercial fishing benefits.	No response required
§122.21(r)(11)	All evaluated	If mitigation efforts prior to October 14, 2014, were discussed and monetized, was an appropriate method(s) used to monetize those benefits and was the discussion of results reasonable and adequate?	The (r)(11) report notes that no mitigation efforts were put into place prior to October 14, 2014.	No response required
§122.21(r)(11)	All evaluated	For each evaluated technology, please comment on the following: a. Were biological benefits to the environment or species (other than those impinged and entrained) identified and monetized, and were they appropriately evaluated and adequately discussed? b. Were significant biological environmental benefits omitted?	The analysis considers, in qualitative narrative, the broader biological benefits of the alternatives (e.g., impacts on state and federally listed T&E species). While not monetized, the discussion provides sufficient information for decisionmakers. It does not appear that any significant environmental benefits were omitted.	No response required
§122.21(r)(11)	CCRS	For use of a CCRS, was the benefit of the reduction in the thermal discharge monetized? If so, were appropriate methods used and was the discussion of the results reasonable and adequate?	The report notes "[B]ased on the results from §316(a) thermal discharge studies (Baxter and Simmons 2008), the thermal discharge from the existing CWIS operations at BFN do not cause appreciable harm or adverse environment impacts; thus, reduction of the thermal discharge from operating a CCRS is not expected to lead to meaningful biological benefits." As such, no monetization of the benefits of reducing thermal discharges is undertaken.	No response required
§122.21(r)(11)	CCRS	For the use of a CCRS, did the report consider the negative and positive social costs and benefits of direct and indirect public impacts and, if so, was the evaluation reasonable and adequate?	The report considered, and in some cases monetized, a range of positive and negative social costs. The analysis and narrative are reasonable and adequate to support decision making.	No response required
§122.21(r)(11)	CCRS	For the use of a CCRS, did the report consider the negative and positive environmental costs and benefits of direct and indirect	The report discusses a broad range of environmental costs and benefits that could result under the CCRS	No response required

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
		environmental impacts and, if so, was the evaluation reasonable and adequate?		
§122.21(r)(11)	All evaluated	Please discuss whether the authors identified important assumptions and uncertainties and sufficiently considered their potential impact on the results.	Yes, the authors clearly present important assumptions and qualitatively describe uncertainties.	No response required
§122.21(r)(11)	All evaluated	In your professional opinion, do you think the information provided is reasonable and adequate for the NPDES permitting authority to make the entrainment BTA determination?	The social cost and benefit analyses conducted of the two alternative technologies are undertaken with sufficient rigor to support the BTA determination.	No response required
§122.21(r)(11)	All evaluated	Please provide additional relevant comments or suggestions not covered by the charge questions.	No additional comment.	No response required

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Browns Ferry Nuclear Power Plant
Peer Review
Engineer Charge Questions

Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
§122.21(r)(10)	Closed-cycle recirculation system (CCRS)	Did the evaluation appropriately consider the site-specific features (site geometry, geology, water availability) relative to CCRS technical feasibility, design, and cost?	Yes. The evaluation did consider site specific features relative to the technical feasibility, design and cost for implementation of a closed-cycle recirculation system. This included identification of the source water body that was detailed in (r)(2) and an overall description of and location of major components for the currently installed mechanical cooling towers. This included a discussion of the warm water channel and the cold water channel, the "hump", the overflow weir to control water level in the cold water channel, traveling screens and gates installed in the cooling water system. The physical condition of the cooling towers was addressed as well as proposed upgrades and modifications. Land availability was discussed and the proposed location of future structures to support plant modification was identified. Alternate cooling water sources such as waste water was discussed but it was noted that the plant location prohibits the availability and use of alternate water sources. The cost estimate for the proposed work was identified as Class 5. The authors noted that while they attempted to obtain realistic and accurate values for the proposed work, there were a great deal of "unknown" conditions that are not able to be determined until a more detailed study is performed. As a nuclear facility, BFN is responsible to a number of local, state and federal agencies including the NRC which may consider significant modifications to cooling water systems as unanalyzed safety concerns that will either delay or restrict implementation of cooling water system modifications.	No response required
§122.21(r)(10)	CCRS	Was the evaluation and estimate of the heat rate penalty (loss of cooling efficiency due to the higher temperatures from a CCRS compared to the source waterbody temperature) and energy penalty (energy to operate cooling water pumps and cooling tower fans) reasonable and adequate?	The evaluation determined that installation of a CCRS would have a heat rate capacity that would be 10% higher than the current condenser heat rate. This would not result in a heat rate penalty but the authors did note that during winter months the intake water temperature will be warmer than normal, and this will reduce overall plant efficiency. The authors identified that operation of a CCRS will result in a generation loss nine months each year for an average total loss of 17 MWe annually. The authors also identified that there would be a need to install a design feature that will prevent CWC from flowing into the intake pumping station forebay which serves as part of the UHS for the safety-related RHRSW pumps and EECS during design basis events. Water from the CCRS would periodically raise forebay water temperature above the UHS specification. Current plant Technical Specifications define UHS as being 95 degrees F. However, if the UHS meets or exceeds 92.5 degrees F, plant generation needs to be reduced from 100% to or below 96.3%. Effectively this is a heat rate penalty.	No response required

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
§122.21(r)(10)	CCRS	Did the evaluation of plant efficiency consider condenser design requirements as well as the potential need to retrofit condensers?	The main condensers were evaluated for performance as part of the most recent BFN EPU application. Documentation provided to the review team indicated that the main condensers have been re-tubed, and that work included the replacement of admiralty brass tubes with stainless steel tubes. The evaluation of the condenser(s) concluded that sufficient system capacity was available to ensure that the plant could maintain adequate condenser backpressure following installation of the EPU modification. It was also noted that the EPU evaluation assumed performance of the CCW system and towers at their original capacity and were not evaluated for closed-cycle cooling.	No response required
§122.21(r)(10)	CCRS	Did the evaluation consider alternative cooling tower designs and was an appropriate and adequate discussion of those design options provided including commercial availability and performance criteria?	The report states that BFN is currently equipped with seven mechanical draft cooling towers that augment CCW flow during the summer. While some of the towers are reported to be in a degraded condition, a third-party review by a cooling tower vendor recommended refurbishment of existing towers as needed. This would include replacement of Towers 1 and 2. The cooling capability of this arrangement would be expected to provide sufficient cooling to allow BFN to operate in closed-cycle cooling.	No response required
§122.21(r)(10)	CCRS	Were the compliance costs (capital and O&M) and social costs, labeled as annualized net present value (NPV)? Discuss whether the methods used for the estimates were reasonable and adequate.	For CCRS, capital cost estimates were defined in 2020 dollars without consideration of escalation. The estimates included but were not limited to material, labor, equipment, contractor overhead and profit, allowances, margin and fees, engineering, licensing, and permitting costs. RS Means was the basis for the majority of cost estimates. This estimate also identified annual maintenance expenses. Listed values appear reasonable, but it is not known if the cost estimates included typical cost escalation associated with performing work at a nuclear facility. Appendix G, Social Costs and Compliance Costs of Entrainment Reducing Technologies at Browns Ferry Nuclear Plant Based on Adjustments of Facility Costs provides a detailed review of costs for the two methodologies being considered. This document provides an overview of the methodology to adjust facility costs to social costs that includes capital, maintenance, energy and administrative costs. Annual fixed costs were spread equally over the twelve months of each year. NPV and annualized costs were discounted at rates of 3% and 7% and were adjusted to 2018 dollars. The NPV and annualized social costs for the two methodologies examined are considered reasonable and adequate.	No response required
§122.21(r)(10)	CCRS	Discuss whether the authors identified important assumptions and uncertainties and	While the installation of a CCRS appears feasible, the authors properly identified significant challenges to the project. They noted that beyond the procurement of materials, the project	No response required

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
		sufficiently considered these for their potential impact on the results.	would require extensive site work including clearing, grading, excavation, earthwork, equipment installation and system tie-ins. The authors noted that following implementation of a CCRS, an increase in staff personnel would be required for annual maintenance and maintenance costs would increase. Some new equipment would be required to conform to seismic 1 criteria, and that some features of the CCRS would require an extensive review and analysis as directed by 10CFR 50.59. Such a review and analysis could expand project scope and significantly impact the construction schedule.	
§122.21(r)(10)	CCRS	Based on the Rule's requirements for this set of information, in your professional opinion, do you think the technical information provided is reasonable and adequate?	Yes, the information provided within the evaluation is reasonable and adequate.	No response required
§122.21(r)(10)	CCRS	Please provide additional relevant comments or suggestions not covered by the charge questions.	The Executive Summary contains estimated total loss of generating power due to the operation of the fine mesh traveling screens and the fish handling and return system. The total loss of generating power for the CCRS should also be included within this section. Additional acronyms should be considered for the List of Acronyms and Abbreviations. The following appear to be missing from the list: ARCW, EECW (page 31), EPU, FSAR, HPFP, NWP, and RCW.	Agreed, the average annual loss in net power due to implementation of CCRS was estimated at 69 MWe. This will be included with the Executive Summary. Additional acronyms will be added to the List.
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	In your opinion, was the design basis for the fine-mesh screens proposed reasonable and adequate given existing screen well constraints, operational requirements, plant safety, and fish protection expectations?	The authors noted that advantages for using dual-flow traveling screens include an increase in screen open area over a conventional flow-through traveling screen and the elimination of debris and organism carryover. The orientation of the dual-flow traveling screens would allow for a larger screen area in the intake as compared to traditional traveling screens that are positioned perpendicular to the flow stream. The report states that use of fine mesh screens with larger openings would help to minimize flow-through velocities and continuous operation of the traveling screens would minimize debris accumulation and impingement time. Fish buckets would also minimize damage to the fish. The design basis for the traveling screens is reasonable and adequate.	No response required
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	In your opinion, was the evaluation of fine-mesh screen operational issues reasonable and adequate (debris loading, screen rotation speed, frequency of backwash, etc.)?	The use of dual-flow screens is appropriate in that they would increase submerged screen area and support velocity reduction through the traveling screens. The authors note that the screens are intended for continuous operation that will help to minimize debris accumulation on the screens. It was also noted that this type of screen eliminates possible debris carry-over. The screens would be equipped with two backwash systems that will operating continuously. A low-pressure spray would	No response required

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
			remove fish from the traveling screen and a high-pressure spray would remove debris from the screens. To further minimize debris loading on the traveling screens, trash racks were proposed for each screen. It was also noted that a normal bypass and a safety-related bypass are included in the design to support access to cooling water for the safety-related RHRSW pumps and EECS in the event of a complete screen blockage. The evaluation of operational issues is reasonable and accurate.	
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	Discuss whether or not the proposed design(s) for the fish return system was reasonable and adequate for the source waterbody location where the fish would be returned?	The design of the proposed fish return system is reasonable and adequate. The proposed design calls for low pressure spray to move fish from the traveling screen to the return trough with low pressure spray. The pitch of the trough would provide for a reasonable flow rate of water and fish would be transported to a point downstream of the intake structure to prevent or minimize fish from re-entering the intake. The diameter of the fish trough would also maintain a depth of water to support transport of the fish at a rate similar to their normal swimming speed. 40 CFR 125.92 is the basis for the fish handling and return system.	No response required
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	Discuss whether the methods and estimated capital and O&M cost of fine-mesh screens were reasonable and adequate. Were major cost components over or understated in development of the cost estimates?	In accordance with review guidelines, a Class 5 estimate was provided. As noted in the report, certain costs have been estimated with assumptions that aim to be accurate but remain uncertain. The values are estimates and materials and components are lumped together. The values are considered conservative and should cover unforeseen conditions that could result in an increase in scope. The estimates provided are reasonable and adequate.	No response required
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	Were the compliance costs (capital and O&M) presented as an annualized cost and net present value (NVP)? Discuss whether the methods used for the estimates were reasonable and adequate.	Appendix G, Social Costs and Compliance Costs of Entrainment Reducing Technologies at Browns Ferry Nuclear Plant Based on “Adjustments of Facility Costs” provides a detailed review of costs for the two methodologies being considered and discussed the methodology to adjust facility costs to social costs that includes capital, maintenance, energy and administrative costs. Annual fixed costs were spread equally over the twelve months of each year. NPV and annualized costs were discounted at rates of 3% and 7% and were adjusted to 2018 dollars. The NPV and annualized social costs for the two methodologies examined are reasonable and adequate.	No response required

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
			The cost estimates are Class 5 estimates, and the authors note that they would be refined with performance of the next phase of design. The reviewer recognizes the value of RS Means as a respected tool for cost estimating. Implementation of design changes at a nuclear facility typically exceeds cost and time estimates derived from RS Means. Delay in work schedules is often due to varying plant conditions, restricted access to certain plant locations, pre-job and post-job briefings, performance of QA and QC checks and safety reviews. It is possible, therefore, that current cost estimates may escalate.	
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	Please discuss whether the authors identified important assumptions and uncertainties, and sufficiently considered their potential impact on the results.	The "Impacts of Fine Mesh Implementation" are addressed in section 12 of §122.21(r)(10). This included a review of losses to generation, noise, visual, water consumption, ultimate heat sink, regulatory, licensing, environmental and safety, plant programs such as fire protection, flex and maintenance rule, siting issues and impacts to Alabama's electrical grid. This review also included a review of the construction schedule and identified the various construction activities needed for implementation of the traveling screens. Among other items, this review identified generation losses due to additional power consumption needed to operate the traveling screens and the associated equipment. The report states that new screens would not create new or significant visual impacts for the surrounding areas, would not impact water consumption, and would not adversely impact safe shutdown of the plant. It was noted that the greatest risk from installing fine mesh screens is the increased likelihood of screen blockage. This was addressed by the inclusion of normal and safety bypasses. It was determined that the new screens and bypass could fall under the scope of Maintenance Rule 10 CFR part 50.65 and the new screening structure and safety bypass line would be designed as Seismic Category 1 structures/components. The report noted that following excavation of the intake area in preparation for installing new screens, soil testing would be performed to evaluate the load bearing capacity of the soil. The report also stated that the loss of BFN generation due to parasitic loads would need to be provided from another generating station. The assumptions made and the uncertainties identified in the review process were sufficiently addressed to evaluate their impact on the proposed project.	No response required
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	Based on the Rule's requirements for this set of information, in your professional opinion, do you think the technical information provided was reasonable and adequate?	Yes, the technical information, drawings, photos and plans provided in this report are reasonable and adequate.	No response required

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
§122.21(r)(10)	Dual-flow, fine-mesh traveling screens	Please provide additional relevant comments or suggestions not covered by the charge questions.	In order for the fine-mesh screen option to be protective against impingement, it seems the design should consider a maximum through-screen velocity of 0.5 fps. The authors selected 1.5 fps "as a compromise between competing design factor of reduced impingement survivability caused by higher velocities and increased screening area required at lower velocities." It may be helpful to provide additional details of the extent of the difference in impact between 0.5 and 1.5 fps velocities on impingement survivability as well as the difference in screening area needed to accommodate both 0.5 and 1.5 fps through-screen velocities to help readers better understand why 1.5 fps was selected.	Screen mesh sizes between 0.5 mm and 2 mm were evaluated, as well as velocities between 0.5 fps and 2 fps. In order to meet the entrainment reduction standard of at least 60%, a mesh size of 0.5 mm was selected. With that mesh size, a through screen velocity of 1.5 fps was selected in order to keep the screen area "reasonable" (approximately 20,000 ft^2 , which is more than double the existing screen surface area). For a velocity of 0.5 fps, the screen area would have to increase to approximately 55,000 ft^2 (almost three times the area for a 1.5 fps screen).
§122.21(r)(11)	CCRS	For use of a CCRS, was the benefit of the reduction in the thermal discharge evaluated? And if so, was the discussion of the results reasonable and adequate?	For the two technologies evaluated, it was noted that there is no significant impacts to changes in the thermal discharge. It was noted that CCRS operation would expect to result in a substantial reduction in the extent and magnitude of the thermal discharge. It was also noted that based on a previous study, the discharge from the existing CWIS did not result in an adverse environmental impact and therefore reduction in the thermal discharge is not expected to be biologically beneficial. The conclusion of the thermal discharge evaluation is reasonable and adequate.	No response required
§122.21(r)(12)	CCRS	Comment on whether the evaluation, quantification, and discussion of the following were reasonable and adequate: • Energy consumption • Human health and environmental impacts from air emissions • Noise Impacts • Compatibility with surrounding land use • Compatibility with surrounding viewsheds	The authors noted that conversion to closed-cycle cooling would result in a reduction of gross generating capacity due to a decrease in thermal efficiency resulting from an increase in condenser cooling water temperature. This reduction in thermal efficiency would occur during nine month of the year and the annual loss to generation would be approximately 17 MWe. As presented in (r)(10), the total annual losses due to operational losses and parasitic losses would be a net loss of 69 MWe or an annual energy penalty of 544,000 MWh at a 90% utilization factor. The authors explained that replacement power from a fossil burning plant would result in a significant amount of nitrous oxide, carbon dioxide, sulfur dioxide and volatile organic compounds being added to the atmosphere every year. During construction, air quality impacts are expected to be minor, temporary and localized to the BFN site. During normal plant operation, the authors identified that CCRS cooling would have an impact on air emissions as cooling towers generate drift, or water droplets entrained in the exhaust air stream. Drift leaving the top of the cooling towers would have the same chemistry as the cooling water system. Drift results in environmental concerns including water consumption, fogging that may result in ice formation around the towers and damage	No response required

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
			to equipment, transfer of particulate solids to soil around the station, and impacts on vegetation. It was also noted that safety concerns such as reduced visibility, slipping and fall hazards could impact BFN staff conducting activities near the cooling towers. During construction, increases in site noise level from demolition, site preparation and foundation work would occur. However, this increase in noise level would occur during normal working hours over a limited period of time. During normal operation, TVA uses, as a guideline, the equivalent sound level of 60 dBA at the property line. A study in 2012 determined that noise levels at the nearest residence without cooling towers in operation was 59.7 dBA. TVA has indicated that an additional environmental sound pressure level assessment would be conducted. If this study determines that noise generated from the cooling towers exceeds FICON guidelines, TVA would likely need to develop and implement additional acoustic mitigation. The authors have described the site as a heavily disturbed area, with limited wildlife habitat, none of which is high quality, and terrestrial habitats found on the site are common to the area. However, it was noted that to avoid the unlikely take of northern long-eared bat, Indiana bat and the bald eagle during preparation of the spoils disposal area, TVA would follow USFWS guidance on tree removal and follow TVA's bat strategy. Implementation of CCRS technology would not require additional cooling towers and the towers alone would not impact surrounding viewshed. However, local atmospheric conditions indicate that dense, naturally occurring fog can be expected for approximately 25 days each year. The author(s) noted that the impact of the plumes would need to be examined in more detail. The discussions associated with these topics are reasonable and adequate.	
§122.21(r)(12)	CCRS	Was the discussion of public safety impacts (i.e., vapor plumes, icing, fogging, and emergency cooling water availability) reasonable and adequate?	Public safety impacts related to CCRS operation discussed included fogging, low visibility, and icing that could pose safety concerns for BFN personnel conducting activities in and around the cooling towers. Limited visibility due to ground level fog was also identified as a security concern limiting visibility and reduced clarity around the plant during fogging conditions. The authors noted that CCRS operation would increase forebay water temperature and this area serves as the plant UHS. As discussed in (r)(10), the CCRS design addresses two scenarios	No response required

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
			when the UHS temperature limit of 92.5 degree F could be challenged. Discussion of public safety impact and emergency cooling water availability are reasonable and adequate.	
§122.21(r)(12)	CCRS	Was the evaluation of facility reliability due to CCRS retrofit reasonable and adequate? Did it consider impacts due to cooling water availability?	It was noted that continual use of cooling towers may lead to an increased magnitude in the impacts over what BFN normally experiences with intermittent usage. That is, with more equipment and continual use of that equipment, additional maintenance would be required, and more frequent equipment outages should be expected. The evaluation of facility reliability associated with a CCRS retrofit is reasonable and adequate. Intake water flow for CCRS operation is required for makeup only. Referencing (r)(10) and (r)(2), BFN water consumption with CCRS would be approximately 0.2 percent of the daily flow in Wheeler Reservoir. The projected consumption rate for the proposed CCRS would be approximately 0.4 percent of current daily usage. Section (r)(10) also states that intake flow using CCRS would reduce intake flow by approximately 92%. When CCRS is operational, water usage would be reduced to approximately 160,000 gpm vs. the CCW flow rate for the site which is 2,100,000 gpm. The large size of Wheeler Reservoir and the average makeup rate ensure that water availability would not be an issue with a CCRS retrofit. Evaluation of impacts to water availability are reasonable and adequate.	No response required
§122.21(r)(12)	CCRS	Did the evaluation compare changes in water consumption with the CCRS? If yes, were the methods reasonable and accurate? Were the impacts of water consumption documented?	In (r)(12), the authors referenced (r)(10) indicating that current plant cooling water flow is approximately 2,100,00 gpm. Daily flows in Wheeler Reservoir at BFN is approximately 22 million gpm. Following installation of CCRS, plant makeup is expected to be approximately 160,000 gpm that would be used to offset water losses due to evaporation, drift, and blowdown. The volume of blowdown rate was estimated at approximately 115,000 gpm. The comparison in water usage when transitioning from CCW to CCRS is reasonable and accurate.	No response required
§122.21(r)(12)	CCRS	Comment on whether the discussion of reasonable attempts to mitigate the impacts identified and evaluated was reasonable and adequate.	Construction related impacts including but not limited to air quality, noise, visual impacts, cultural and environmental impacts were reviewed. Operational impacts including but not limited to air quality and atmospheric impacts, noise, water consumption impacts, visual impacts, energy consumption and safety and reliability impacts were also reviewed. In some cases, the authors were able to make a determination that there	No response required

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
			were no impacts anticipated either during construction or during CCRS operation. For some, including energy consumption and noise generation associated with CCRS operation, the authors stated that future noise testing and the need for additional electrical generation from other facilities would be required. Attempts to identify impact to construction and operation were reasonable and the evaluation of the potential impacts was reasonable and adequate.	
§122.21(r)(12)	CCRS	Comment on whether the complexity of the permit process involving federal, state, and local agency interactions was fully evaluated?	The authors identified several agencies at the federal, state, and local levels that would require interaction with to obtain permits pertaining to proposed plant operational modifications, changes to the intake structure, excavation, and dredging. The agencies include but are not limited to USACE (Nationwide and individual permits), ADEM, USFWS, EPA, Alabama Construction General Permit, and FICON. The permitting process would also require consultation with the State Historic Preservation Officer regarding the potential for affects to cultural resources. Concerning any changes to plant safety related system, a review and safety evaluation of any changes will require a 10 CFR 50.59 safety review. The permit process for the installation of CCRS is complex and this effort appears to have been fully evaluated.	No response required
§122.21(r)(12)	CCRS	Please discuss whether the authors identified important assumptions and sufficiently considered their potential impact on the results.	The authors identified a number of important assumptions associated with the feasibility and difficulty of converting a CCW system to a CCRS. This included but was not limited to the need for additional spillways, the need for a second gate (gate #2), the decrease in plant generation due to a reduction is overall thermal performance once the CCRS was installed, the fact that the plant would require additional operators to deal with cooling towers that would operate continuously, additional maintenance costs, safety concerns concerning MDCT drift and plumes, and the impact or potential impact of plant operability associated with potential UHS elevated temperatures. The authors also recognized that construction related activities such as noise would be temporary, and noise of the construction activities would occur during normal daily work hours. For continuous operation of CCRS, remote sound levels would need to be monitored and installation of different fans or other sound abatement equipment would be required. The authors also identified that plant personnel performing activities around the cooling towers may be subjected to hazardous conditions such as ice and poor visibility when plumes were occurring. The plumes were also recognized as a security concern as the plumes could limit visibility and required clarity for surveillance cameras.	No response required

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
§122.21(r)(12)	CCRS	Based on the Rule's requirements for this information, in your professional opinion, do you think the information provided is technically reasonable and adequate?	The information provided addresses non-water quality environmental and other impacts study per the requirements listed in 40 CFR Parts 122 and 125. This included changes to energy consumption, estimates of air pollutant emissions and impacts associated with those emissions, changes in noise, impacts to safety and availability of emergency cooling, a discussion of facility reliability, a discussion of significant changes in water consumption, and a discussion of all reasonable attempts to mitigate these factors. The information provided is technically reasonable and adequate.	No response required
§122.21(r)(12)	CCRS	Please provide additional relevant comments or suggestions not covered by the charge questions.	In the list of Acronyms and Abbreviations, the acronyms and phrase name do not always match. For example, EA and EECW. Capitalization should be consistent. May want to add Alabama SHPO (page 32). On page 15, text refers to spoils pile in figure 2-2 (page 6) but the spoils pile was not identified. The spoils pile is also identified in Figure 3-3, also on page 15. Perhaps this figure could be used to identify the spoils pile.	Agreed, these discrepancies will be corrected. Alabama SHPO will be added. Similar comment received from another reviewer. Figure 2-2 will be revised to identify the spoils disposal site.
§122.21(r)(12)	Dual-flow, fine-mesh traveling screens	Was the scope of the non-water quality environmental evaluation relating to fine-mesh screens complete? If not, please identify significant non-water quality environmental or other impacts that were omitted and discuss why they are important to the entrainment BTA determination.	The scope of non-water quality environmental evaluation included a review of the impact relating to the installation of fine mesh screens on terrestrial ecology, groundwater, air quality, noise, visual, waste management, cultural resources, environmental and plant operations. The scope of this review covered potential changes during construction and during plant operation following installation of the fine mesh screens. The scope of this review is complete.	No response required
§122.21(r)(12)	Dual-flow, fine-mesh traveling screens	Did the study adequately identify and evaluate reasonable attempts to mitigate issues identified for fine-mesh screens?	The study determined that installation of fine mesh screens would have construction impacts due to dredging. The spoils would be moved to an area currently used for spoils and the height of the spoils pile would be minimized. The proposed traveling screen would conform to the currently installed structure and would cause little change to the current view. The same is true for the fish handling and return system. Installation of fine mesh screens would result in parasitic losses and a reduction in plant net generation. This lost generation would then need to be provided by another plant. The study noted that two bypass lines on each end of the new traveling screen would ensure that debris loading, or screen collapse would not affect the EECW or RHRSW systems ability to respond nor would the fine mesh screen impact UHS water temperature. The study adequately identified and evaluated issues and mitigating responses associated with installation of fine mesh screens.	No response required
§122.21(r)(12)	Dual-flow, fine-mesh traveling screens	Discuss whether the authors identified important assumptions and uncertainties, and	The authors did identify important assumptions and uncertainties such as plant reliability with the increased potential	No response required

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Requirement	Technology Type	Charge Question	Peer Review Comment (indicate if QUESTION or FINDING)	Author Response
		sufficiently considered their potential impact on the results.	for fine mesh screens to foul or collapse. With small screen openings, they identified that the screens were at an increased risk for fouling, increased differential pressure across the screens, and the possible partial reduction in flow to safety related cooling water system. The authors also concluded that this type of failure is mitigated by redundancy and that failure of one screen is compensated by the remaining 21 screens. Seismic category 1 screen bypass piping installed at each end of the fine mesh screen intake structure would ensure that sufficient water is available for RHRSW and EECS.	
§122.21(r)(12)	Dual-flow, fine-mesh traveling screens	Based on the Rule's requirements for this information, in your professional opinion, do you think the information provided is technically reasonable and adequate?	Yes, based on the Rule's requirements, the information provided is technically reasonable and accurate.	No response required
§122.21(r)(12)	Dual-flow, fine-mesh traveling screens	Please provide additional relevant comments or suggestions not covered by the charge questions.	None.	No response required

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Appendix C. Approval Letters from Peer Reviewers

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Charles C. Coutant, Ph. D.
Aquatic Ecologist

120 Miramar Circle
Oak Ridge, TN 37830-8220
865-483-5976
e-mail: ccoutant3@comcast.net

January 20, 2022

William K. Nesmith
Tennessee Valley Authority
9882 Waterside Way
Soddy Daisy, TN 37379

via email: wknesmith@tva.gov

Re. TVA PO Number 6988770, 316(b) Peer Review Browns Ferry Nuclear Plant §122.21(r)(2)-(12) reports

Dear Mr. Nesmith:

As contracted on September 7, 2021, I reviewed draft reports, provided my answers to charge questions and further comments for my biologist's review on November 30, and reviewed the final responses to my comments.

As indicated in my responses to the charge questions, I found the document well done. The biological information in all sections was thorough, well analyzed using appropriate methods, and clearly presented. The biological information was well integrated with the benefits analysis comparing the existing entrainment with benefits of selected alternative entrainment and impingement reduction technologies. I concur with resulting quantitative conclusions.

Further, the authors responded appropriately to my general and specific comments by making minor revisions to the text.

It was a pleasure to review the document.

Sincerely,



Charles C. Coutant, PhD

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IEc

INDUSTRIAL ECONOMICS, INCORPORATED

January 20, 2022

Mr. Charles Day
Enercon
100 W. Martin Luther King Blvd, Suite 400
Chattanooga, TN 37402

Peer Review for Browns Ferry Nuclear Plant

Dear Mr. Day:

I served as peer reviewer of the economic-related contents of the §122.21(r)(10-11) information prepared for Tennessee Valley Authority's (TVA's) Browns Ferry Nuclear Plant located along the Tennessee River in Limestone County, Alabama. I sent my responses to the charge questions to TVA and its consultants on December 1, 2021. The authors' resolutions to address my comments were provided to me on January 7, 2022. Review of the resolutions confirms that my comments were addressed satisfactorily, and the information provided is reasonable and adequate for decision-making purposes.

I appreciate the opportunity to provide these services to TVA. If you have any questions or concerns, please contact me at 617.354.0074.

Sincerely,

Robert E. Unsworth

Digitally signed by Robert E. Unsworth
DN: cn=Robert E. Unsworth, o=Industrial Economics, Incorporated, ou=Principal, email=unsworth@indecon.com, c=US
Date: 2022.01.20 09:50:25 -05'00'

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Kleinschmidt

We provide practical **solutions** *for complex renewable energy, water, and environmental projects.*

January 19, 2022

Mr. Charles Day
Enercon
100 W. Martin Luther King Blvd, Suite 400
Chattanooga, TN 37402

Peer Review for Browns Ferry Nuclear Plant

Dear Mr. Day:

I served as peer reviewer of the engineering-related content of the §122.21(r)(10-12) information prepared for Tennessee Valley Authority's (TVA's) Browns Ferry Nuclear Plant located along the Tennessee River in Limestone County, Alabama. I sent my responses to the charge questions to TVA and its consultants on December 9, 2021. The authors' resolutions to address my comments were provided to me on January 7, 2022. Review of the resolutions confirms that my comments were addressed satisfactorily, and the information provided is reasonable and adequate for decision-making purposes.

I appreciate the opportunity to provide these services to TVA. If you have any questions or concerns, please contact me at 860.718.0320.

Sincerely,

KLEINSCHMIDT ASSOCIATES

Harold Thompson

Harold Thompson, P.E.
Senior Engineer

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Tennessee Valley Authority

Browns Ferry Nuclear Power Plant

National Pollutant Discharge Elimination System (NPDES) Permit No. AL0022080

Updated Final §316(b) Rule Information

40 CFR 122.21(r)(10)-r(12) Submittals

Executive Summary



Prepared for:
Tennessee Valley Authority

January 2022

Prepared by:
Enercon Services, Inc.

ENERCON
Excellence—Every project. Every day.

500 TownPark Lane
Kennesaw, GA 30144

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Executive Summary – 40 CFR 122.21(r)(10) – (12) Submittals

Tennessee Valley Authority (TVA) owns and operates Browns Ferry Nuclear Plant (BFN), located on the Wheeler Reservoir in Limestone County, Alabama. BFN Units 1, 2, and 3 are designed to continuously withdraw non-contact cooling water from the Reservoir. As a result, BFN is subject to compliance with the U.S. Environmental Protection Agency (EPA) Clean Water Act (CWA) Section 316(b) cooling water intake structures final rule at existing facilities (Final §316(b) Rule). Currently, BFN withdraws and discharges non-contact cooling water from Wheeler Reservoir in accordance with National Pollutant Discharge Elimination System (NPDES) Permit Number AL0022080.

EPA's Final §316(b) Rule established requirements under the CWA for existing power generating facilities that withdraw more than 2 million gallons per day (MGD) of water from waters of the United States and use at least 25 percent of that water for cooling purposes. Those requirements, implemented through NPDES permits, apply to the location, design, construction, and capacity of cooling water intake structures that reflect the Best Technology Available (BTA) for minimizing adverse environmental impact (AEI).

There are two main components of the Final §316(b) Rule for existing facilities such as BFN. The first requires the owner or operator of the facility to choose one of seven options for meeting BTA requirements for reducing impingement. The second component requires the facility to conduct studies to help their permitting authority determine whether and what site-specific controls, if any, would be required to reduce entrainment.

To address these two components, the Final §316(b) Rule establishes additional permit application requirements for existing power plants that include twelve distinct submittals per 40 CFR 122.21(r)(2) – (13). The enclosed submittal fulfills the submittal requirements of the Comprehensive Technical Feasibility and Cost Evaluation Study, Benefits Valuation Study, and Non-Water Quality Environmental and Other Impacts Study per §122.21(r)(10) – (12).

To assist with the development of the §122.21(r) submittals, BFN enlisted the services of engineering, biological, and economic consulting firms. The §122.21(r)(10) – (r)(12) submittals contained in this report were prepared by Enercon Services, Inc. (ENERCON), Normandeau Associates, Inc. (Normandeau), and NERA Economic Consulting (NERA) on behalf of TVA.

The purpose of BFN's §122.21(r)(10) – (12) submittals is to provide the pertinent information to assist the Alabama Department of Environmental Management (ADEM) in making a BTA determination after consideration of all factors relevant to such a determination under the Final §316(b) Rule for BFN. A summary of each §122.21(r)(10) – (12) requirement follows:

§122.21(r)(10) - Comprehensive Technical Feasibility and Cost Evaluation Study

This section provides a description of the technologies and/or operational measures (TOMs) that were selected for further evaluation based on the requirements of the Rule. The TOMs that were selected for detailed and comprehensive evaluation are:

(1) closed-cycle cooling using existing mechanical draft cooling towers; and

(2) fine mesh dual-flow traveling water screens.

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Water reuse and alternate sources of cooling water were evaluated based upon the total flow potentially available from onsite and local offsite sources, consistent with the requirements of §122.21(r)(10)(i), but were ultimately not retained for the comprehensive evaluation due to the minimal amount of alternative water sources available at BFN. As part of this study, conceptual designs, cost estimates, and implementation schedules are presented for each technology along with a preliminary evaluation of potential operational, construction, and regulatory impacts. Social costs and compliance costs are calculated for the two TOM candidates.

§122.21(r)(11) - Benefits Valuation Study

This section provides an evaluation of potential benefits for the two entrainment reduction TOM candidates evaluated pursuant to §122.21(r)(10). The potential benefits were developed using data generated by the Entrainment Characterization Study completed pursuant to §122.21(r)(9). The Benefits Valuation Study includes the elements specified in §122.21(r)(11). Each category of benefits is described narratively and, when possible, benefits are quantified in physical or biological units and monetized using appropriate economic valuation methods.

§122.21(r)(12) - Non-Water Quality Environmental and Other Impacts Study

This section includes a detailed, BFN-specific discussion of the changes in non-water quality environmental and other impacts attributed to each TOM selected for detailed and comprehensive evaluation pursuant to §122.21(r)(10), including impacts increased and impacts decreased. The study includes estimates of changes to energy consumption, addresses air pollutant emissions and atmospheric effects, impacts to noise impacts to safety, discussion of facility reliability, significant changes in consumption of water, and a discussion of reasonable efforts to mitigate each of these factors. Specifically related to mechanical draft cooling towers, effects of plume formation and its ability to travel away from BFN would need to be examined more closely prior to detailed design.

Summary of the Submittals

The enclosed submittals include detailed information developed pursuant to the requirements codified in §122.21(r)(10) – (12) of the Final §316(b) Rule. The Executive Summary provides a summary of the existing controls at BFN as well as an overview of the candidate TOMs selected for a comprehensive technical feasibility and cost evaluation study.

Existing Controls

Traveling Water Screens with Fish Handling/Return System

The BFN condenser circulating water system withdraws screened cooling water from Wheeler Reservoir. Water is drawn through existing 0.25 in. x 0.30 in. coarse mesh Hydrolox traveling water screens. Each traveling water screen is equipped with a high-pressure screenwash spray to clean the screen and prevent excessive head loss due to debris build up. The screenwash spray discharge is routed to a fish handling and return system to carry fish and debris to the river, downstream of the intake structure.

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Candidate Additional Technologies and/or Operational Measures

Closed-Cycle Cooling

BFN currently has seven linear mechanical draft cooling towers, cooling tower lift pumps, cold and warm water channels, and a series of gates and weirs. The towers are operated in "helper" mode to aid with once-through cooling of the condenser circulating water system (CCW) and are not used for closed-cycle cooling. Implementation of closed-cycle cooling would entail significant upgrade and replacement of various system components. The conceptual design includes replacement (Towers 1 and 2) and upgrade (Towers 4 and 7) of existing cooling towers, replacement of lift pumps, upgrade of discharge valves, installation of new power distribution and control equipment, construction of new Gate 2 structure, modifications necessary to protect the Ultimate Heat Sink (UHS), and refurbishment of the condensing circulating water system. The following provides a high-level summary of the findings and conclusions contained within this report.

- The total estimated capital cost for retrofitting BFN to closed-cycle cooling using mechanical draft cooling towers would be $307,940,000 based upon 2018 dollars. This includes construction, permitting and engineering costs. It should be noted that the capital cost shown in the body of the r(10) report is in 2020 dollars, however it is has been annualized to 2018 dollars in Appendix G for ease of comparison.
- Operation and maintenance costs for the cooling towers and supporting equipment are estimated to increase by $1,000,000 annually. This includes labor, equipment, and water treatment chemicals.
- The conversion of BFN to closed-cycle cooling would impact the Alabama electrical supply grid due to the operational losses associated with a closed-cycle cooling system. The average annual loss in net power generation due to implementation of closed-cycle cooling is approximately 69 MWe. This results in an annual loss in electricity supplied to the grid of approximately 544,000 MWh, assuming a 90% utilization factor. Alternate sources of power would be required to replace this lost power on a continual basis.
- The total project schedule for retrofitting BFN to closed-cycle cooling is estimated to be approximately eight years. This includes 30 months to complete the detailed engineering design and 84 months for permitting, procurement, construction, tie-in, and startup testing (some activities would be completed concurrently).
- Federal and state reviews, permits, and authorizations would be required for the closed-cycle cooling design presented from the USACE, NRC, and ADEM. The permitting process would also require consultations with the USFWS and the Alabama Department of Conservation and Natural Resources regarding the potential for effects to protected species and with the State Historic Preservation Officer regarding the potential for affects to cultural resources. TVA, as a federal agency, would be required to assess the project under NEPA. It is recommended that any detailed design efforts include a detailed permitting evaluation for the project, as significant regulatory reviews are anticipated in order to implement this alternative. Implementation could face delays due to the potential for lengthy federal and state permit processes.

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Fine-Mesh Screens

The conceptual design to implement fine-mesh screens at BFN includes construction of a new screening structure, installation of new 0.5 mm fine-mesh dual-flow traveling water screens in a new screening structure, installation of a new fish handling and return system, and installation of a new electrical distribution system. The existing through flow traveling water screens would remain in place and the existing intake pumping station would not be modified. The following provides a high-level summary of the findings and conclusions contained within this report.

- The total estimated construction cost for retrofitting BFN with 0.5 mm fine-mesh traveling water screens is $84,300,000 based upon 2018 dollars. This includes construction, permitting and engineering costs.
- Operation and maintenance costs for the 0.5 mm fine-mesh traveling screens and supporting equipment are estimated to be $160,000 annually. Additionally, periodic dredging of the intake forebay in the vicinity of the safety bypass pipes would be required to assure availability of the UHS under all design basis events. Estimated dredging cost (inclusive of engineering and permitting) would be $360,000 based upon 2018 dollars. These costs are assumed to occur every ten years.
- Retrofitting BFN with 0.5 mm fine-mesh traveling water screens would result in increased parasitic power losses from the power requirements of the additional equipment. The average increase in parasitic losses due to the additional equipment is approximately 802 kW. This would result in a loss of electricity supplied to the grid of 6,330 MWh per year, assuming a 90% utilization factor. Alternate sources of power would be required to replace this power lost on a yearly basis.
- The total project schedule for retrofitting BFN with 0.5 mm fine-mesh traveling water screens is estimated to be approximately six years. This includes 12 to 18 months to complete the detailed engineering design and 54 months for permitting, procurement, construction, tie-in, and startup testing (some activities would be completed concurrently).
- Federal and state reviews, permits, and authorizations would be required for the proposed 0.5 mm fine-mesh traveling water screens, including USACE, NRC, and ADEM. The permitting process could also require consultations with the USFWS and the Alabama Department of Conservation and Natural Resources regarding the potential for affects to protected species and with the State Historic Preservation Officer regarding the potential for affects to cultural resources. TVA, as a federal agency, would be required to assess the project under NEPA. It is recommended that any detailed design efforts include a permitting evaluation for the project, as significant regulatory reviews are anticipated in order to implement this alternative. Implementation could face delays due to the potential for lengthy federal and state permit processes.

Summary of the Results

Results regarding the potential two additional TOMs are summarized in the table below. Table ES-1 highlights results related to biological effectiveness, total social costs, total social benefits

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across the useful operating life of each technology, and cost benefit ratios using well-established economic methodologies. All dollar values are presented in 2018 dollars for comparison purposes. Compliance costs for the two technologies, based on a 2.3% private real discount rate, are $444.07M for closed-cycle cooling and $87.48M for fine-mesh screens.

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Table ES- 1: Summary of Comparisons of Entrainment Reduction Technologies

Technology	Entrainment Mortality Reduction		Total Project Social Cost, Present Value (Millions, 2018$)		Total Project Social Benefits, Present Value (Millions, 2018$)		Net Social Costs (Millions, 2018$)		Cost-Benefit Ratio	
	Age-1 Equivalents	Equivalent Adults								
Discount Rate	-	-	3%	7%	3%	7%	3%	7%	3%	7%
Closed-Cycle Cooling	92.4%	92.4%	$398.73	$316.90	$1.63	$1.08	$397.10	$315.82	244.6	293.4
0.5 mm Fine-Mesh Traveling Water Screens	17.6%	16.6%	$79.00	$68.78	$0.65	$0.46	$78.35	$68.32	121.5	149.5

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Overall Conclusions

EPA's Final §316(b) Rule establishes a process for a site-specific determination of entrainment control requirements at existing facilities with cooling water intake structures.

The selection of any such site-specific entrainment controls must be based on a determination by the permitting agency of the maximum reduction in entrainment warranted after consideration of the information provided by the applicant's §122.21(r) submissions and the consideration of the factors relevant to a BTA determination pursuant to 40 CFR §125.94 and §125.98, including, but not limited to, air emission impacts, energy impacts and whether the cost of additional entrainment controls are justified by the associated potential benefits.

BFN's §122.21(r)(10) – (12) submittals include evaluation of engineering, ecological, biological, regulatory, and economic assessments consistent with the Final §316(b) Rule. This evaluation includes investigation of the plant operational factors, implementation costs, and the monetized value of the resources potentially protected under each of the potential entrainment control technologies that were determined to be most appropriate potential additions to the current controls.

The present values of net social costs (i.e., social costs minus social benefits) range from an estimated $315.82 million to $397.10 million for closed-cycle cooling, with the range based upon differences in the discount rate. The present values of net social benefits (i.e., social benefits minus social costs) from implementation of 0.5 mm fine-mesh traveling water screens range from $68.32 million to $78.35 million, depending on the discount rate.

The implementation of closed-cycle cooling or fine mesh screens at BFN is not considered a prudent or practical measure for entrainment reduction due to the challenges, impacts, costs, schedule, and risks identified in this Comprehensive Technical Feasibility and Cost Evaluation Study.

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FACTORS THAT ADEM MUST AND MAY CONSIDER AT § 125.98(F)

The Rule requires at §125.98(f) that ADEM make an entrainment Best Technology Available (BTA) determination for Browns Ferry Nuclear Plant (BFN). The specific requirements of this provision state:

"(f) Site-specific entrainment requirements. The Director must establish site-specific requirements for entrainment after reviewing the information submitted under 40 CFR 122.21(r) and § 125.95. These entrainment requirements must reflect the Director's determination of the maximum reduction in entrainment warranted after consideration of factors relevant for determining the best technology available for minimizing adverse environmental impact at each facility. These entrainment requirements may also reflect any control measures to reduce entrainment of Federally-listed threatened and endangered species and designated critical habitat (e.g. prey base). The Director may reject an otherwise available technology as a basis for entrainment requirements if the Director determines there are unacceptable adverse impacts including impingement, entrainment, or other adverse effects to Federally-listed threatened or endangered species or designated critical habitat. Prior to any permit reissuance after July 14, 2018, the Director must review the performance of the facility's installed entrainment technology to determine whether it continues to meet the requirements of § 125.94(d).

> *(1) The Director must provide a written explanation of the proposed entrainment determination in the fact sheet or statement of basis for the proposed permit under 40 CFR 124.7 or 124.8. The written explanation must describe why the Director has rejected any entrainment control technologies or measures that perform better than the selected technologies or measures, and must reflect consideration of all reasonable attempts to mitigate any adverse impacts of otherwise available better performing entrainment technologies.*
> *(2) The proposed determination in the fact sheet or statement of basis must be based on consideration of any additional information required by the Director at § 125.98(i) and the following factors listed below. The weight given to each factor is within the Director's discretion based upon the circumstances of each facility.*
>> *(i) Numbers and types of organisms entrained, including, specifically, the numbers and species (or lowest taxonomic classification possible) of Federally-listed, threatened and endangered species, and designated critical habitat (e.g., prey base);*
>> *(ii) Impact of changes in particulate emissions or other pollutants associated with entrainment technologies;*
>> *(iii) Land availability inasmuch as it relates to the feasibility of entrainment technology;*
>> *(iv) Remaining useful plant life; and*

(v) Quantified and qualitative social benefits and costs of available entrainment technologies when such information on both benefits and costs is of sufficient rigor to make a decision.

(3) The proposed determination in the fact sheet or statement of basis may be based on consideration of the following factors to the extent the applicant submitted information under 40 CFR 122.21(r) on these factors:

(i) Entrainment impacts on the waterbody;

(ii) Thermal discharge impacts;

(iii) Credit for reductions in flow associated with the retirement of units occurring within the ten years preceding October 14, 2014;

(iv) Impacts on the reliability of energy delivery within the immediate area;

(v) Impacts on water consumption; and

(vi) Availability of process water, gray water, waste water, reclaimed water, or other waters of appropriate quantity and quality for reuse as cooling water.

(4) If all technologies considered have social costs not justified by the social benefits, or have unacceptable adverse impacts that cannot be mitigated, the Director may determine that no additional control requirements are necessary beyond what the facility is already doing. The Director may reject an otherwise available technology as a BTA standard for entrainment if the social costs are not justified by the social benefits."

Below, based on the factors that ADEM must and may consider in making the entrainment BTA determination, information developed in this report provides relevant information responsive to the factors that ADEM must and may consider in making the determination.

Factors That Must Be Considered:

1. *Numbers and types of organisms entrained, including, specifically, the numbers and species (or lowest taxonomic classification possible) of Federally-listed, threatened and endangered species, and designated critical habitat (e.g., prey base)* – A two-year entrainment characterization study was conducted at BFN in 2018 and 2019 and the results are summarized in Entrainment Characterization Study (§ 122.21(r)(9)) with entrainment losses quantified in Benefits Evaluation Study (§ 122.21(r)(11)). The primary periods of entrainment during both years occurred from March to August, with peak abundance occurring in April to May. Total entrainment of all species was estimated to be 3.01 billion finfish in 2018 and 3.22 in 2019. The baseline entrainment was dominated by highly fecund shad (gizzard and threadfin) that are forage species and made up 88% of the entrainment in 2018 and 73% of the entrainment in 2019. In 2018, the nonindigenous Mississippi silverside at 4% and freshwater drum at 3% that, together with shad, made up over 95% of the annual entrainment. In 2019, white bass at 18% was the second most dominant entrained species followed by freshwater drum at 5%; these species together with shad made up just under 96% of the entrainment. This information was used as input to quantify the equivalent adults and production foregone resulting from the entrainment losses (§ 122.21(r)(11): Tables 4-4 – 4-7 in Appendix A).

   Importantly, there was no impingement or entrainment of state or federally protected species at BFN nor is there any designated critical habitat at risk due to entrainment. There have been three species of concern (Paddlefish, Bigeye chub, and Silver redhorse) collected in electrofishing and gill net data since 1993, but occurrence appears to be extremely rare (§ 122.21(r)(11): Section 5 in Appendix A). Aside from the aforementioned species of concern, the remaining (see §122.21(r)(4)(vi)) are either known to be extirpated

from Alabama or to occur only in habitat that is vastly different from that found in Wheeler Reservoir (i.e. in smaller creek systems, in riffle and riffle-run habitat, underground pools, limestone springs, etc.). Given this, no or negligible non-use benefits are expected from protecting threatened and endangered species by entrainment reduction technologies.

2. *Impact of changes in particulate emissions or other pollutants associated with entrainment technologies* – There are no significant particulate emissions or other pollutants associated with fine-mesh screens. Some particulate emissions and other pollutants would be generated with a Closed Cycle Recirculating System (CCRS) retrofit. However, because BFN operates using a freshwater intake source (i.e., not a high salt or mineral content) and BFN's existing cooling towers would have to operate in compliance with an ADEM-issued air permit, the drift from the Mechanical Draft Cooling Towers (MDCTs) would not be expected to contain high levels of dissolved solids or introduce fine particulate matter into the atmosphere. Therefore, air quality impacts and causal human health effects from the drift from the CCRS are not expected to be significant.

   A summary of other impacts is provided in Non-Water Quality And Other Environmental Impacts Study (§ 122.21(r)(12)) and includes:

   - A combined full load power loss of 69 MW as a result of use of BFN energy to operate the CCRS pumps and a heat-rate penalty due to less efficient condenser cooling with a CCRS. This will result in increased emissions at other TVA fossil facilities that will need to increase generation to makeup this loss to consumers.
   - Paradise Shores, a local residential community, and local roadways would experience intermittent lowered visibility from fogging and nighttime light scatter from ground level plumes from cooling tower operation.
   - Light to moderate plume-induced icing during freezing conditions would also occur within several miles south-southeast and/or north-northeast of BFN.
   - Noise level increases from the CCRS could be experienced at nearby Paradise Shores, but is not expected to be a significant issue.

3. *Land availability inasmuch as it relates to the feasibility of entrainment technology* – Implementation of a CCRS at BFN would not require additional land; it would utilize BFN's seven existing cooling towers with Tower 1 and 2 replacements, lift pump upgrades, and additional modifications as outlined in Section 3 of § 122.21(r)(12). With the exception of construction of a new Gate 2 structure and partial removal of the existing Gate 2, the modifications required for a CCRS would take place within a 224-acre project area on the BFN reservation as shown in Figure 3-1 of § 122.21(r)(12).

4. *Remaining useful plant life* – BFN has significant remaining life, and plans to operate well into the future. TVA is currently proposing to submit a subsequent license renewal application to the Nuclear Regulatory Commission (NRC) for BFN Units 1, 2, and 3, which would permit operation for an additional 20 years past the current operating license terms that expire in 2033, 2034, and 2036 for Units 1, 2, and 3 respectively.

5. *Quantified and qualitative social benefits and costs of available entrainment technologies when such information on both benefits and costs is of sufficient rigor to*

make a decision – A rigorous analysis of retrofitting BFN with a CCRS or fine-mesh screens (both modified through-flow and dual-flow traveling screens) was conducted and provided in § 122.21(r)(10), § 122.21(r)(11), and § 122.21(r)(12). The cost of a CCRS retrofit exceeds the annualized benefit by ratios of 293 to 1 and 245 to 1 at discount rates of 7% and 3%, respectively. The 0.5 mm fine-mesh traveling water screens evaluation resulted in a cost to benefit ratio of 150 to 1 and 122 to 1 at discount rates of 7% and 3%, respectively (Table 1).

There is legislative and judicial history to aid in deciding whether these cost-benefit ratios are appropriate for mandating application of an alternative technology at BFN. The Clean Water Act [1977], presents the idea of weighing costs relative to benefits (Section 304(b)(1)(B)), referring to effluent limitation guidelines. Judicial decisions introduced the phraseology of "wholly disproportionate." The actual phraseology of "wholly disproportionate" as rendered in the judicial history states that "[t]he balancing test between total cost and effluent reduction benefits is intended to limit the application of technology only where the additional degree of effluent reduction is wholly out of proportion to the costs of achieving such marginal level of reduction for any class or category of sources" (*Kennecott v. United States EPA*). The "wholly disproportionate cost test" was first applied to Section 316(b) during *In the Matter of Public Service Company of New Hampshire* 10 ERC 1257 (May and Van Rossum 1995) and in the decision for that case, the sole basis for applying the "wholly disproportionate" cost test came from the aforementioned legislative history of the CWA. The ruling stated that Section 316(b) did not require implementation of technology whose cost was "wholly disproportionate" to its environmental benefits. Following the Seabrook II Decision (Seacoast 1979), the "wholly disproportionate" cost test has been applied differently in various cases, depending on the specific facts of the case. In the previously issued § 316(b) Phase III Rule, EPA promulgated national standards only for new offshore oil and gas extraction facilities, but also prepared a cost-benefit analysis of regulating additional Phase III facilities (i.e., existing manufacturing facilities that use cooling water). In this analysis, EPA found a ratio of costs to benefits that ranged from 17-to-1 to 22-to-1 and found this to be "wholly disproportionate." Ratios as low as two or three to one have also been determined as wholly disproportionate. Comparison of these precedents with the cost benefit ratios for BFN in Table 1 below suggests that the costs of any of the alternative technologies would be wholly disproportionate to benefits.

Table 1. Summary of Comparisons of Entrainment Reduction Technologies at BFN

Technology	Entrainment Mortality Reduction		Total Project Social Cost, Present Value (Millions, 2018$)		Total Project Social Benefits, Present Value (Millions, 2018$)		Net Social Costs (Millions, 2018$)		Cost-Benefit Ratio	
	Age-1 Equivalents	Equivalent Adults								
Discount Rate	-	-	3%	7%	3%	7%	3%	7%	3%	7%
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0.5 mm Fine-Mesh Traveling Water Screens	17.6%	16.6%	$79.00	$68.78	$0.65	$0.46	$78.35	$68.32	121.5	149.5

Factors That May Be Considered:

1. *Entrainment impacts on the waterbody* – Long-term monitoring of the Wheeler Reservoir indicates no measurable adverse environmental impacts to the aquatic community at the population level from the operations of the BFN CWIS, and supports there is a balanced, indigenous population of fish and aquatic life.

   For over 26 years, the TVA Reservoir Ecological Health Monitoring Program has provided valley-wide water quality and aquatic community assessments. Since the inception of the program, 15 ecological assessments have been conducted on Wheeler Reservoir, the cooling water source water for BFN. These assessments are based on five key ecological indicators: dissolved oxygen, chlorophyll, fish (Reservoir Fish Assemblage Index), bottom life (Reservoir Benthic Index), and sediment quality. The Reservoir Ecological Health evaluation program examines each indicator separately based on expectations under reference conditions and assigns each an ecological classification of “poor”, “fair” or “good” and then results are combined into a single, composite score for the reservoir.

   The ecological health of Wheeler Reservoir has rated “fair” or “good” all years monitored except 2007 and 2011 (Figure 1). Fish community and sediment quality indicators have been assessed a “good” or “fair” rating at each monitoring location each year. Chlorophyll, dissolved oxygen, and benthic community ratings have fluctuated between “good”, “fair”, and “poor”, generally in response to variations in prevailing weather patterns from year to year and the associated changes in reservoir flows and nutrient loadings. More information on the ecological health of Wheeler Reservoir can be found on TVA’s Environment website.

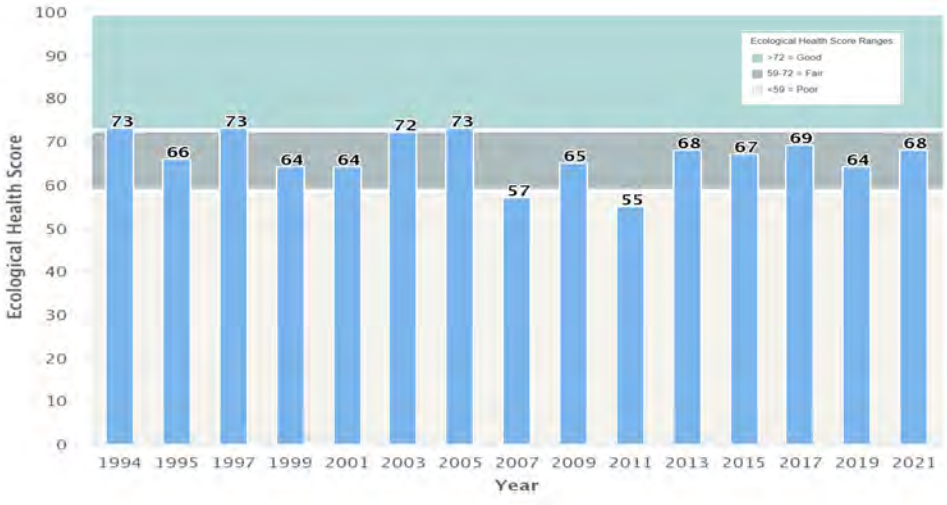


Figure 1. Wheeler Reservoir Ecological Health Ratings, 1994-2021

As presented above, water quality and habitat issues provide the greatest influence on reservoir ecological health. Entrainment has never been identified as a factor affecting the fish community of Wheeler Reservoir. This outcome is expected considering the highly abundant and prolific species that dominate entrainment samples at BFN. Further, the placement and operation of the BFN CCW intake result in a number of benefits with regard to reducing potential entrainment including:

- Location in a man-made reservoir where fisheries are actively managed and supplementally stocked (status acknowledged in § 125.95(a)(3));
- Incorporation of a skimmer wall at the opening to the intake canal and deep withdrawal helps deter entrainment of fish eggs and larvae from the upper water column;
- Reproductive strategy of reservoir fish species of recreational and commercial interest (mostly nest builders vs. pelagic/open water spawners) is such that entrainment of early life forms is reduced. EPA previously acknowledged this attribute in its Phase II regulations and exempted facilities on reservoirs from the entrainment requirements;
- Location away from shallow embayment areas that might offer optimal spawning habitats for important sport fish; thus, entrainment is reduced; and
- Proportion of water withdrawn is small (8.9%) compared to the long-term average river flow (~48,000 cfs) passing the intake structure.

2. *Thermal discharge impacts* – In terms of thermal impacts, BFN employs seven MDCTs that are used as helper towers as necessary to ensure that the facility meets Alabama's thermal discharge standards. Since cooling towers are considered BTA for thermal discharges no significant thermal discharge impacts are assumed to result from BFN's current operations.

   BFN has a history of thermal compliance. Thus, specifying a BTA for entrainment at BFN that would involve flow reductions via a CCRS would not solve any existing adverse thermal discharge impacts as no appreciable impacts presently occur.

3. *Credit for reductions in flow associated with the retirement of units occurring within the ten years preceding October 14, 2014* – No units were retired at BFN in the ten years preceding October 14, 2014.

4. *Impacts on the reliability of energy delivery within the immediate area* – The evaluation determined that if required to install an entrainment reduction technology it would do so rather than retire BFN's Units 1, 2 and/or 3. Further if BFN were required to install a CCRS there would be a loss of 69 MW of power generation as a result of power needed to operate the CCRS pumps and fans and loss of cooling efficiency due to use of a CCRS rather than water from the reservoir. As discussed, there would also be increased cost to TVA customers to replace BFN's generation with higher cost generation from external resources.

5. *Impacts on water consumption* – Operating the plant in closed-cycle cooling mode would increase water consumption due to evaporative losses and drift (i.e. water not returned to the reservoir). It is estimated that the rate of evaporation and drift for the cooling towers would be approximately 45,000 gpm (Section 3.2.3 of § 122.21(r)(12)). EPRI (2011) found an approximate 50% increase in evaporative losses associated with retrofits to wet MDCTs compared to evaporative losses for open cycle flow.

6. *Availability of process water, gray water, waste water, reclaimed water, or other waters of appropriate quantity and quality for reuse as cooling water* – As discussed in Section 3.2.3, the EPA in the Rule's Technical Development Document (USEPA 2014) Section 6.1.4 titled Water states "*For power plants, water reuse (outside of closed-cycle cooling) is typically not an available option, as there is very little water that is used for purposes other than non-contact cooling; the "credit" would be extremely small. EPA has seen examples where*

cooling water is reused in air pollution control processes." This was determined to be the case for BFN as there is no available alternative source capable of supplying the volume of cooling water necessary to operate the facility using this alternative. Water reuse was evaluated through use of a CCRS as discussed in Chapter 2 of § 122.21(r)(10).

The Rule states at § 125.98(f)(4) that "*The Director may reject an otherwise available technology as a BTA standard for entrainment if the social costs are not justified by the social benefits."*

Comparison of these precedents with the cost benefit ratios for BFN in Table 1, suggests that the costs of any of the alternative technologies would be disproportionate to benefits. The overall conclusion based on the information presented in this report is that all of the entrainment reduction technologies evaluated had social costs that were wholly disproportionate to their entrainment reduction benefits. This combined with no reasonable risk to designated state or federally protected species or their designated critical habitat, compliance with Tennessee's thermal mixing zone standards, and a healthy Wheeler Reservoir recreational fishery support a determination that the existing CWIS is BTA for entrainment at BFN.

Evaluating the Presence and Maintenance of a Balanced Indigenous Population of Fish and Wildlife in the Tennessee River Downstream of TVA's Browns Ferry Nuclear Plant

Athens, Limestone County, Tennessee



Tennessee Valley Authority

June 2021

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EXECUTIVE SUMMARY

This document presents results of biological monitoring conducted during autumn 2020 as a means to evaluate the status of the aquatic community in the Tennessee River (Wheeler Reservoir) downstream of TVA's Browns Ferry Nuclear Plant thermal discharge. This report is intended to support continuance of the 316(a) thermal variance for the plant discharge based on successful demonstration, in accordance with Section 316(a) of the Clean Water Act, that a balanced indigenous population (BIP) of fish and wildlife was present and being maintained in the river downstream of the plant.

In evaluating the selected fish community metrics relevant to determination of the maintenance of a BIP of fish and wildlife, it is apparent that the fish community structure at the thermally affected downstream reach was similar to that at the unaffected upstream reach.

In evaluating the data in the context of EPA's interpretation of the regulatory definition of a BIP, TVA believes that a BIP is currently being demonstrated in Wheeler Reservoir based on the most recent biological data collected in 2020 (see Section 3.0 of this report). The interpretation requires demonstration that the following attributes are present and being maintained in the waterbody:

1. The population is typically characterized by diversity at all trophic levels,
2. The population has the capacity to sustain itself through cyclic seasonal changes,
3. The necessary food chain species are present,
4. Pollution-tolerant species are not dominant, and
5. Indigenous species are appropriately represented.

Based on the findings reported herein, TVA believes that continuation of the current thermal variance [daily maximum temperature of 93 °F (33.9 °C) at the end of the mixing zone and a daily average of 90 °F (32.2 °C)] for the Browns Ferry Nuclear Plant discharge (Outfall DSN001) will nevertheless reasonably assure the protection and propagation of a BIP.

1.0 INTRODUCTION

This document presents results of biological monitoring conducted during autumn 2020 as a means to evaluate the status of the aquatic community in the Tennessee River (Wheeler Reservoir) downstream of the Tennessee Valley Authority's (TVA) Browns Ferry Nuclear Plant (BFN) thermal discharge. This report is intended to support continuance of the thermal variance for the plant discharge (Outfall DSN001) in a renewed National Pollutant Discharge Elimination System (NPDES) permit for the facility (NPDES Permit No.: AL0022080) based on successful demonstration, in accordance with Section 316(a) of the Clean Water Act, that a balanced indigenous population (BIP) of fish and wildlife was present and being maintained in the river downstream of the plant.

This report is constructed to target § 316(a) regulatory requirements and the characteristic elements of a BIP. In the context of § 125, Subpart H, this report constitutes the § 316(a) "demonstration" the Director requires in considering whether to grant a thermal variance in the NPDES permit for a facility. The readers are directed to Appendix A for the details of field study design, biological community sampling methods, and Reservoir Fish Assemblage Index methodology.

1.1 Facility Information

The BFN plant located in Limestone County, Alabama (Figure 1), employs three nuclear-powered steam generating units that were brought into operation sequentially from 1974 to 1977. With a total generating capacity of 3,952 megawatts (MW), the plant generates approximately 27-billion kilowatt-hours of electricity each year, enough to supply 2 million homes.

The facility is located on the right descending bank of Wheeler Reservoir on the Tennessee River and withdraws cooling water from Wheeler Reservoir via an intake channel and skimmer boom at Tennessee River mile (TRM) 294.4 (Figure 2). Current operation utilizes a once-through condenser circulating water (CCW) system with seven helper cooling towers to dissipate waste heat, withdrawing water from the Tennessee River through an intake structure at TRM 294.3 and discharging through a multi-port diffuser located downstream from the plant at TRM 293.6 (Figure 2). This straight-through flow path is known as "open cycle" or "open mode" operation. Through various gates, some of this cooling water can also be directed through cooling towers to reduce its temperature as necessary to comply with environmental regulations. This flow path is known as the "helper mode." The physical capability also exists to recycle the cooling water from the cooling towers directly back to the intake structure without being discharged to the reservoir; this is known as the "closed mode" of operation. Heated effluent is discharged to Wheeler Reservoir via Outfall DSN001 located at TRM 293.9 as authorized by the NPDES permit (Figure 2).

Maximum flow rate of the CCW for all three units is approximately 3,171 million gallons per day (mgd) or 4,915 cubic feet per second (cfs). The BFN plant's total per-unit condenser circulating flow is generally higher than the original design values due to system upgrades, including the refit of the condensers with larger diameter and lower resistance tubes (NRC 2005). All three units reject approximately 22.0×10^9 BTU per hour of waste heat. This waste heat increases the

temperature of the cooling water by approximately 16.4 °C (29.5 °F) before it is discharged into the river. The actual condenser flow, and hence the change in temperature from ambient (ΔT), may vary somewhat with the circulating water pump head and the condenser efficiency.

Relevant plant operational data—mean daily temperatures at the CCW intake and discharge, mean daily flow through the CCW system, and mean daily power generation by the three nuclear units at BFN—were compiled from 2014 through 2020 and are included in Appendix B. Biological monitoring was conducted upstream and downstream of BFN on November 10 and 11, 2020.

1.2 Description of the Receiving Waterbody

Browns Ferry Nuclear Plant is located on the right descending bank of Wheeler Reservoir (TRM 294) approximately 15 miles northwest of Decatur, Alabama, and 15 miles southeast of Rogersville, Alabama (Figure 1). Wheeler Reservoir was impounded in 1936 and at full pool covers approximately 67,070 acres.

In the vicinity of BFN, the reservoir includes both a main channel, about 2,000 feet wide and 30 feet deep, and adjacent, shallow overbanks about 5,000 feet in total width and from two to six feet deep. The river channel passes close to the plant before being separated into two channels by the former Browns Island, approximately 0.6 miles downstream (Figure 2).

Flow of the Tennessee River at BFN is controlled primarily by releases from Guntersville Dam (GUH) upstream and Wheeler Dam (WEH) downstream (flow past the plant is made up of approximately 26% GUH releases and 74% WEH releases), and to a lesser extent by the Elk River which enters the reservoir approximately 10 miles downstream of BFN at TRM 284 (Figure 1). Flow past the plant is highly variable, ranging from an annual daily average of 20,000 to 80,000 cfs (1977-2020). Peaking release patterns at GUH and WEH can result in hourly fluctuations of flow within a day, even temporarily "sloshing" weak flows in the upstream direction (TVA 2005). Daily average flows during 2020 were generally higher than historical flows during January through May and October through November, and generally similar during June, September and December (Figure 3).

1.3 Regulatory Basis

Browns Ferry Nuclear Plant's NPDES permit (effective date of June 7, 2018), inclusive of the thermal variance, is set to expire on August 31, 2023. The current status of a BIP in Wheeler Reservoir is relevant to the re-verification of the thermal variance in the next permit.

1.3.1 Applicable Thermal Criteria

ADEM has developed specific designations and "use classifications" for the state's surface waters and has developed temperature criteria intended to support those uses. The Tennessee River at the location of BFN has been designated a Tier II waterbody – defined by ADEM Rule 335-6-10-.12 as "[a body of water] where the quality exceeds levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water" – and has been classified for the

following uses: Swimming and Other Whole Body Water-Contact Sports; and Fish and Wildlife (ADEM Rule 335-6-11-.02). Temperature criteria relevant to these use classifications (ADEM Rule 335-6-10-.09) specify that:

(ii) The maximum temperature in streams, lakes, and reservoirs in the Tennessee and Cahaba River Basins, shall not exceed 86 °F [30 °C].

The BFN plant's "once-through" cooling water system design utilizing cooling towers in helper mode provides for the most thermodynamically efficient method of generating electricity and as a result produces a heated discharge. Regarding such discharges, the ADEM rule states:

(iii) The maximum in-stream temperature rise above ambient water temperature due to the addition of artificial heat by a discharger shall not exceed 5 °F [2.7 °C] in streams, lakes, and reservoirs in non-coastal and non-estuarine areas.

(v) In lakes and reservoirs there shall be no withdrawal from, nor discharge of heated waters to, the hypolimnion unless it can be shown that such discharge or withdrawal will be beneficial to water quality.

(vi) In all waters the normal daily and seasonal temperature variations that were present before the addition of artificial heat shall be maintained, and there shall be no thermal block to the migration of aquatic organisms.

Such thermal discharge typically exceeds ADEM's established temperature criteria. Therefore, within an established mixing zone downstream of the discharge, multiport diffusers mix the thermal effluent to adequately meet the state water quality standard at the end of the mixing zone. Regarding this, the ADEM rules provide that:

(vii) Thermal permit limitations in NPDES permits may be less stringent than those required by subparagraphs (i)-(iv) hereof when a showing by the discharger has been made pursuant to Section 316 of the Federal Water Pollution Control Act (FWPCA), 33 U.S.C. §1251 et seq. or pursuant to a study of an equal or more stringent nature required by the State of Alabama authorized by Title 22, Section 22-22-9(c), Code of Ala. 1975, that such limitations will assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife, in and on the body of water to which the discharge is made. Any such demonstration shall take into account the interaction of the thermal discharge component with other pollutants discharged.

TVA has previously made such successful demonstration for the BFN thermal discharge in support of mixing zone criteria as further discussed below.

1.3.2 Currently Permitted Conditions

Currently permitted thermal discharge limitations for BFN specify that the daily maximum temperature is not to exceed 93 °F (33.9 °C) at the end of the mixing zone and a daily average of 90 °F (32.2 °C) (Part I, Page 1 of 39, NPDES permit AL0022080). This mixing zone criterion is

based on a previous demonstration by TVA, in accordance with CWA §316(a) and ADEM Rule 335-6-10-.09 noted above, that a balanced indigenous population (BIP) of fish, shellfish, and wildlife is supported in the Tennessee River potentially affected by the thermal discharge. The mixing zone criteria, as supported by the biological studies, also encompass other components of the ADEM temperature criteria, specifically the change in temperature from ambient/upstream conditions and the maintenance of daily and seasonal temperature variations. The BFN plant has maintained a good compliance record with its mixing zone criteria throughout each NPDES permit term since first authorized in the late-1970s; ongoing biological monitoring has consistently demonstrated that the mixing zone criteria are protective of aquatic communities in the river near the facility.

1.3.3 Criteria for Thermal Variances under § 316(a)

The regulatory provisions that implement CWA §316(a) provide limited guidance on precisely what the demonstration study must contain to be considered adequate and do not identify precise criteria against which to measure whether a "*balanced and indigenous*" aquatic community is protected and maintained. Instead, the regulations provide broad guidelines.

Under the broad regulatory guidelines, the discharger must show that the thermal variance desired, "*considering the cumulative impact of its thermal discharge together with all other significant impacts on the species affected*," will "*assure the protection and propagation of a balanced, indigenous community of shellfish, fish and wildlife in and on the body of water into which the discharge is to be mad*e (40 CFR §125.73). Critical to the demonstration is the meaning of the term "balanced indigenous community". The rules provide the following definition:

> "The term "*balanced indigenous community*" is synonymous with the term balanced, indigenous population (i.e., BIP) in the Act and means a biotic community typically characterized by diversity, the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species and by a lack of domination by pollution tolerant species. Such a community may include historically non-native species introduced in connection with a program of wildlife management and species whose presence or abundance results from substantial, irreversible environmental modifications" (40 CFR §125.73).

Pursuant to this regulatory definition, a successful demonstration must show that under the desired thermal variance, and in light of the cumulative impact of the thermal discharge together with all other significant impacts on the species affected, the following characteristics, which are indicative of a BIP, will continue to exist: (1) diversity, (2) the capacity of the community to sustain itself through cyclic seasonal changes, (3) the presence of necessary food chain species, and (4) a lack of domination by pollution tolerant species.

There are several methodologies a discharger may pursue in making a §316(a) demonstration. Under the regulations, new dischargers must use predictive methods (e.g., laboratory studies, literature surveys, or modeling) to estimate an appropriate thermal variance that will assure the

protection and propagation of a balanced, indigenous community prior to commencing the thermal discharge. However, existing dischargers, such as BFN, need not use predictive methods. For such dischargers, §316(a) demonstrations may be based upon the "*absence of prior appreciable harm*" to a balanced, indigenous community (see 40 CFR §125.73(c)(1)(i) and (ii)). Such demonstrations must show either that:

i) No appreciable harm has resulted from the thermal component of the discharge taking into account the interaction of such thermal component with other pollutants and the additive effect of other thermal sources to a balanced, indigenous community of shellfish, fish, and wildlife in and on the body of water into which the discharge has been made; or

ii) Despite the occurrence of such previous harm, the desired alternative effluent limitations (or appropriate modifications thereof) will nevertheless assure the protection and propagation of a balanced, indigenous community of shellfish, fish, and wildlife in and on the body of water into which the discharge is made.

Furthermore, in determining whether or not prior appreciable harm has occurred, the regulations provide that the permitting agency consider the length of time during which the applicant has been discharging and the nature of the discharge. The regulations do not define "*prior appreciable harm*." However, using the definition of "balanced, indigenous community," mixing zone criteria are generally granted under either of the following circumstances:

1. When a discharger shows that the characteristics of a BIP (i.e., diversity, the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species, and a lack of domination by pollution tolerant species) exist. Stated another way, the existence of such characteristics essentially prove that the aquatic community has not been appreciably harmed; or

2. Despite any evidence of previous harm, the characteristics of a BIP, as stated above, will nevertheless be protected and assured under the alternate limit.

1.3.4 Mixing Zone Requirements in Alabama Rule 335-6-10-.09

As noted above, §316(a) pertains to the Fish and Wildlife use classification and provides NPDES-permitted facilities a regulatory compliant means of demonstrating that promulgated temperature criteria may be more stringent than necessary to support a BIP. In such cases, less stringent thermal criteria (i.e., thermal variances) are justified. However, other use classifications such as Public Water Supply and Swimming must be protected as well. Compliance with ADEM temperature criteria for these uses is typically determined after the discharge has had the opportunity to mix with the receiving water; that is, an allowable mixing zone is determined.

ADEM rules define the mixing zone as:

"[T]hat portion of the receiving waters where mixture of effluents and natural waters take place." [335-6-10-.05(3)]

The rules further provide that mixing zones shall not exceed the following dimensions:

"(1) A maximum length of 2,400 feet downstream of the diffusers,

(2) a maximum width of 2,000 feet, and

(3) a maximum length of 150 feet upstream of the diffusers to the top of the diffuser pipes and extends to the bottom downstream of the diffusers."

While TVA's proposed §316(a) demonstration study plan fully examines the effects of the thermal discharge on the aquatic life components of the mixing zone requirements, the potential effects to other non-aquatic life use classifications are generally not evaluated. Therefore, this plan has been revised herein to incorporate and/or collect additional information needed to address the reasonable potential for impairment of other non-aquatic life uses in the Tennessee River near the facility.

2.0 BIOLOGICAL STUDIES AND ASSESSMENTS

2.1 Previous § 316(a) Demonstration Study

Prior to construction and operation of BFN, TVA conducted comprehensive studies of fish populations in Wheeler Reservoir, initially to determine an inventory of the fish community and subsequently to monitor the status of the community. Since BFN began full operation in 1977, TVA has conducted extensive studies related to §316(a) demonstration, including:

- analysis of the effects of thermal variance on aquatic communities (conducted jointly with EPA) (TVA 1998)
- analysis and monitoring of the freshwater mussel community (TVA 1992)
- biological and environmental effects of physical changes made to the plant (TVA 2005, 2006)
- an overview of the conditions of Wheeler Reservoir (TVA 1990)
- hydrothermal modeling of proposed extended power uprates at the plant (TVA 2005)
- evaluation of water quality
- continued monitoring of the fish community (TVA 1978)
- monitoring of periphyton, phytoplankton, aquatic macrophytes, zooplankton, and benthic macroinvertebrates (TVA 2010)
- a supplemental §316(a) demonstration study of the BFN thermal effluent (TVA 1983)

Major findings of these studies included:

- Wheeler Reservoir behaves more like a large river, with comparatively high flow rates generally keeping water in the channel well-mixed with little stratification.

- Water temperature patterns in Wheeler Reservoir are constantly changing in response to varying meteorology and hydrology of the area. Spatial variations in water temperature occur between the main channel and the overbanks, with the overbanks more susceptible to extreme water temperatures.

- The reservoir has a notable gradient in dissolved oxygen (DO) concentration, decreasing from the surface to the bottom. Low DO concentrations are particularly evident during summer and fall seasons.

- Uprate of power production at BFN to 120% of original design capacity of units 2 and 3 was determined to have no significant thermal impact on the aquatic community of Wheeler Reservoir.

- Wheeler Reservoir contains diverse communities of phytoplankton, zooplankton, and benthic macroinvertebrates. Species richness in the benthic macroinvertebrate communities during pre-operational and operational monitoring was similar.

- Both diversity and abundance of freshwater mussels historically identified in Wheeler Reservoir, particularly of riverine species, have decreased significantly since impoundment of the Tennessee River. Species found currently include four endangered species, and the mussel community has diverged into two groups: those species that inhabit the old river channel and those that have colonized the overbanks. Two sections of Wheeler Reservoir upstream of BFN are currently maintained as mussel sanctuaries.

- Analysis of data for occurrence and abundance of fish species indicated no significant impacts due to operation of BFN, and avoidance of the plume was not detected for any species of fish.

- One study found that sauger (*Sander canadensis*) were not concentrated in the thermal plume during winter months nor inhibited from movement past BFN. Results of gonadal inspections indicate that the heated discharge did not adversely affect reproduction of cool-water fish.

Phytoplankton, zooplankton and benthic macroinvertebrate communities downstream of BFN have been similar to those upstream during most years of operation, or if differences were noted, they were not attributable to operation of BFN.

2.2 Contemporary Studies

In 1999, TVA initiated its Reservoir Ecological Health Monitoring program (f.k.a., "Vital Signs" program). Results were designed to measure ecological and water quality health on a reservoir-

wide basis during autumn, which would be the accepted study design for measuring the presence and maintenance of a BIP to support existing § 316(a)-based thermal variances through the life of the permit. In 2006, in addition to the agreed-upon annual monitoring conducted during autumn, ADEM asked TVA to sample during spring 2007, and compare these data to autumn 2006 and autumn 2007 to determine if a BIP is maintained seasonally in areas affected by the BFN thermal discharge. Autumn monitoring has continued from 2008 to the present.

Study design at the time (2000) was based on measuring biotic integrity using multi-metric community structure assessment techniques and focused on fish community sampling in three zonal areas of the reservoir during autumn: the inflow, transitional and forebay zones. Macroinvertebrate community sampling began in 2000. Biological sampling zones are illustrated in Figures 4 and 5.

In 2009-2010, there was increasing regulatory interest at the federal level in having NPDES permit applicants update studies supporting thermal variances and to better focus study design on the regulatory definition of a BIP as provided in 40 CFR §125.73. Accordingly, TVA developed Study Plans incorporating sampling locations closer to its power plants to supplement data collected in the three reservoir zonal areas, and included more traditional comparative analysis techniques in addition to the long-used multi-metric assessment techniques. New assessments of wildlife communities that could potentially be impacted by thermal discharges were also conducted (Figures 4 and 5).

TVA's biological assessment data has consistently indicated that fish assemblages of Wheeler Reservoir downstream of the BFN thermal discharge were similar to those of upstream reference locations. The findings have demonstrated, with acceptance by ADEM and EPA Region 4, the presence, protection and maintenance of a BIP in Wheeler Reservoir in support of continuing the thermal variance in the BFN NPDES permit.

2.3 Previously Accepted BIP Assessment Practice

As previously indicated, beginning in 2000 and up until present, TVA's use of multi-metric assessment techniques was for the most part the accepted primary method of demonstrating a BIP for supporting the continuance of the existing thermal variance at BFN, and the status of the fish community was the primary community of interest.

TVA's multi-metric Reservoir Fish Assemblage Index (RFAI) attempts to address characteristics of a BIP in a holistic manner by measuring 12 population "metrics", scoring the metrics based on expectations of healthy populations in the region, and summing the scores to arrive at an overall RFAI score and subsequent rating. The maximum RFAI score attainable is 60. Ecological health ratings are then applied to the scoring ranges: 12-21 "Very Poor", 22-31 "Poor", 32-40 "Fair", 41-50 "Good", or 51-60 "Excellent". It has generally been accepted that an RFAI rating of "Fair" or better in the thermally affected area can be considered demonstration of a BIP, particularly where RFAI scores for unaffected upstream areas are similar. A difference of six points or less between

the thermally affected area and unaffected upstream area indicates statistical similarity of the fish communities between the two sites (see Appendix A).

TVA has conducted autumn (and spring 2007) monitoring of the benthic macroinvertebrate community in Wheeler Reservoir during most years since 2000, developing its Reservoir Benthic Index (RBI) of biotic integrity for Tennessee River reservoirs. Multi-metric assessment methods for evaluating ecological health of benthic communities in large river systems and/or artificial reservoir settings are not as well established as they are for wadeable streams, but nonetheless, provide valuable supplemental information in support of the fish community assessment. TVA's RBI is similarly calculated as the RFAI except that it uses seven metrics specific to the macroinvertebrate assemblage. Each metric is assigned a score based on reference conditions and then summed to produce an overall RBI score for each sample site. The maximum RBI score is 35. Ecological health ratings are then applied to scoring ranges: 7-12 "Very Poor", 13-18 "Poor", 19-23 "Fair", 24-29 "Good", or 30-35 "Excellent." A difference of four points or less between the thermally affected area and unaffected upstream area indicates statistical similarity of the benthic macroinvertebrate community between the two sites.

As stated by EPA Region 1 in the supporting documents for the draft Merrimack Station NPDES permit[1]: "Assessing changes in the resident fish community of a water body often provides the most conspicuous evidence of impacts to the overall aquatic community . . . ." The BIP determination in that proceeding (in 2011) relied largely on fish community data for the Hooksett Pool portion of the Merrimack River, the receiving water for the Merrimack Station thermal discharge. However, EPA Region 1 also noted that a comprehensive § 316(a) demonstration is not just limited to fish; planktonic organisms, macroinvertebrates, "habitat formers" (e.g., aquatic vegetation), and wildlife are all important communities to be assessed, but importantly "at the level of detail appropriate to the facility's potential to impact these communities." Explaining further, EPA indicated "no hard and fast rule can be made as to the amount of data that must be furnished [for a successful § 316(a) demonstration] . . . and much depends on the circumstances of the particular discharge and receiving waters." [2]

2.3.1 Results of BIP Studies, 2001 – 2019

2.3.1.1 Reservoir Fish Assemblage Index (RFAI) Scores

In 2000 (baseline), autumn RFAI scores were "43-Good" for the downstream site and "41-Good" for the upstream site, and in 2019[3], RFAI scores for autumn were rated "37-Fair" for the downstream site and "48-Good" for the thermally unaffected site upstream of BFN (Figure 6). Average RFAI scores for the period of 2000 through 2019 were "41-Good" at the downstream site

[1] EPA Region 1. 2011. Draft NPDES Permit for the PSNH Merrimack Station; Appendix C, page 36.
[2] *Seabrook*, 1977 EPA App. LEXIS 16, at *31; as cited in EPA Region 1. 2011. Draft NPDES Permit for the PSNH Merrimack Station; Appendix C, page 25.
[3] Fish communities upstream and downstream of BFN were sampled in 2019 using RFAI methodology, but were done so for reasons other than BIP studies (i.e., other components like benthic macroinvertebrates, wildlife, thermal plume, etc. were not monitored in 2019). However, RFAI scores were included in sampling history for these stations.

and “42-Good” at the upstream site. With the exception of 10- and 11-point score differences between sites in 2005 and 2019, respectively, score differences have been six points or less (statistically similar; Appendix A) during every sample, and differences have averaged 3.6 points (Table 1).

Spring sampling at the same sites in 2007 resulted in RFAI scores that were highly similar to those during autumn 2006 and autumn 2007. The thermally affected downstream site scored “42-Good” during autumn 2006, “44-Good” during spring 2007, and “42-Good” during autumn 2007. During these three periods, the reference upstream site scored “41-Good”, “42-Good”, and “39-Fair”, respectively (Table 1).

Over the period 2000–2019, averages of the following between the thermally affected downstream site and upstream reference sites were generally similar (Table 2):

- Average numbers of species
    - Two more indigenous species upstream than downstream
    - One more top carnivore species upstream than downstream
    - Centrarchid, benthic invertivore, and intolerant species same between sites

- Average proportions
    - Downstream site, as compared to upstream site:
        - Lower for percent tolerant individuals (by ~7%)
        - Higher for percent of sample dominated by one species (by ~5%)
        - Higher for percent for non-native individuals (by ~9%)
        - Lower percent top carnivore individuals (by ~5%)
        - Higher for percent omnivore individuals (by ~7%)
        - Lower for percent individuals with anomalies (by 0.2%)
- Catch rate
    - Average number of fish per effort was about 4 fish higher downstream

2.4 Metric-by-Metric Comparison of 2020 Data between Reaches, and Comparison to 2000 – 2019 Data

To determine if there are any differences in the ecological health of the fish communities at the thermally affected downstream site and upstream reference site in 2020, this section presents results of 2020 monitoring from the two sites, focusing on the twelve metrics of the RFAI methodology. This section also includes a comparison of 2020 data with that of 2000–2019 to determine if there are any differences between current fish communities and historical.

2.4.1 Results of 2020 BIP Study

Table 2 presents RFAI scores and observed data values for the individual metrics of the RFAI during autumn 2020. More detailed 2020 results including metric scores of the RFAI, and lists and abundances of fish species collected during 2020 can be found in Appendix D. Based on

review of Tables 2 and 3, the following observations can be made regarding the overall RFAI scores and fish community metrics for the downstream site:

- Total RFAI scores – Scores for autumn 2020 were similar between downstream ("46-Good") and upstream ("49-Good") sites, and both were the highest observed at the respective reaches (Table 1). With the exception of 2005 and 2019, RFAI scores at both reaches have been not been statistically different (i.e. "similar", or differed by six points or less; Appendix A). When compared between reaches, scores since 2000 have not been significantly different (P=0.13).

- Number of species (indigenous) – There was no difference between reaches in numbers of indigenous species collected during autumn 2020 (P=0.78; Appendix D). Both reaches have shown gradual increases in numbers of species collected since 2000 (Figure 7), and consequently, the upstream reach saw its highest numbers during autumn 2020 and the downstream reach only 3 less than its highest. Total indigenous species upstream have been consistently higher (P=0.03) than those downstream since 2000, but only by an average of about two species.

- Number of centrarchid species (excluding black bass) – The numbers of centrarchid species collected at both reaches have remained steady since 2000, and have only differed by more than two species during one sample. Even so, numbers of centrarchid species have been significantly higher upstream (P=0.04). The average difference between reaches has been 0.8 species. This continued in 2020, with six species collected upstream and five species downstream. The same five centrarchid species were observed in both reaches, with the exception of warmouth, which was only collected upstream (Appendix D).

- Number of benthic invertivore species – One more benthic invertivore species was collected at the upstream reach (5) than the downstream reach (4) during autumn 2020. Average numbers of benthic invertivore species collected since 2000 were five at both reaches, and as a result, have not been significantly different between reaches (P=0.53).

- Number of intolerant species – Numbers of intolerant species have varied little among samples, ranging from collections of three to eight species at both reaches over the samples. Species collected during 2020 fell within this range. One more intolerant species was collected downstream than upstream, yet collections were consistently higher downstream (P=0.04; Appendix D). Numbers of intolerant species collected since 2000 however has been significantly higher upstream (P=0.05), but means have differed by only 0.5 species.

- Percent individuals as tolerant – Percentages in 2020 were about 11% higher downstream, but neither numbers of tolerant species nor autumn catch rates of tolerant fish were significantly different between reaches (P=0.86 and P=0.60, resp.; Appendix D). This

percentage has showed little difference between upstream and downstream reaches since 2007, and has exhibited similar trends between reaches during most years (Figure 8). As a result, percentages of tolerant fish were not significantly different between reaches since 2000 (P=0.18). Seven species considered pollution tolerant contributed to these proportions downstream and eight upstream (Appendix D).

- Percent of sample dominated by one species – Mississippi silverside was the most prevalent species collected at both reaches during autumn 2020, and the percentage of this species was about 18% higher at the upstream reach (Appendix D). This percentage has varied widely at both reaches since 2000, and no significant difference in this metric between reaches was observed (P=0.37).

- Percent individuals as non-indigenous – Percentages have varied widely at both reaches since 2000, but have trended similarly (Figure 9). When compared among the sample years, the percentages of non-indigenous fishes have not been significantly different between reaches (P=0.22). The value for the downstream reach in 2020 was similar to historical averages, but the value at the upstream reach was 30% higher. Two non-indigenous species were collected in both reaches in 2020 (Appendix D).

- Number of top carnivore species – Numbers of top carnivore species collected in 2020 were the highest ever collected at both downstream (12) and upstream (13) reaches, and were three species higher than respective long-term averages. Historically, higher numbers of species have been collected at the upstream reach (P=0.001), but by an average difference of less than 2 species (Table 2). Additionally, numbers of top carnivore and catch rates were not significantly different between reaches in 2020 (Appendix D).

- Percent individuals as top carnivores – Percentages of top carnivores at both reaches in 2020 were the highest observed since sampling began. Prior to 2020, this metric has exhibited relatively little variation, with percentages ranging from 5 to 20% during most samples. Differences in percentages between reaches have been less than 10% during most sample years, but have been significantly higher at the upstream reach (P=0.02).

- Percent individuals as omnivores – Percentages of omnivores have generally followed the same patterns at both reaches among samples, and have trended down to percentages at or near the lower end of the historical ranges in 2020. The upstream reach has exhibited higher percentages during twelve of seventeen sample years (Figure 10), but even so, the reaches have not been significantly different (P=0.12). Eight omnivorous species contributed to the proportions observed in both reaches during 2020, with five being collected at both reaches (Appendix D).

- Average number per effort – Catch rates at both reaches have been highly variable over the sample years, ranging from 14 to 76 fish per effort at both reaches. Even though

average catch rates were 10 fish per effort higher at the downstream reach, catch rates have not been significantly different over the sample years (P=0.23).

- Percent of individuals with anomalies – The percent of individuals exhibiting anomalies has remained consistently low at both reaches, rarely rising above 2%. No difference in percent anomalies has existed between reaches (P=0.33).

In evaluating these metrics, it is apparent from the RFAI scores and observed values for each of the twelve metrics that there has been no significant shift in fish community structure at the downstream reach in 2020 when compared to previous years. Reasons for this conclusion include:

- RFAI scores, numbers of indigenous species, numbers of top carnivore species, and percentage of the sample as top carnivores all exhibited some of the highest, if not the highest, values observed since sampling began.

- With the exception of percentage of sample as omnivores, observed values for the remaining metrics at the downstream reach were well within the historical ranges.

- No significant difference in reaches historically for most (7 of 12) metrics and RFAI scores. For the metrics showing significant differences, differences in historical averages were small:
    - Numbers of indigenous species – 2.2 species
    - Numbers of centrarchid species– 0.8 species
    - Numbers of intolerant species – 0.5 species
    - Numbers of top carnivore species – 1.6 species
    - Percent individuals as top carnivores – 5.8%
- With exception of numbers of intolerant species collected per effort, no significant differences between reaches in 2020 for all parameters tested (Appendix D).

3.0 EPA-DEFINED Elements of a Balanced Indigenous Population

Specific definitional elements of a BIP have been provided by EPA Region 4. Fulfillment of BIP expectations for fish communities downstream of BFN are described below.

3.1 Focusing on the EPA Region 4 BIP Descriptions

EPA Region 4 has identified in past communications with TVA (and other electric utilities) the five essential elements that it has determined constitute a BIP based on interpretation of the regulations. In a letter from EPA to Tennessee Department of Environment and Conservation

(TDEC) dated August 11, 2011 regarding its review of the Gallatin Fossil Plant NPDES permit renewal,[4] EPA included guidance on demonstrating a BIP. In the letter EPA states:

> The definition of "balanced, indigenous community" at 40 CFR § 125.71(c) contains several key elements. To be consistent with the regulations, each of these key elements should be specifically addressed in the demonstration, and the Study Plan should be designed to generate information relevant to these elements. Those elements include: (1) "a population typically characterized by diversity at all trophic levels;" (2) "the capacity to sustain itself through cyclic seasonal changes;"(3) "presence of necessary food chain species;"(4) "lack of domination by pollution-tolerant species;" and (5) "indigenous".

Further, EPA Region 4 provided helpful insight on each of the BIP elements identified in its letter to TDEC. Below, each element is presented along with TVA's interpretation of the most current BFN biological data for autumn 2020.

With regard to BIP element 1, EPA indicates:

> "A population typically characterized by diversity at all trophic levels" means that all of the major trophic levels present in the unaffected portion of the water body should be present in the heat-affected portions. The EPA recognizes that community structure differences will occur, however, the number of species represented in each trophic level in the unaffected portions should be reasonably similar in the heat-affected portions of the water body.

Trophic levels are usually interpreted as the typical ecological levels of producers (algae, macrophytes), herbivores (zooplankton, invertebrate grazers, and algae-eating fish), and predators (predatory invertebrates and fish). The presence of these trophic levels can be deduced from the feeding habits (guilds) of the fish sampled. The RFAI multi-metric analysis was designed to evaluate appropriate densities and diversity of these trophic states present in the fish community.

Numbers of indigenous fish species and individuals representing each trophic guild for all autumn samples upstream and downstream of BFN are presented in Table 4.

A list of benthic macroinvertebrates and corresponding densities from all autumn samples upstream and downstream of BFN presented in Table 5 with functional feeding group designations. More detailed 2020 results, including results of statistical tests, metric scores of the RBI and lists and abundances of benthic macroinvertebrate species collected during autumn 2020 can be found in Appendix D.

[4] Letter dated August 11, 2011 from Christopher B. Thomas, Chief, Pollution Control & Implementation Branch, Water Protection Branch, EPA Region 4 to Paul E. Davis, Director, Division of Water Pollution Control, TDEC, regarding EPA review and comments on the draft NPDES permit for TVA's Gallatin Fossil Plant (NPDES TN0005428). Provided in Appendix E.

From review of Tables 4 and 5, TVA concludes:

Fish Community (Table 4)

- All expected major trophic levels present in the unaffected portion of the waterbody are present in the affected portion in 2020.

- The number of species representing each trophic guild in the affected reach was "reasonably similar" to that for the unaffected portions of the waterbody during autumn 2020. All six trophic guilds were either represented equally between reaches or differed by only one species. This was supported by statistical tests performed on numbers of species and catch rates for each trophic guild which showed no differences between reaches (Appendix D).

- The most prevalent guilds in both reaches (by number of species) have been top carnivores (e.g., largemouth bass), insectivores (e.g., bluegill), and omnivores (e.g., gizzard shad). Most guilds have shown no consistent dominance between the reaches (Table 4); the only guild to exhibit significant differences between reaches was top carnivores (P=0.002). As discussed in Section 2.4.1, more top carnivore species were collected upstream during 13 of the 17 autumn samples. Even with the significant difference, the difference in historical averages was only 1.6 species (Table 3).

- By numbers of individuals, insectivores have almost always (13 of 17 samples) been more abundant in the downstream sampling reach than in the upstream reach, and the difference has been significant (P=0.05). All other trophic guilds have shown no consistent dominance in abundance between reaches (Table 4).

- Trophic guild representation (number of species) in both reaches has gradually increased since 2000 to values at the upper end of historical ranges (Figure 7).

Macroinvertebrate Community (Table 5)

- All expected functional feeding groups were present upstream and downstream of BFN during autumn 2020.

- The number of species represented for each functional feeding group in the affected reach was "reasonably similar" to the unaffected portions of the waterbody.

- The most prevalent species groups during autumn 2020 were Predator, Collector-Gatherer and Scraper. Dominance of these groups between upstream and downstream reaches varied annually, but long-term averages were similar in both thermally affected and unaffected areas.

- Average densities of Collector-Gatherers were greater downstream during all years except one, and historical average densities were almost two times higher.

- While the number of species representing each functional feeding group has remained generally stable for both sample areas, mean densities have increased in both sample areas.

With regard to BIP element 2, EPA indicates:

> "The capacity to sustain itself through cyclic seasonal changes" means that any additional thermal stress will not cause significant community instability during times of natural extremes in environmental conditions. Community data should be collected during normal seasonal extremes as well as during optimal seasonal conditions. Data should be compared between heat affected and unaffected portions of the receiving water body to account for normal community changes corresponding with a change in season.

To provide a detailed analysis of the seasonal maintenance of BIP in areas affected by the BFN thermal discharge, data from the spring 2007 sample was compared in Table 6 to autumn 2006 and 2007 data. To maximize number of data points, values of metrics in Table 6 were computed for each electrofishing effort and compared using ANOVA and Tukey's Studentized Range Test.

Total scores of the multi-metric assessment were similar for both reaches, differing by no more than three points between seasons. At the downstream reach, four metrics showed no difference between spring and at least one autumn sample. These included numbers of indigenous species, numbers of non-indigenous species, proportion of sample as tolerant, and proportion of sample as omnivores.

Those indicating statistical differences between spring and both autumn samples were abundance of indigenous fish, benthic invertivore species, and intolerant species. Even though abundance of indigenous fish at the downstream reach tested as significantly higher during spring and the unaffected upstream reach did not, the distribution and magnitude of means at the upstream reach closely mirrored those at the downstream. This suggests that seasonal abundances between reaches may be more similar than test results showed. For numbers of benthic invertivore and intolerant species, spring averages were only about one species per effort more than autumn. These observations support that the downstream fish community has sustained itself through seasonal changes.

To assess maintenance of BIP of the benthic macroinvertebrate community through seasons, data were compared during autumn 2006 and spring 2007 in Table 7. The RBI scores downstream of the plant were equal and rated "Excellent" during both seasons, and all metrics scored equally between seasons.

With regard to BIP element 3, EPA indicates:

> "Presence of necessary food chain species" means that the necessary food webs remain intact so that communities will be sustaining. We believe that exhaustive food web studies are not necessary provided that invertebrate, fish and wildlife communities are otherwise healthy, i.e., represented by sufficiently high species diversity and abundance (appropriate for that portion of the receiving water body) for the identified trophic levels and sustaining through normal seasonal changes.

As noted previously, all major functional feeding groups present in the unaffected portion of the waterbody were present in the affected portion. The number of species representing each functional feeding group in the affected reach was "reasonably similar" to those in the unaffected reach, and prevalence (abundance) of the major functional feeding groups varied between the downstream and upstream sites over the sample history (Table 5). In addition, the downstream reaches have scored in the "Excellent" range during eight of ten sample years, including the last four.

For the fish community (Table 4), all major trophic levels present in the upstream reach were observed in the downstream reach, and collections were not different between reaches. When compared among all samples, most guilds showed no difference in numbers of species or abundance between reaches. Numbers of top carnivore species was significantly higher upstream (by less than two species; Table 3) and numbers of insectivore individuals significantly higher downstream. These results indicate that the long-term presence of necessary food chain items at the downstream reach has not been different from upstream.

With regard to BIP element 4, EPA indicates:

> "Non-domination of pollution-tolerant species" means that in the case of thermal effluent community assemblages in heat affected portions of the water body dominated by heat tolerant species do not constitute a BIP. The EPA recognizes that because all species have varying levels of thermal tolerance, communities in the heat affected portions of the receiving water body may possess altered assemblages in terms of species present and abundance. All community data should be collected, analyzed and presented to clearly demonstrate that affected communities have not shifted to primarily heat tolerant assemblages.

Table 8 presents the numbers of indigenous fish species and individuals with upper incipient lethal limits (UILT) of 95 °F to 102 °F (considered "heat tolerant") collected upstream and downstream of BFN during spring 2007 and autumn 2000 through 2020. Upstream samples included more heat tolerant species than downstream during ten samples. Even so, a Wilcoxon Rank Sum statistical test performed on the datasets indicates that average numbers of species have not been statistically different between reaches (P=0.07). Additionally, average abundance of heat tolerant individuals has not been different (P=0.12) between reaches. These data indicate no expressed dominance of heat tolerant species in either reach and no historical shift in abundance between reaches.

Table 9 presents the relative abundance of heat tolerant and heat sensitive (UILT ≤91 °F) indigenous fish species collected upstream and downstream of BFN during spring 2007 and autumn 2000 through 2020. In direct comparison, heat tolerant species make up a much greater proportion than heat sensitive species in both upstream and downstream sample reaches. There were no differences in relative abundances of heat tolerant (P=0.22) or heat sensitive (P=0.49) fish between reaches.

With regard to BIP element 5, EPA indicates:

> "Indigenous" has been further clarified in the regulations: "Such a community may include historically non-native species introduced in connection with a program of wildlife management and species whose presence or abundance results from substantial, irreversible environmental modifications. Normally, however, such a community will not include species whose presence is attributable to the introduction of pollutants that will be eliminated by compliance by all sources with section 301(b)(2) of the Act and may not include species whose presence or abundance is attributable to alternative effluent limitations imposed pursuant to section 316(a)." The EPA recognizes that non-indigenous species are present in most aquatic systems in the United States. All community data should be analyzed and presented to demonstrate that community assemblages in the heat-affected portions of the receiving water body are not significantly different from non-affected communities with regard to the number of non-indigenous species in the assemblages.

Table 11 presents the number of non-indigenous fish species and the number of individuals representing these species collected upstream and downstream of BFN during spring 2007 and autumn 2000 through 2020. Though Wheeler Reservoir represents an artificial, man-made feature, available data indicate there are very few non-indigenous fish species present in the reservoir around BFN, and similar numbers of species were collected in both reaches during spring and autumn samples. A Wilcoxon Rank Sum statistical test performed on the autumn 2020 dataset indicates that non-indigenous species and abundances were not different between reaches (Appendix D). However, long-term (2000-2020) presence of non-indigenous fishes has been higher at the upstream reach (P=0.006) by about one more species per sample. Abundance of non-indigenous fishes has not been different between reaches (P=0.28). Recent increases have been observed at the downstream reach since 2015 (Figure 9). These increases can be attributed primarily to one species, Mississippi silverside, which are known to school in large numbers. When encountered, these large numbers often result in "oversampling" by electrofishing efforts, causing misrepresentation of the species in relative proportions of the community. Thermal tolerance data for the non-indigenous species are presented in Table 12. Of the eight non-indigenous species identified, UILT data designate striped bass and yellow perch as heat sensitive and hybrid striped bass x white bass, common carp, and grass carp as heat tolerant; data are not available for the remaining three species.

Further, there are no known species in the study area whose presence is attributable to the BFN

thermal discharge or to any known pollutant.

3.2 Other Considerations for a Balanced Indigenous Population

As noted earlier from the EPA Region 1 Merrimack Station permitting, assessing changes and important trends in the resident fish community of a water body often provides the most conspicuous evidence of impacts to the overall aquatic community,[5] but information on other communities such as planktonic organisms, macroinvertebrates, "habitat formers" (e.g., aquatic vegetation), and wildlife also inform decision making with regard to the presence/absence of a BIP.

3.2.1 Macroinvertebrate Community

Because benthic macroinvertebrates are relatively immobile, negative impacts to aquatic ecosystems can be detected earlier in benthic macroinvertebrate communities than in fish communities. These data have been used historically to supplement multi-metric RFAI results, providing a more thorough examination of potential differences in aquatic communities upstream and downstream of thermal discharges.

As noted earlier, the results of macroinvertebrate assessments in Wheeler Reservoir the downstream reaches have scored in the "Excellent" range during eight of ten sample years, including the last four (Figure 11). In addition, the status of the macroinvertebrate community structure, based on specific metrics as presented in Table 7 and summarized in previous Section 3.1 regarding BIP Elements 1 (diversity at all trophic levels), 2 (sustainment through seasonal changes), and 3 (food chain species), demonstrates a seasonally abundant and diverse macroinvertebrate community present at both downstream and upstream reaches.

In summary, ecological conditions of benthic macroinvertebrate communities, when compared among the downstream and upstream reaches, have been "similar" since initiation of sampling and lab-processing of data in 2001. Results support the general conclusion that the BFN thermal effluent has had no adverse environmental impact on the benthic macroinvertebrate community downstream of the plant.

3.2.2 Threatened and Endangered Species

Table 13 provides a list of federal or state protected aquatic species with potential to occur in the Wheeler Reservoir within a 10-mile radius of BFN. One fish species—spring pygmy sunfish—is listed under federal protection, and eight species of fish are under state protection or tracked within Alabama: bigeye chub, flame chub, paddlefish, redline darter, silver redhorse, southern cavefish, stargazing minnow, and Tuscumbia darter. The spring pygmy sunfish is considered extirpated within the vicinity of BFN, and no spring pygmy sunfish have been collected by TVA from 1993 to 2020 in the vicinity of BFN. It is highly unlikely this species would be collected in Wheeler Reservoir given its preference for spring habitat. Silver redhorse is the only of these protected

[5] EPA Region 1. 2011. Draft NPDES Permit for the PSNH Merrimack Station; Appendix C, page 36.

species collected during TVA's reservoir monitoring since 1993, and was done so during eight sample years with the most recent being in 2019 and 2020.

Additionally, TVA queried the U.S. Fish and Wildlife Service (USFWS) Environmental Conservation Online System (ECOS) and the USFWS Information for Planning and Consultation (IPAC) (queried 25 March 2021) to supplement information on rare aquatic species and designated potentially occurring near BFN. The ECOS and IPAC systems utilize known federally listed species by county. These data inherently search broader areas than the TVA Database queries and, consequently, listed additional federally listed species as potentially occurring near the BFN project. While TVA recognizes these additional species may occur or have occurred in Limestone County, Alabama, we have determined that they would not be affected by BFN since they are either no longer occurring in the Tennessee River near BFN or occur in habitats outside of the affected BFN project area within Limestone County.

In 1999, 16 native mussel species were collected in the vicinity of BFN: 14 species at TRM 298 upstream of BFN and 12 species at TRM 292 downstream of BFN. None of these were federally listed species (TVA 2003).

3.2.3 Wildlife Community

Beginning in 2011, visual wildlife surveys have been conducted to assess bird, reptile, and mammal populations around BFN. Numbers and categories of wildlife observed during 2011, 2013, 2015, and 2020 are presented in Table 14. Birds were the primary wildlife group observed each year and similar species were observed along each transect. Similar species and numbers of mammals and reptiles were observed upstream and downstream along each bank during each year.

These observations suggest that wildlife utilizing shoreline areas exist in similar compositions upstream and downstream of BFN. However, some species of reptiles, amphibians, and mammals are not easily detected during visible surveys so documentation of these groups was limited. It is important to note that the visual encounter survey provides a preliminary near shore wildlife assessment to determine if the thermally affected area downstream of a power plant has adversely affected the bird, reptile, amphibian or mammal communities. If such adverse environmental impact is suspected, more sampling strategies that could provide more quantitative data will be proposed to more accurately estimate the presence and diversity of these groups.

3.2.4 Aquatic Habitat

The type, quality, and abundance of aquatic habitats dictate the diversity and abundance of organisms present in aquatic systems. To minimize bias in biological assessments, it is important to adequately describe/characterize shoreline and pelagic habitats in reference and "affected" reaches when attempting to discern potential impacts to biological systems from pollutant sources.

3.2.4.1 Habitat Formers

Habitat formers are mentioned in EPA's § 316(a) guidance document (EPA 1977) as an element of investigation in § 316(a) demonstrations. In freshwater systems, aquatic macrophytes,

submerged and emergent, are the most obvious habitat formers and can be critical to the structure and function of ecological systems.

In the case of the anthropogenically created Wheeler Reservoir, important habitat formers such as aquatic macrophytes are present in low abundance near BFN. Aquatic macrophytes were present in low percentages within both reaches during 2020 habitat surveys conducted by TVA (Tables 15 and 16).

3.2.4.2 Physical Habitat

TVA collects shoreline and river bottom habitat data upstream and downstream of BFN every five years to characterize habitats important to fish (Figure 12). The objective is to find comparable habitats at the upstream and downstream sampling sites to, as much as possible, minimize any habitat differences that might bias interpretation of the results of the thermal study.

Within the sample area downstream of BFN, the average Shoreline Aquatic Health Index (SAHI) score for the left descending bank was 25 and right descending bank was 19. The shoreline sections at the upstream reach scored similarly between reaches: 28 on the left descending bank and 20 on the right descending bank. Scores at both downstream and upstream reaches rated in the "Fair" range. No aquatic macrophytes were observed at either reach (Tables 15 and 16).

Figures 13 through 20 depict proportions of substrate types observed along each transect sampled for river bottom substrate. Seven substrate types were identified at both reaches; cobble and clay were only observed at the reach upstream of BFN. Silt and mollusk shell were the most prevalent substrates in both reaches making up a combined 80% at the downstream reach and 92% upstream (Table 17).

3.2.5 Representative Important Species

In its processing of the Merrimack Station NPDES permit and associated review of § 316(a) studies, EPA Region 1 states: "*[W]hile it is appropriate to identify and focus on representative important species for 'predictive' § 316(a) demonstrations, non-predictive (i.e., retrospective, or 'Type I') demonstrations, which are designed to assess prior appreciable harm, should not be restricted to assessing the status of representative important species. In fact, EPA's Draft 1977 316(a) Technical Guidance recommends that references to Representative Important Species be eliminated from Type I demonstrations* [emphasis added] *(EPA 1977a)…[W]hen assessing community-wide impacts, there is no reason to exclude any resident species that was present prior to the increase in discharges of heated effluent to Hooksett Pool*."[6]

Representative Important Species (RIS) are defined in EPA guidance as those species which are representative in terms of their biological requirements of a balanced, indigenous community of fish, shellfish, and wildlife in the body of water into which the discharge is made (EPA 1977). In

[6] See EPA Region 1. 2011. Draft NPDES Permit for the PSNH Merrimack Station; Appendix C, page 36. https://www3.epa.gov/region1/npdes/merrimackstation/pdfs/MerrimackStationAttachD.pdf

agreement with EPA Region 1's interpretation of the § 316(a) guidance with regard to Type I (non-predictive) demonstrations, all species collected by TVA in RFAI sampling around BFN, including non-indigenous species, were considered to be RIS and were included in the data analyses.

3.2.6 Zone of Passage

TVA collected depth profiles of temperature from the river surface to the bottom at points along transects to characterize and map the BFN thermal plume. Transects were located upstream of the discharge in an area not affected by the thermal plume (ambient), proximate to the thermal discharge point, and at various locations downstream of the discharge concentrated in the near field area of the plume where the change in plume temperature was expected to be most rapid. The total number of transects needed to fully characterize and delineate the plume was determined in the field.

As part of its § 316(a) demonstration studies conducted for BFN in 2011, 2013, 2015, and 2020, TVA collected temperature data profiles in the thermally influenced portion of the Wheeler Reservoir and compared these to profiles collected upstream of the BFN plant in the unaffected portion of the river. Measurements were collected in the autumn of 2011, 2013, 2015, and 2020. Notably, the primary purpose of this activity, in accordance with the BFN § 316(a) Demonstration Study Plan, was to confirm that the study biological sampling stations were located within the BFN thermal plume.

On the date of the autumn 2020 survey, ambient water temperature profiles were collected approximately 1 river mile upstream of the BFN plant at TRM 295.2, and profiles to represent thermal discharge temperatures were collected at TRM 293.9. Profiles were also collected at TRM 293.0, TRM 291.9 and at TRM 291.0. These data indicated that the thermal plume (water temperatures greater than 2 °C or 3.6 °F above ambient temperatures) extended horizontally about halfway across the river from the discharge channel at TRM 294 and downstream to TRM 291.9 (Table 18). Data indicated that the thermal plume extended down to a maximum depth of 4 m at the discharge transect but generally to a depth of 1.5 m. These data confirm that the biological sampling stations located downstream of BFN for the § 316(a) demonstration study have been reliably established within the thermal plume.

All profiles used to characterize the thermal plume (Table 18) make clear that it is confined to the upper strata of the Tennessee River, indicating that an adequate zone of passage exists in the lower strata for fish to traverse the area of the reservoir around the plant.

3.2.6.1 Field Measurements Relative to Zone of Passage

Water temperature, conductivity, dissolved oxygen, and pH were measured along vertical depth profiles at nine locations within each RFAI sample reach (Table 19). Daily average water temperatures in the reach downstream of BFN during 2020 did not exceed the current thermal variance of 90 °F (Figure 21).

During autumn 2020, water temperatures observed within the upstream reach varied little with a range from 64.3 to 65.5 °F, compared to a wider range of 65.3 to 71.1 °F in the downstream reach. Temperatures were lower at the upstream reach by an average of about 2.5 °F at upper depths (0.3 and 1.5 m) and about 2.1 °F across all depths.

These results indicate that a sufficient zone of passage past BFN existed for fish and other aquatic life during autumn 2020.

4.0 DISCUSSION and CONCLUSIONS

A number of factors drive variability in these data creating a challenge for interpretation with regard to the thermal effects of the BFN discharge on the aquatic community downstream of the plant. Inter-annual variations occur naturally in biological systems in response to food availability, predation, and ambient environmental conditions including river flow meteorological conditions; these factors may or may not be equally expressed upstream and downstream of the plant. As described in Section 3.2.4, the artificial nature of reservoirs in general, along with differences in river bottom habitat between the downstream and upstream reaches, also contribute to the challenge. Contributions of these individual factors to variation observed in the data are difficult to tease apart from plant-related thermal impacts, except during extremes of drought and during low flows.

Nonetheless, it seems apparent from the period of record data that the biological community downstream has overall been similar to the biological community upstream based on RFAI scores. Importantly, the RFAI index incorporates § 316(a) definitional elements such as diversity (number of species), trophic levels (categorization by feeding guild), presence of necessary food chain species, non-domination of pollution-tolerant species, and representation of indigenous species. Further, the repetitive sampling and scoring across many years provides a measure of sustainability (and trends).

In evaluating the selected fish community metrics of the RFAI, it is apparent that the fish community structure at the thermally affected downstream reach was similar to that of the thermally unaffected upstream reach in 2020. When compared to the 2000–2019 averages, the 2020 data indicate similarity or improvement in all twelve metrics.

When evaluating the data in the context of EPA's interpretation of the regulatory definition of a BIP, TVA believes that a BIP is currently being demonstrated in Wheeler Reservoir based on the most recent biological data collected in 2020. As such, TVA believes that continuation of the current thermal variance of 93 °F at the end of the mixing zone and a daily average of 90 °F for the BFN plant discharge (Outfall DSN001) will reasonably assure the protection and propagation of a BIP.

Should ADEM determine that a BIP does <u>not</u> currently exist, ADEM has the authority under the § 316(a) regulations to approve TVA's requested thermal variance on the basis that: 1) a BIP was maintained for decades up and until 2017 and 2) there is reasonable assurance that a BIP will be

supported going forward. Such assurance can be confirmed via additional biological monitoring with supporting thermal modeling as a continued condition of the renewed permit. Again, absolute certainty[7] is not required in approving a thermal variance.

4.1 Relationship to Clean Water Act Section 316(b)

When ADEM issues the renewed NPDES permit for BFN, it will include requirements that TVA conduct a number of studies [see § 122.21(r)], the results of which are to inform the Commissioner's decisions with regard to the Best Technology Available (BTA) for reducing entrainment of fish eggs and larvae through the BFN cooling water system. Of specific relevance to the current issue, TVA will have to evaluate, among other technologies, the technical feasibility and cost of retrofitting the plant to closed-cycle cooling. While the focus of interest is entrainment reduction via the reduction in flow that accompanies closed-cycle cooling, the Commissioner can factor into the decision-making process any benefits that might be accrued to the receiving water due to the related reduction in thermal loading.

As such, additional § 316(a) related study of the BFN thermal discharge effects conducted in parallel with the study requirements of § 316(b) over the next permit cycle will allow for the Commissioner's holistic assessment of the impact of BFN operations on the aquatic community from thermal discharge and cooling water intake perspectives, and inform decision making for regulatory compliance with both regulations in the subsequent NPDES permit.

[7] See EPA Region 1. 2011. Draft NPDES Permit for the PSNH Merrimack Station; Appendix C, page 25. https://www3.epa.gov/region1/npdes/merrimackstation/pdfs/MerrimackStationAttachD.pdf

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FIGURES

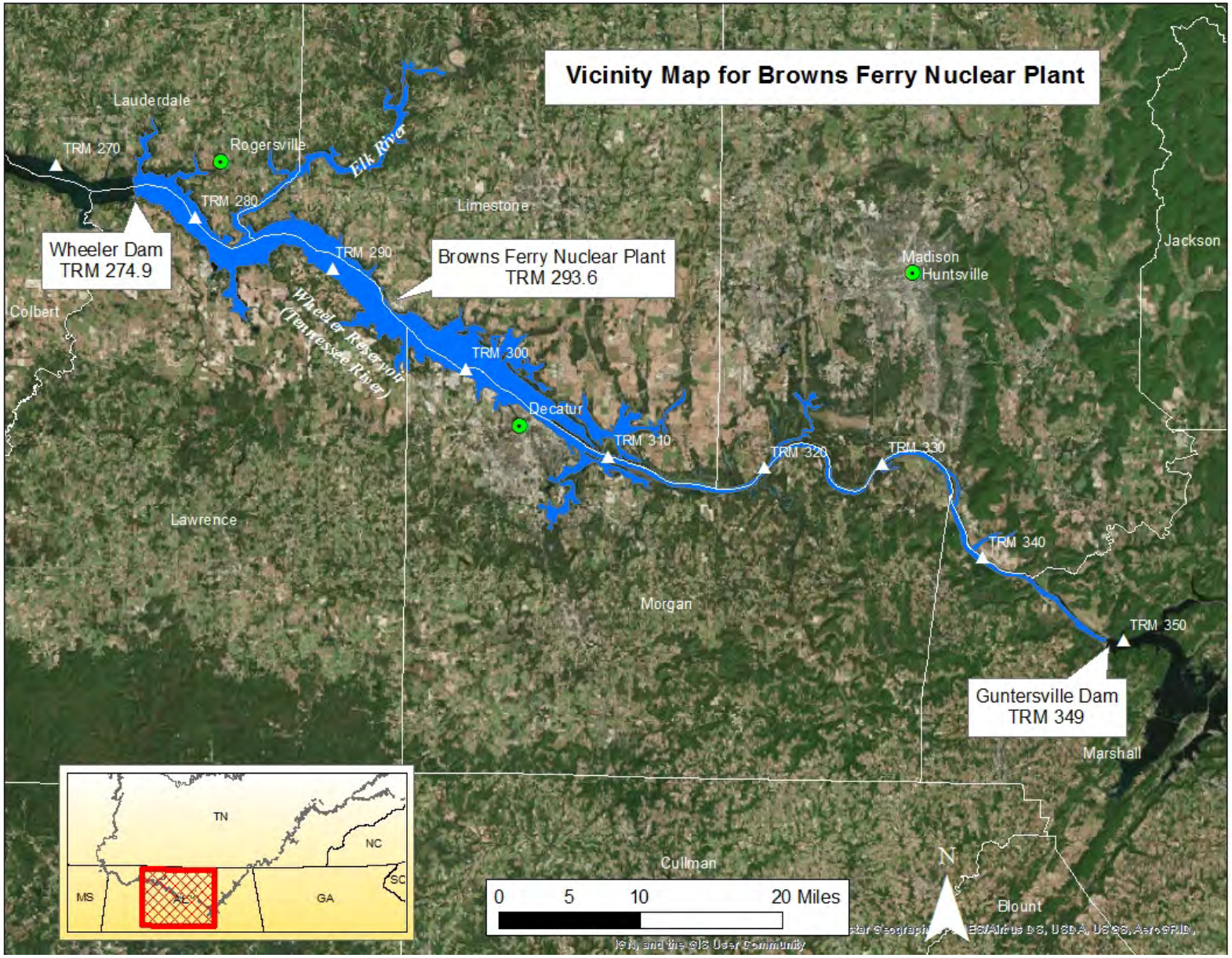


Figure 1. Vicinity map for Browns Ferry Nuclear Plant depicting location of dams upstream (Guntersville) and downstream (Wheeler) from the plant



Figure 2. Location of Condenser Cooling Water (CCW) intake and NPDES-permitted discharge DSN001 at Browns Ferry Nuclear Plant

Tennessee River Daily Average Flows
(Guntersville and Wheeler Dam Releases)

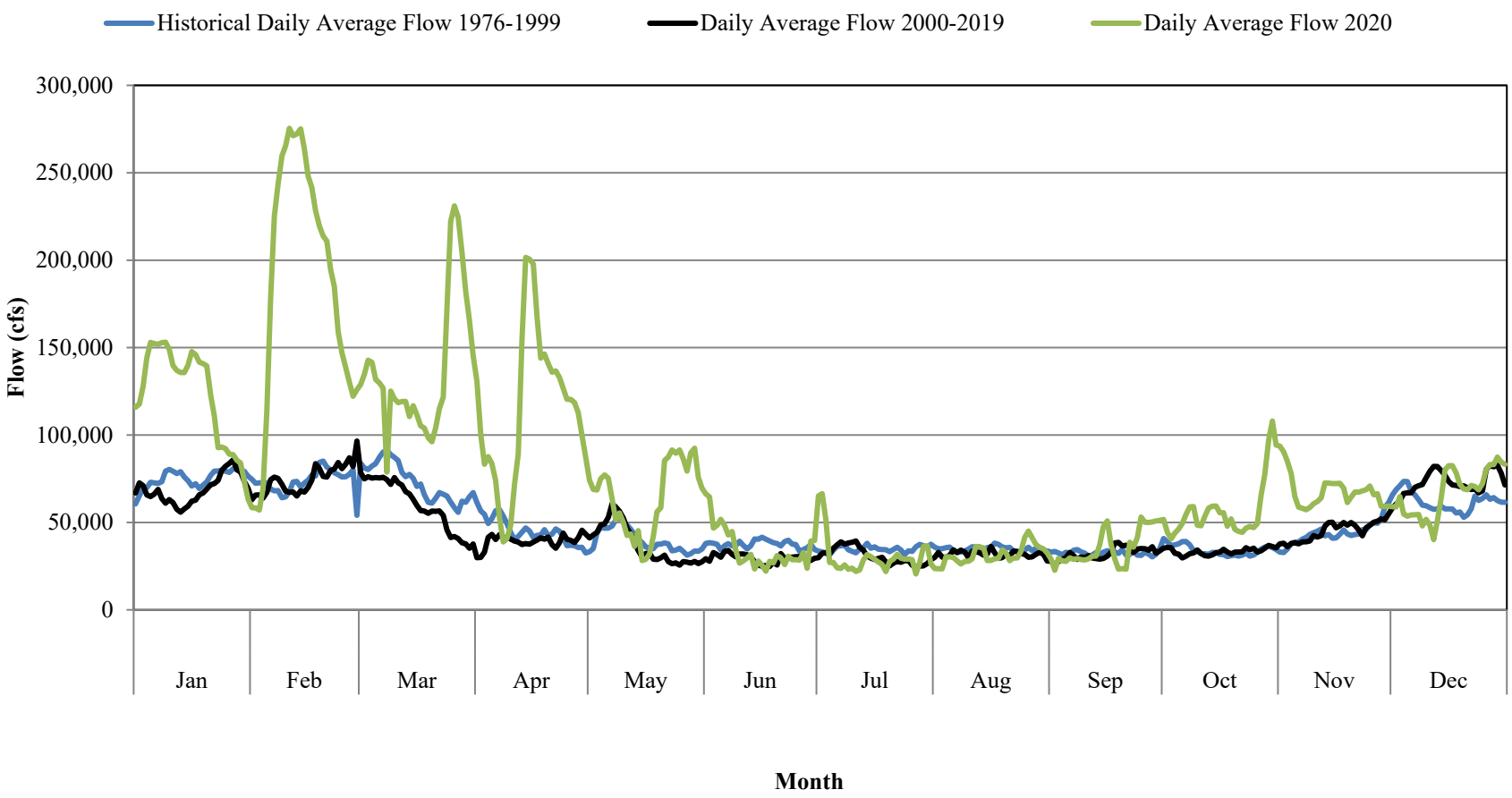


Figure 3. Average daily Tennessee River flows (Guntersville Dam and Wheeler Dam releases) during 1976-1999 (historical flows), 2000-2019 (previous monitoring), and 2020 (current monitoring)

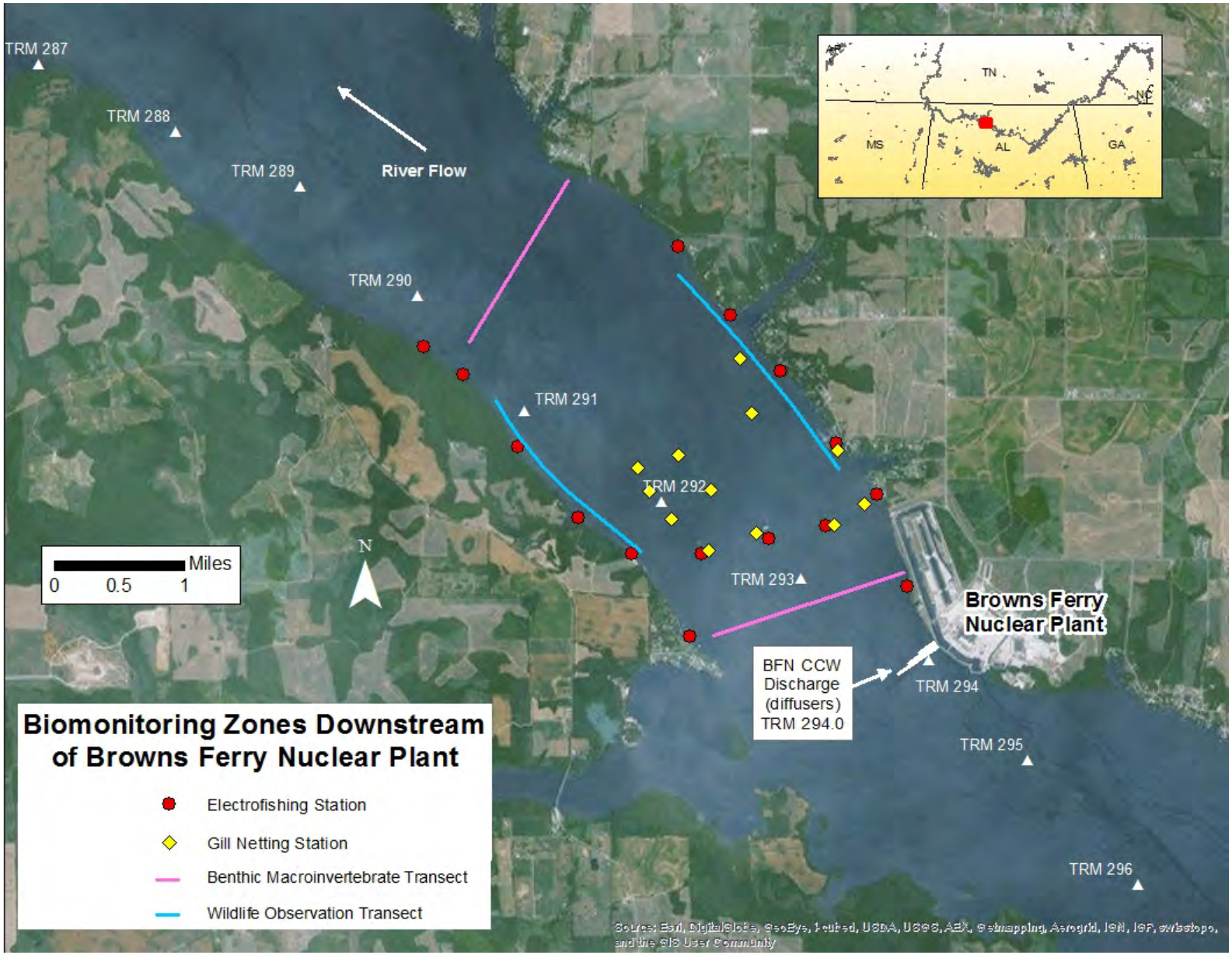


Figure 4. Biological monitoring zone downstream of Browns Ferry Nuclear plant NPDES-permitted discharge Outfall DSN001

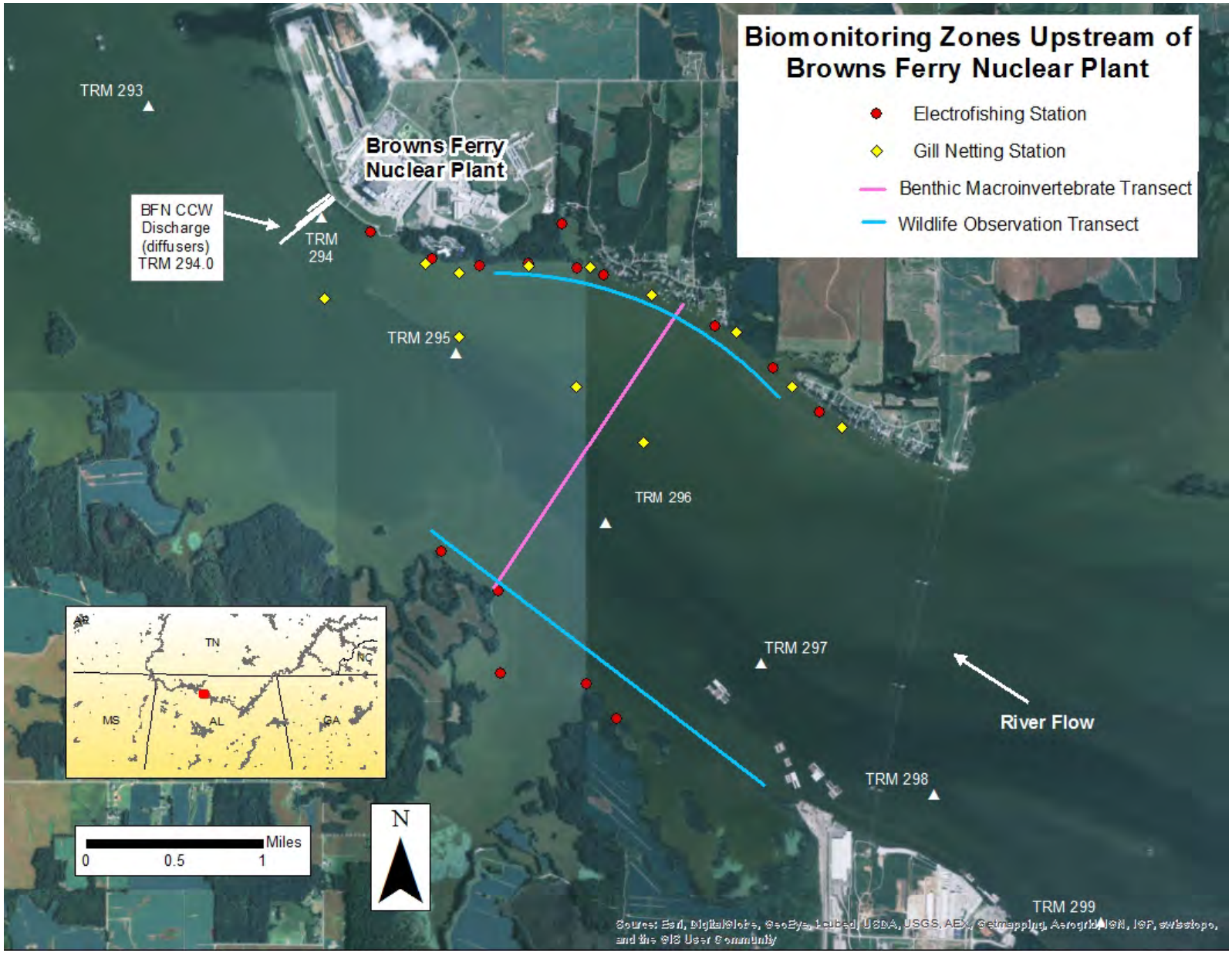


Figure 5. Biological monitoring zone upstream of Browns Ferry Nuclear plant thermal discharge

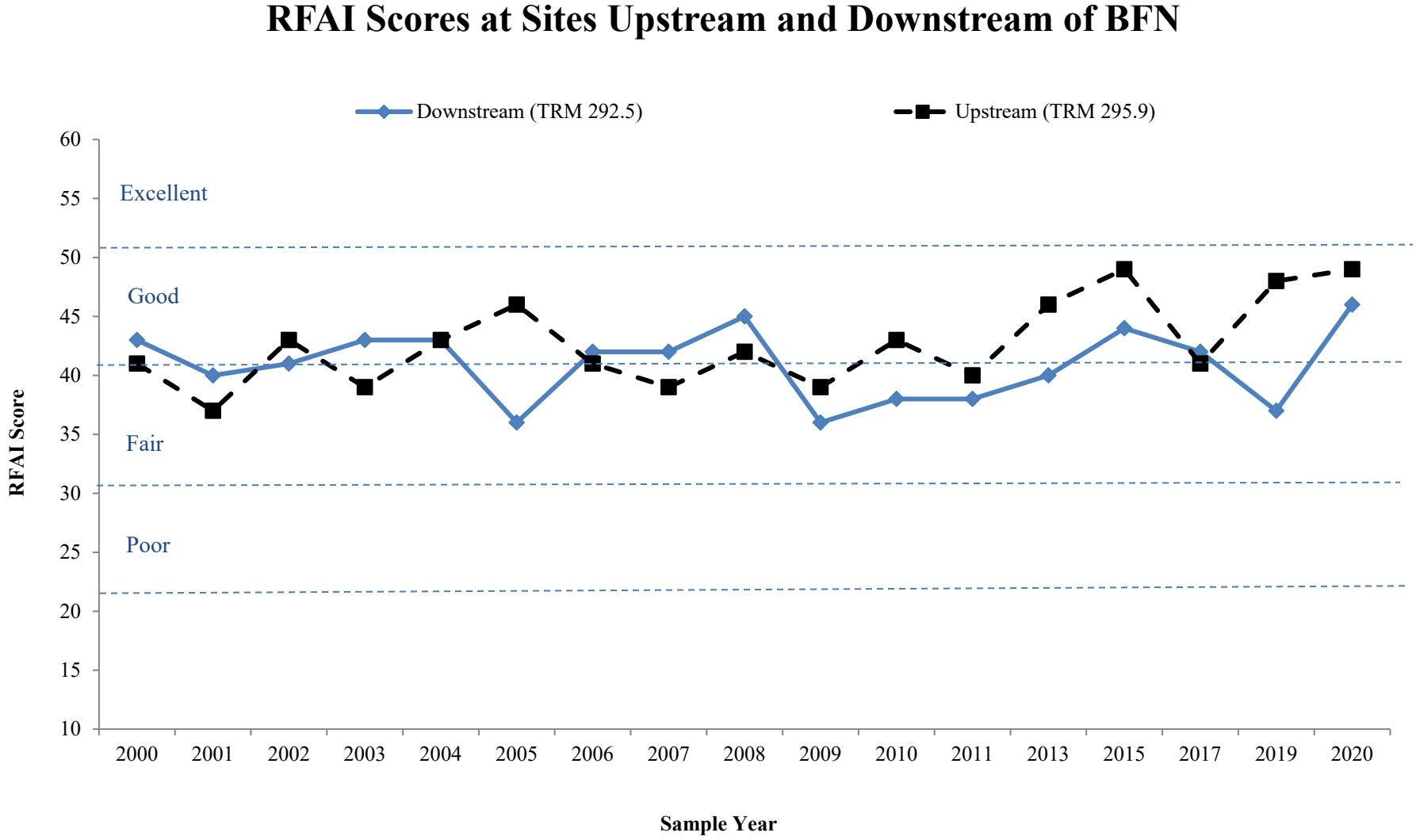


Figure 6. Reservoir Fish Assemblage Index (RFAI) scores and ratings from sites located directly upstream and downstream of Browns Ferry Nuclear plant (BFN; TRM 294) conducted during spring 2007 and autumn 2000-2011, 2013, 2015, 2017, 2019, and 2020 as part of the Reservoir Ecological Health Monitoring Program in Wheeler Reservoir

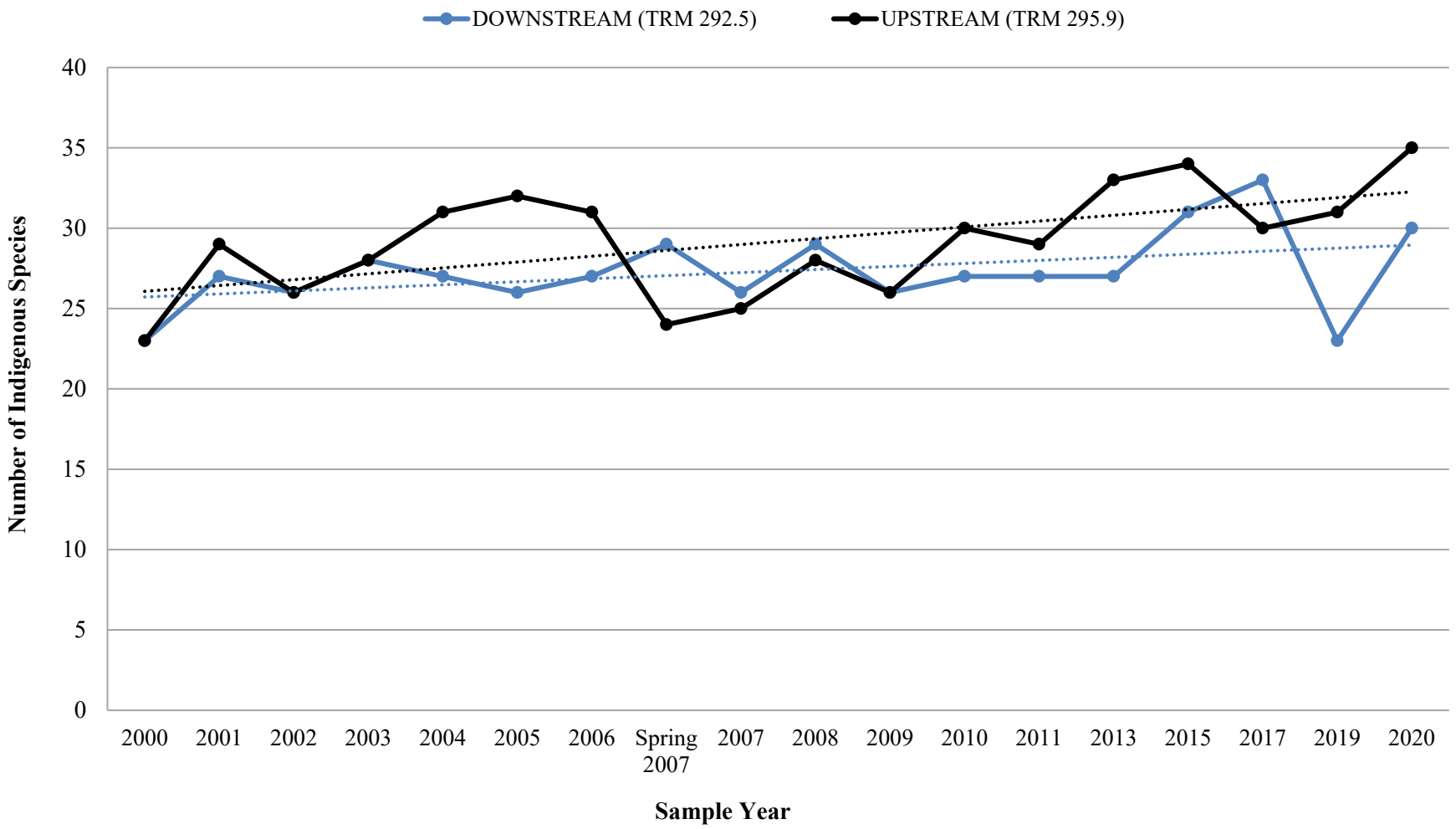


Figure 7. Numbers of indigenous species collected at sites upstream (TRM 295.9) and downstream (TRM 292.5) of Browns Ferry Nuclear Plant during spring 2007 and autumn 2000-2011, 2013, 2015, 2017, 2019 and 2020 as part of the Reservoir Ecological Health Monitoring Program in Wheeler Reservoir

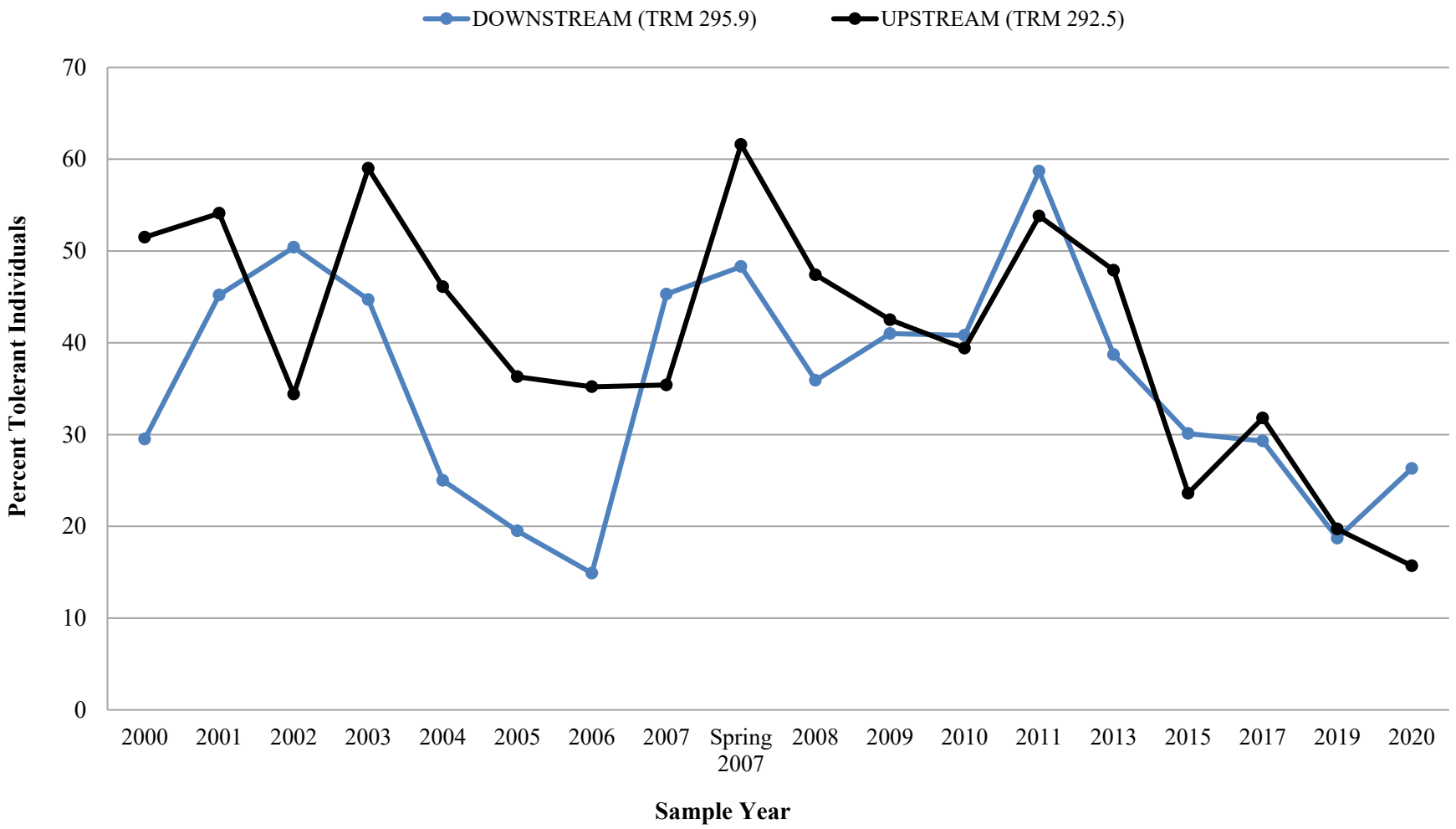


Figure 8. Relative proportions of tolerant fishes collected in autumn samples at sites upstream (TRM 295.9) and downstream (TRM 292.5) of Browns Ferry Nuclear Plant during spring 2007 and autumn 2000-2011, 2013, 2015, 2017, 2019 and 2020 as part of the Reservoir Ecological Health Monitoring Program in Wheeler Reservoir

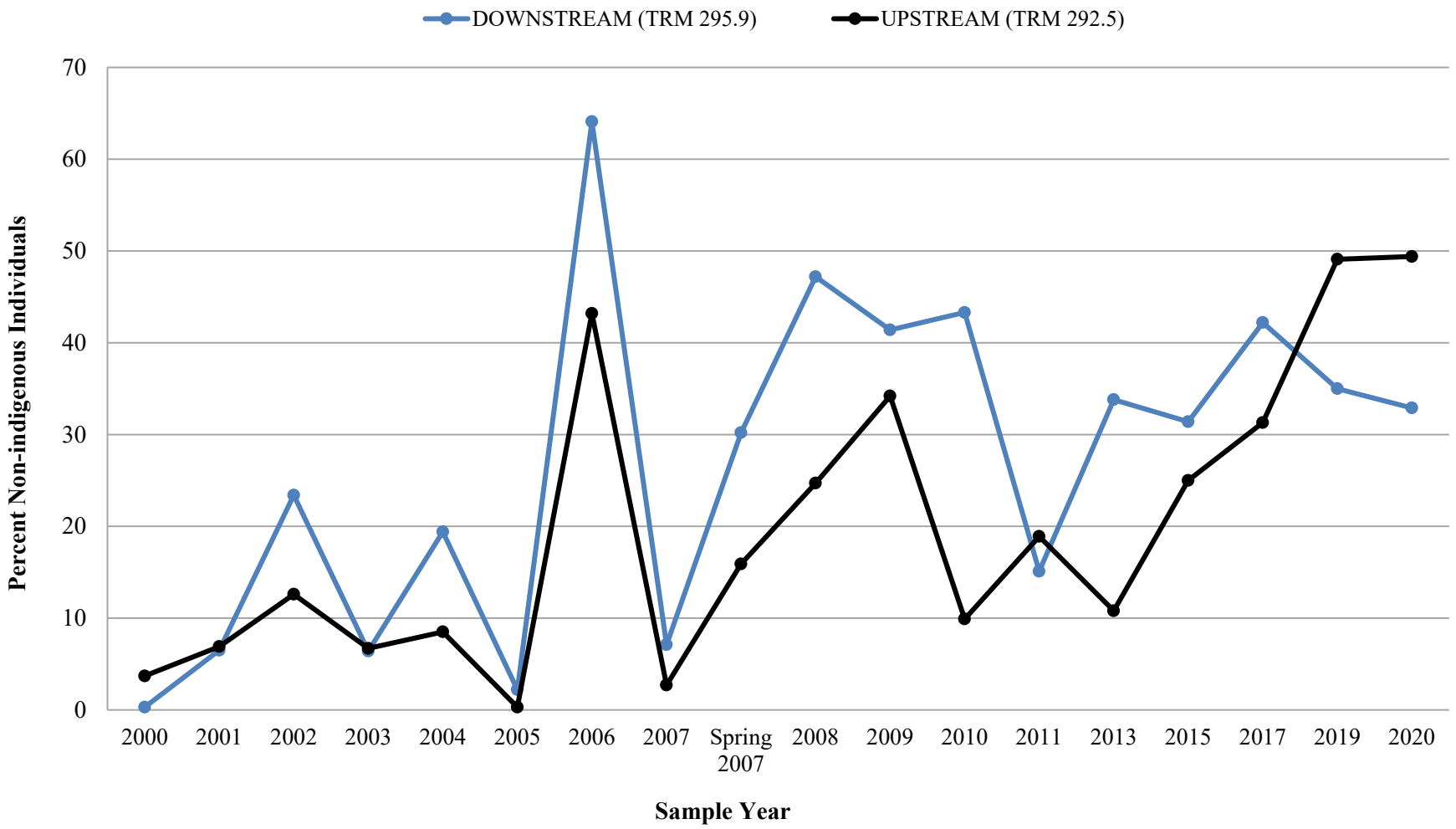


Figure 9. Relative proportions of non-indigenous fishes collected in autumn samples at sites upstream (TRM 295.9) and downstream (TRM 292.5) of Browns Ferry Nuclear Plant during spring 2007 and autumn 2000-2011, 2013, 2015, 2017, 2019 and 2020 as part of the Reservoir Ecological Health Monitoring Program in Wheeler Reservoir

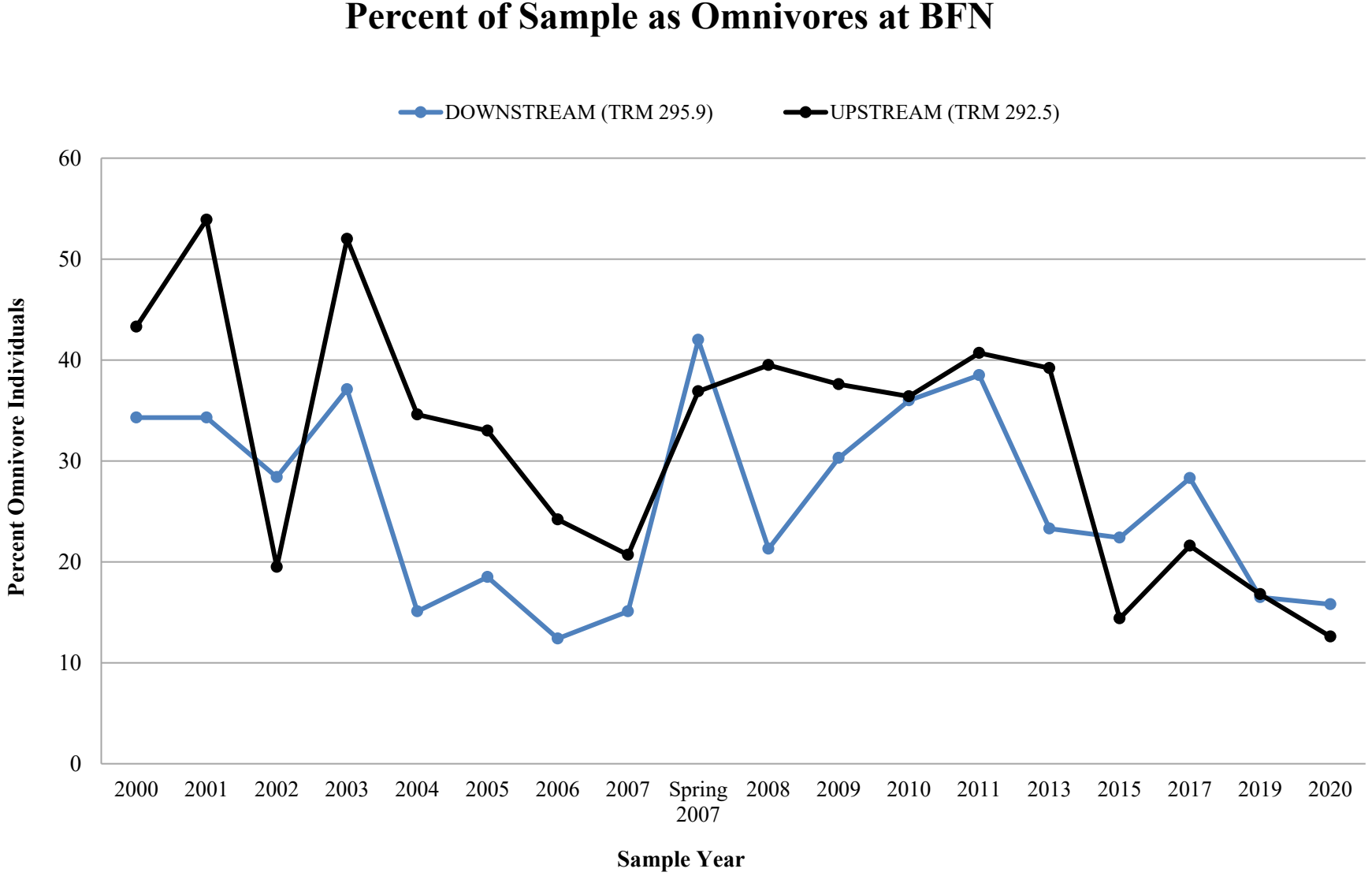
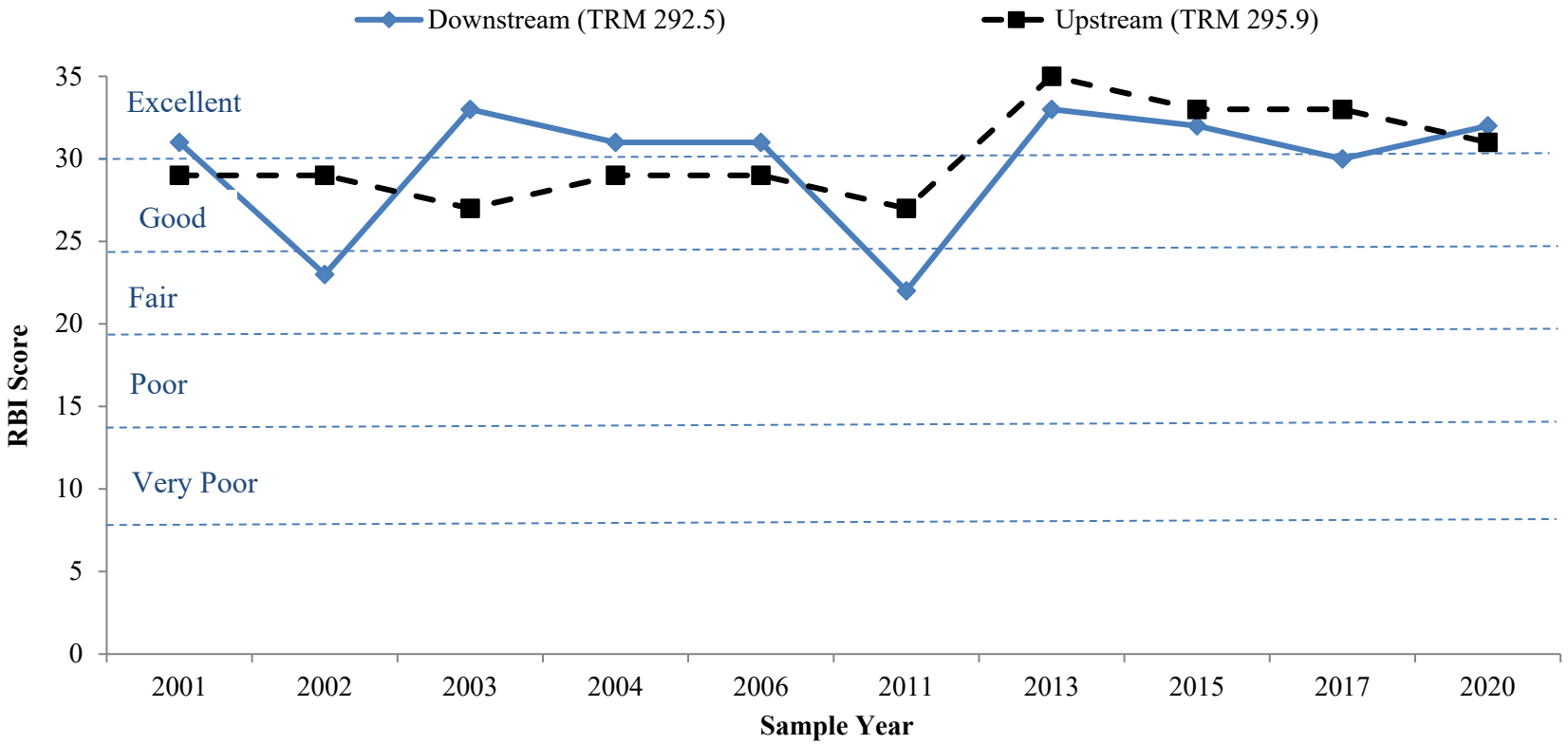


Figure 10. Relative proportions of omnivore fishes collected in autumn samples at sites upstream (TRM 295.9) and downstream (TRM 292.5) of Browns Ferry Nuclear Plant during spring 2007 and autumn 2000-2011, 2013, 2015, 2017, 2019 and 2020 as part of the Reservoir Ecological Health Monitoring Program in Wheeler Reservoir



*Downstream transects located at TRM 291.7 from 2001 to 2004 and 2006, and TRMs 293.2 and 290.4 during 2011, 2013, 2015, 2017, and 2020
^RBI scores for 2011, 2013, 2015, and 2017 are averages of scores for the two downstream transects

Figure 11. Reservoir Benthic Index (RBI) scores^ and ratings from sites located directly upstream and downstream* of Browns Ferry Nuclear plant (BFN; TRM 294) conducted during autumn 2001-2004, 2006, 2011, 2013, 2015, 2017, and 2020 (lab-processed data) as part of the Reservoir Ecological Health Monitoring Program in Wheeler Reservoir

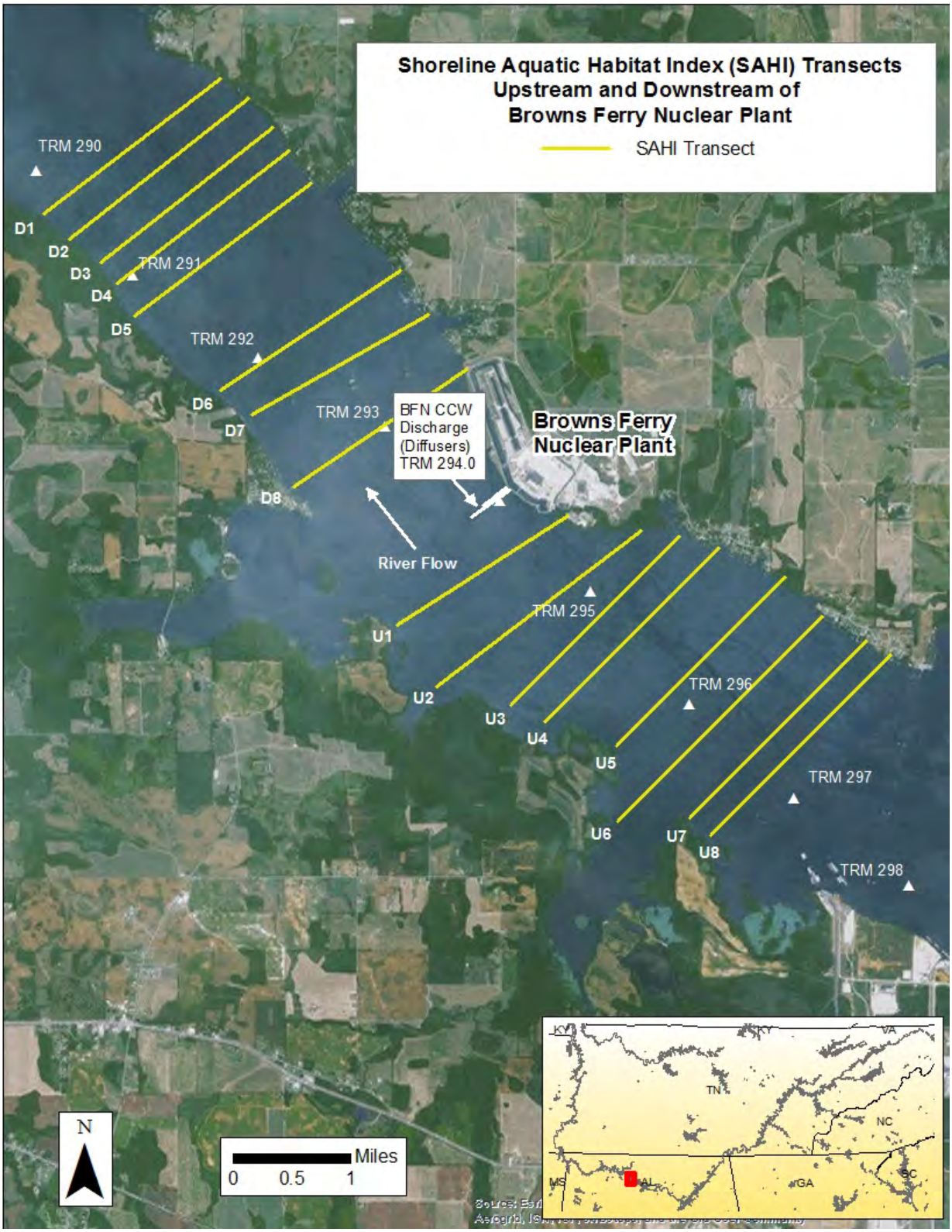


Figure 12. Transects established upstream and downstream of Browns Ferry Nuclear plant for the integrative multi-metric aquatic shoreline and river bottom habitat assessment

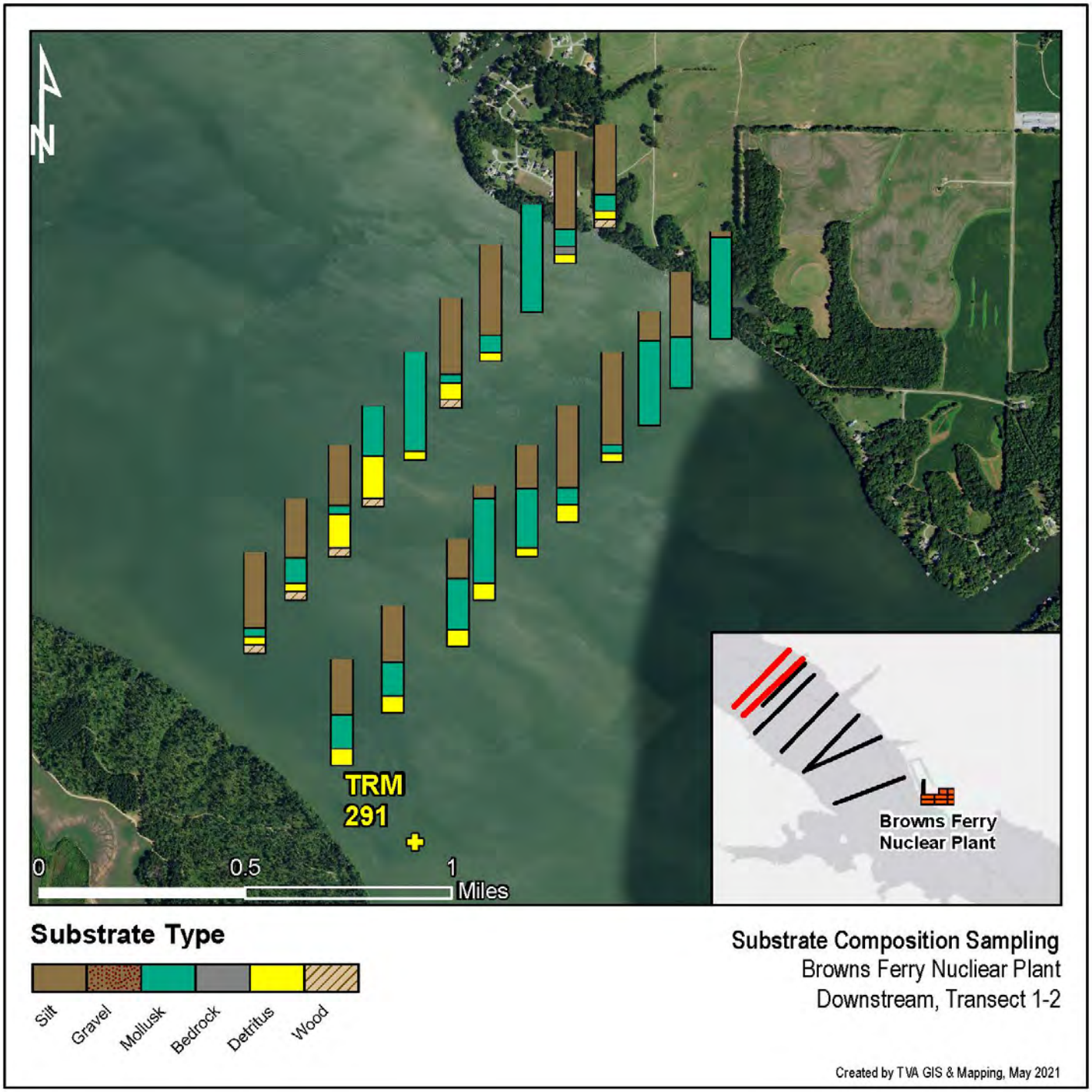


Figure 13. Substrate composition at ten equally spaced points per transect (Transects 1 and 2 shown) across the Tennessee River (Wheeler Reservoir) downstream of BFN, autumn 2020

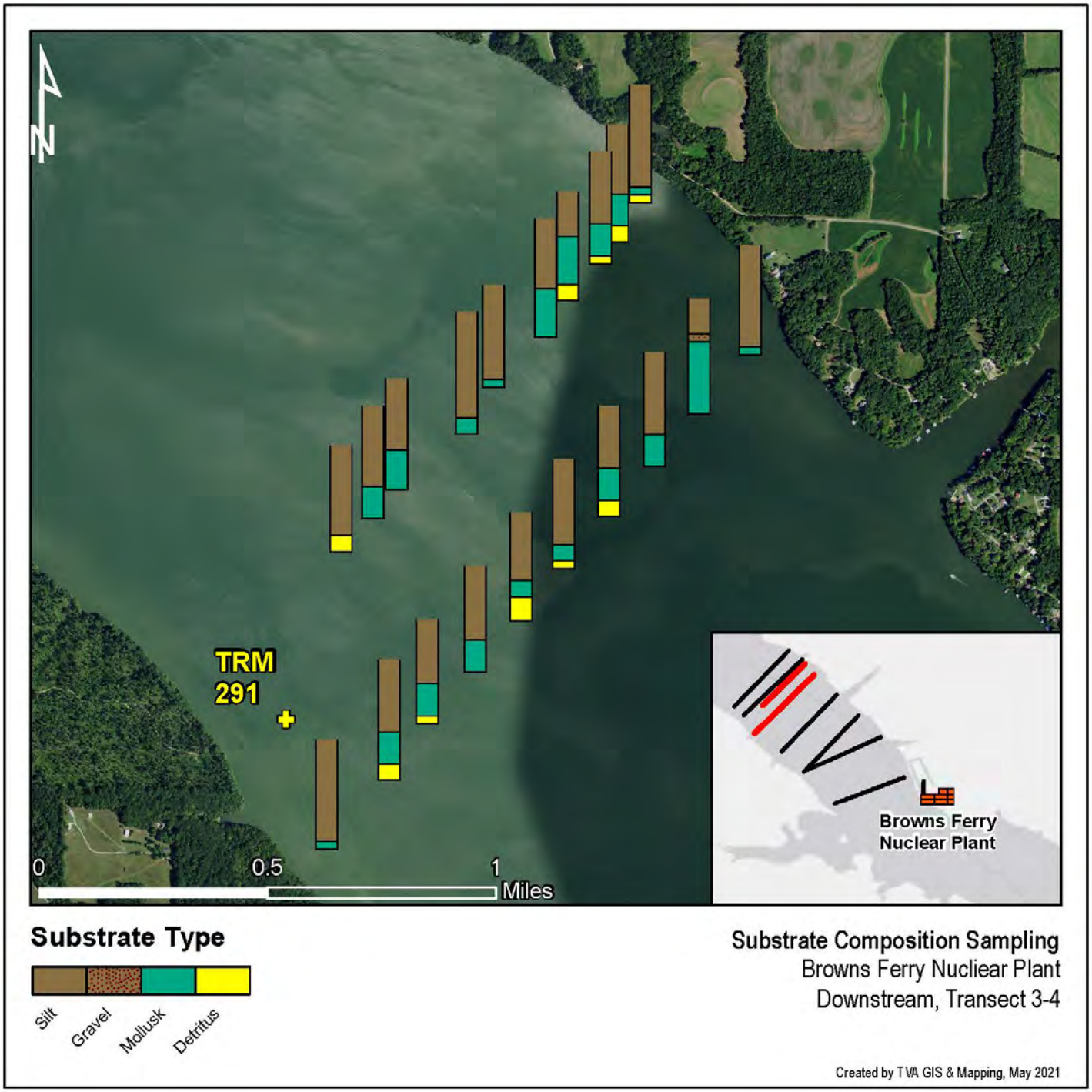


Figure 14. Substrate composition at ten equally spaced points per transect (Transects 3 and 4 shown) across the Tennessee River (Wheeler Reservoir) downstream of BFN, autumn 2020

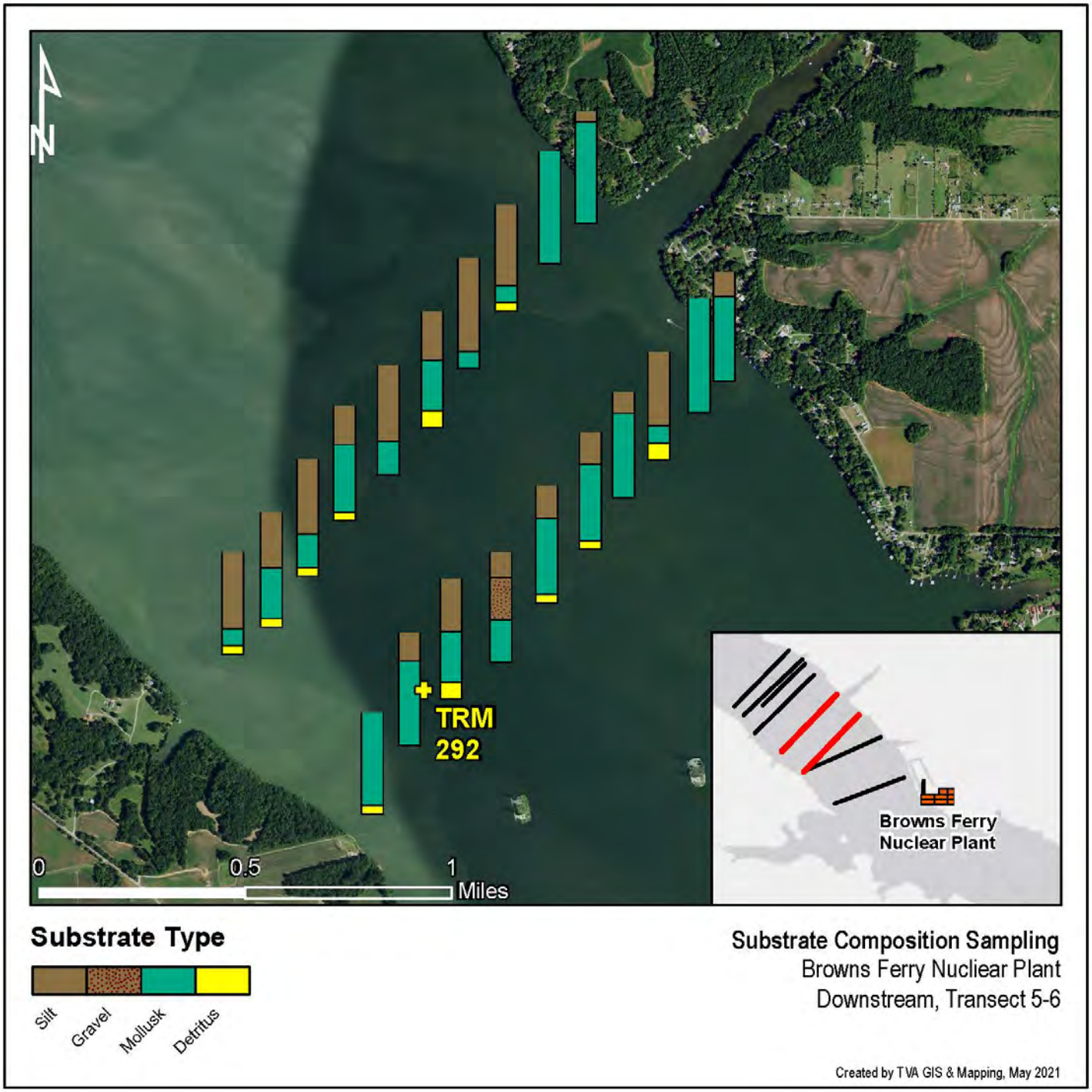


Figure 15. Substrate composition at ten equally spaced points per transect (Transects 5 and 6 shown) across the Tennessee River (Wheeler Reservoir) downstream of BFN, autumn 2020

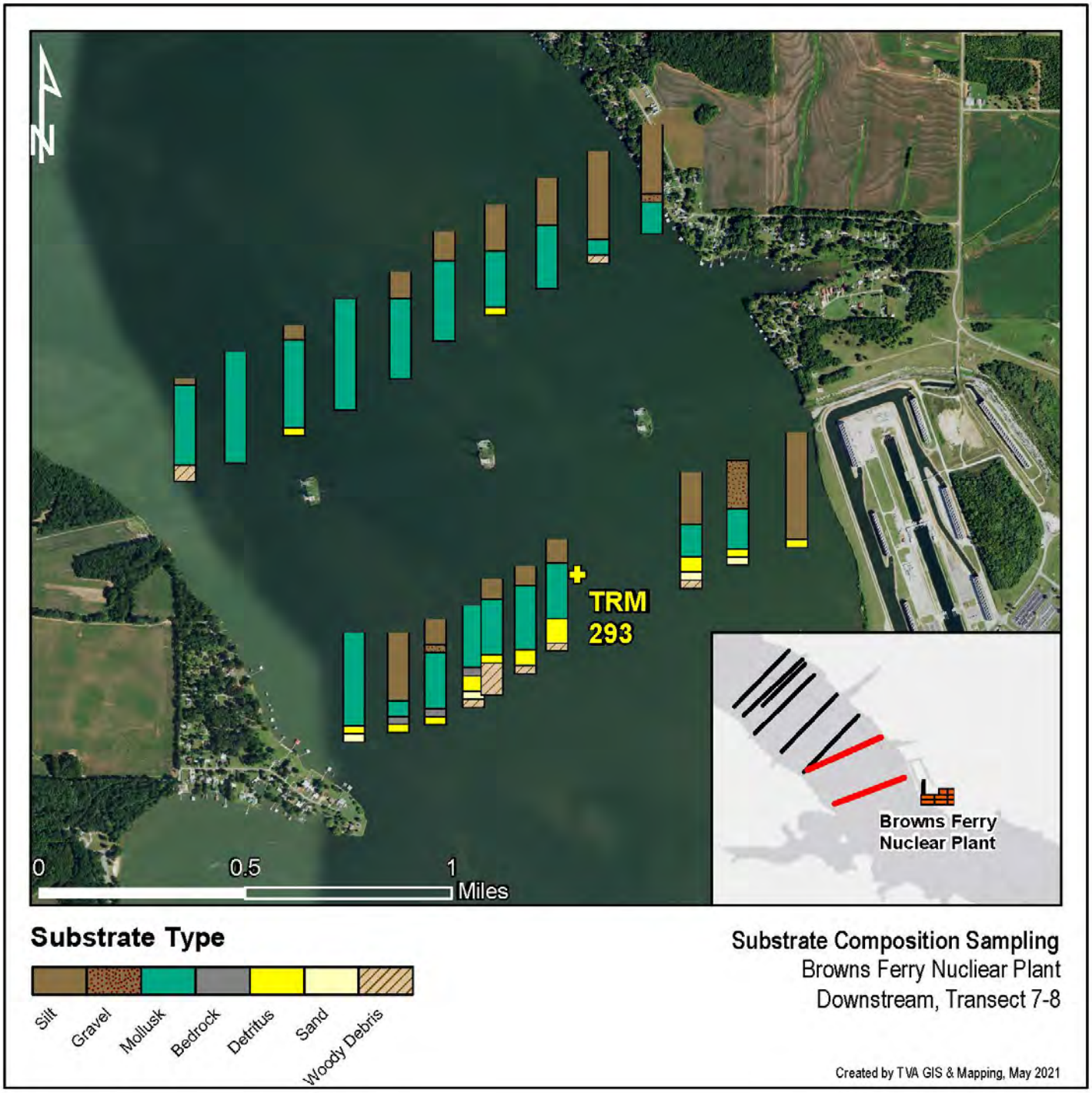


Figure 16. Substrate composition at ten equally spaced points per transect (Transects 7 and 8 shown) across the Tennessee River (Wheeler Reservoir) downstream of BFN, autumn 2020

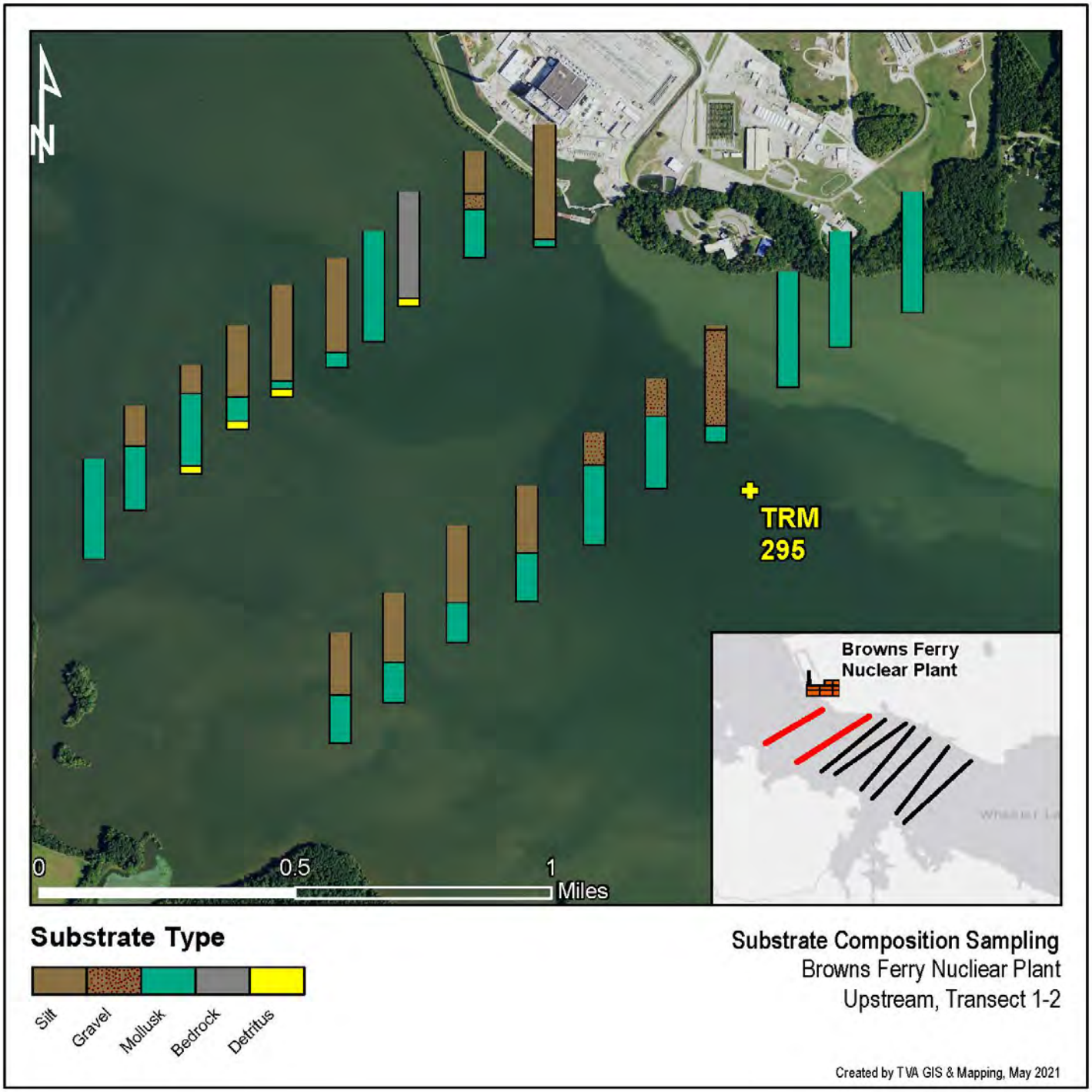


Figure 17. Substrate composition at ten equally spaced points per transect (Transects 1 and 2 shown) across the Tennessee River (Wheeler Reservoir) upstream of BFN, autumn 2020

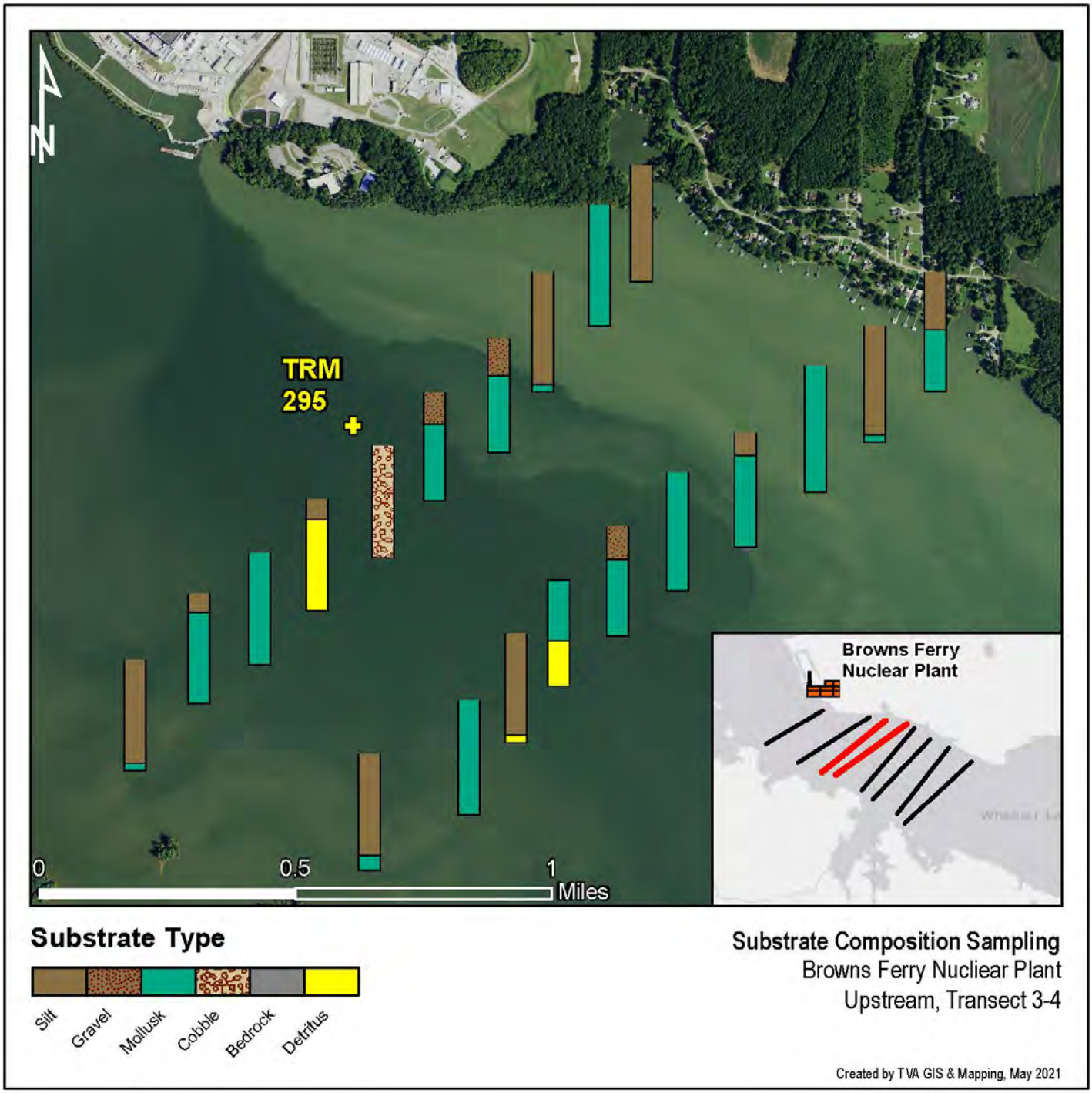


Figure 18. Substrate composition at ten equally spaced points per transect (Transects 3 and 4 shown) across the Tennessee River (Wheeler Reservoir) upstream of BFN, autumn 2020

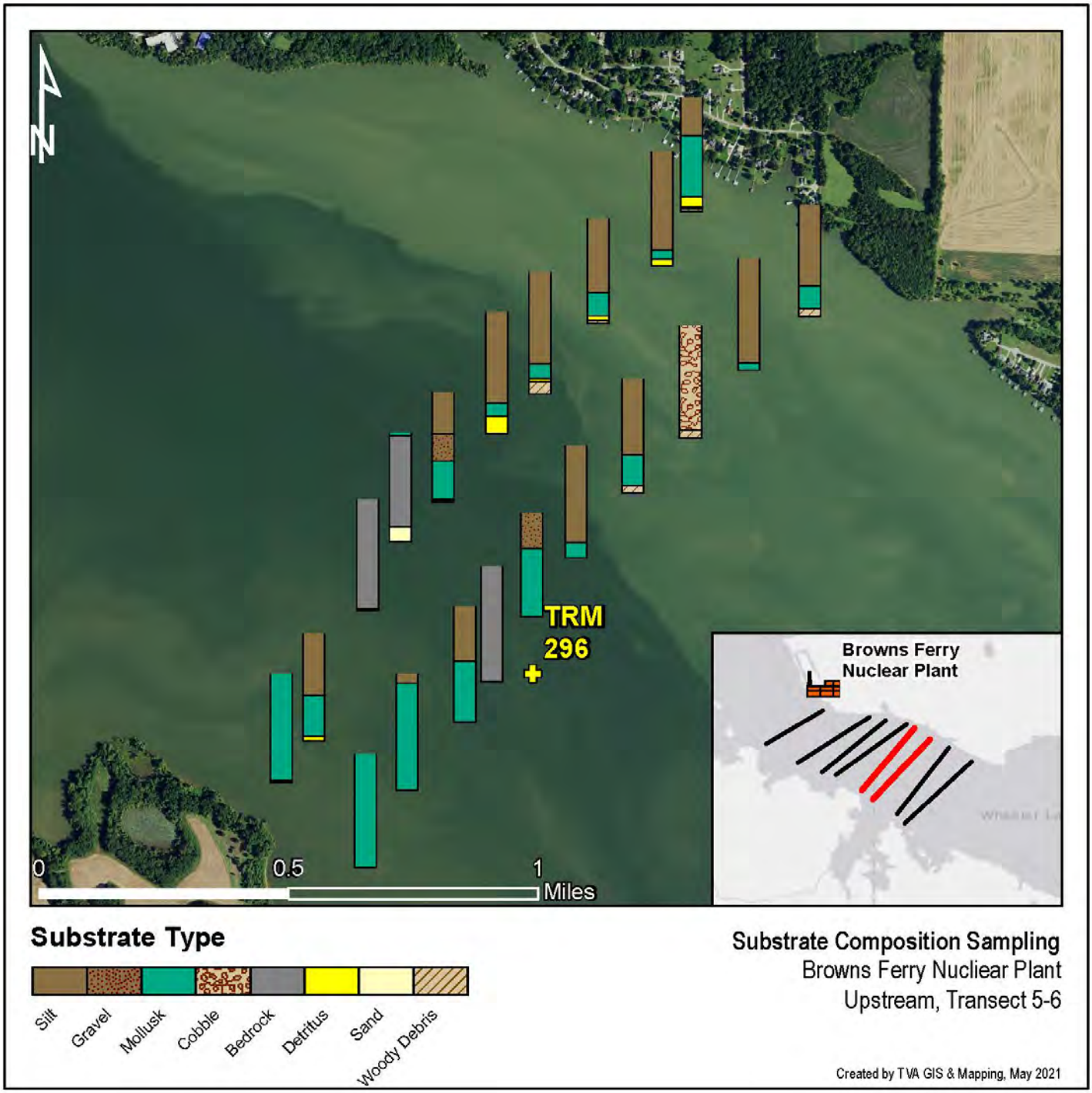


Figure 19. Substrate composition at ten equally spaced points per transect (Transects 5 and 6 shown) across the Tennessee River (Wheeler Reservoir) upstream of BFN, autumn 2020

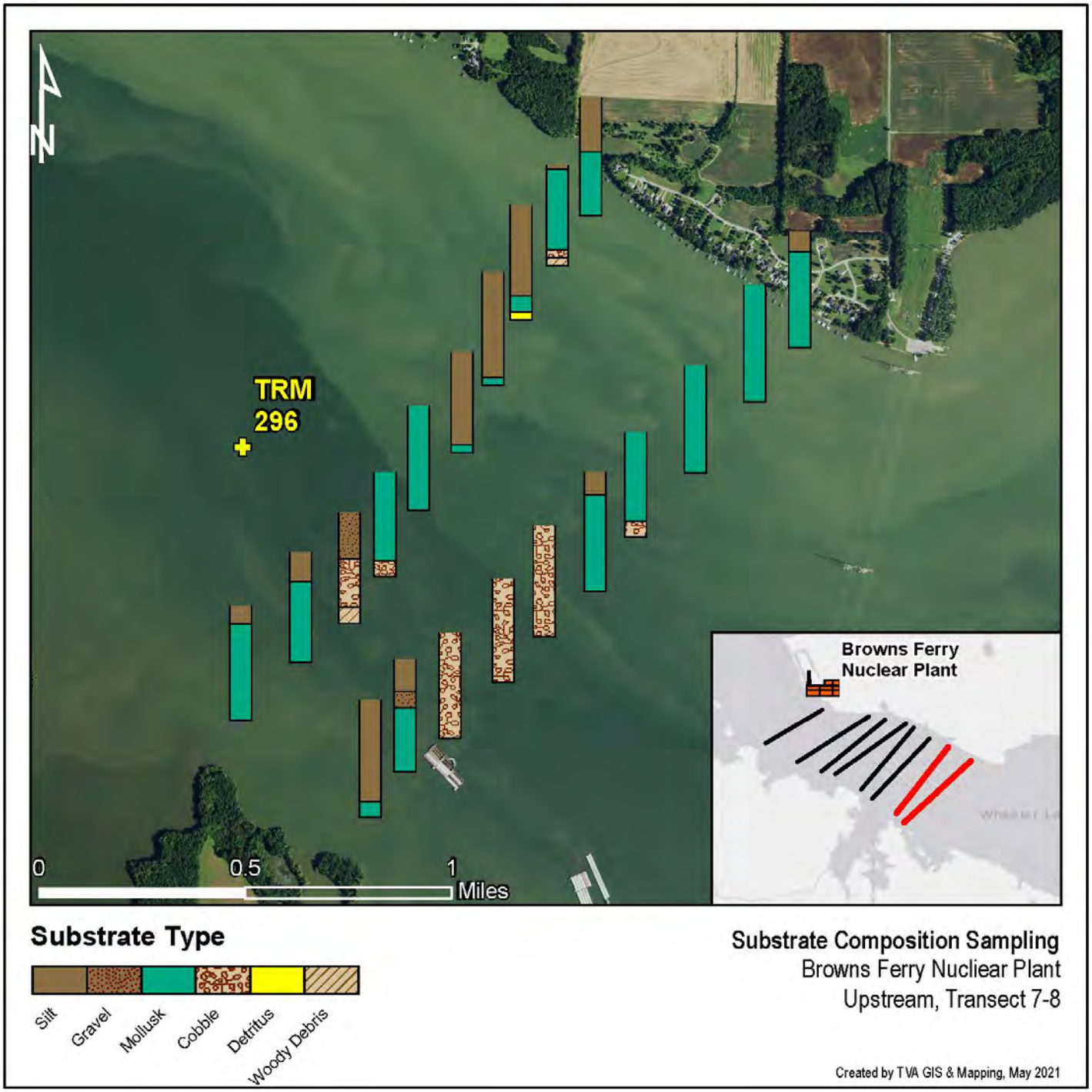
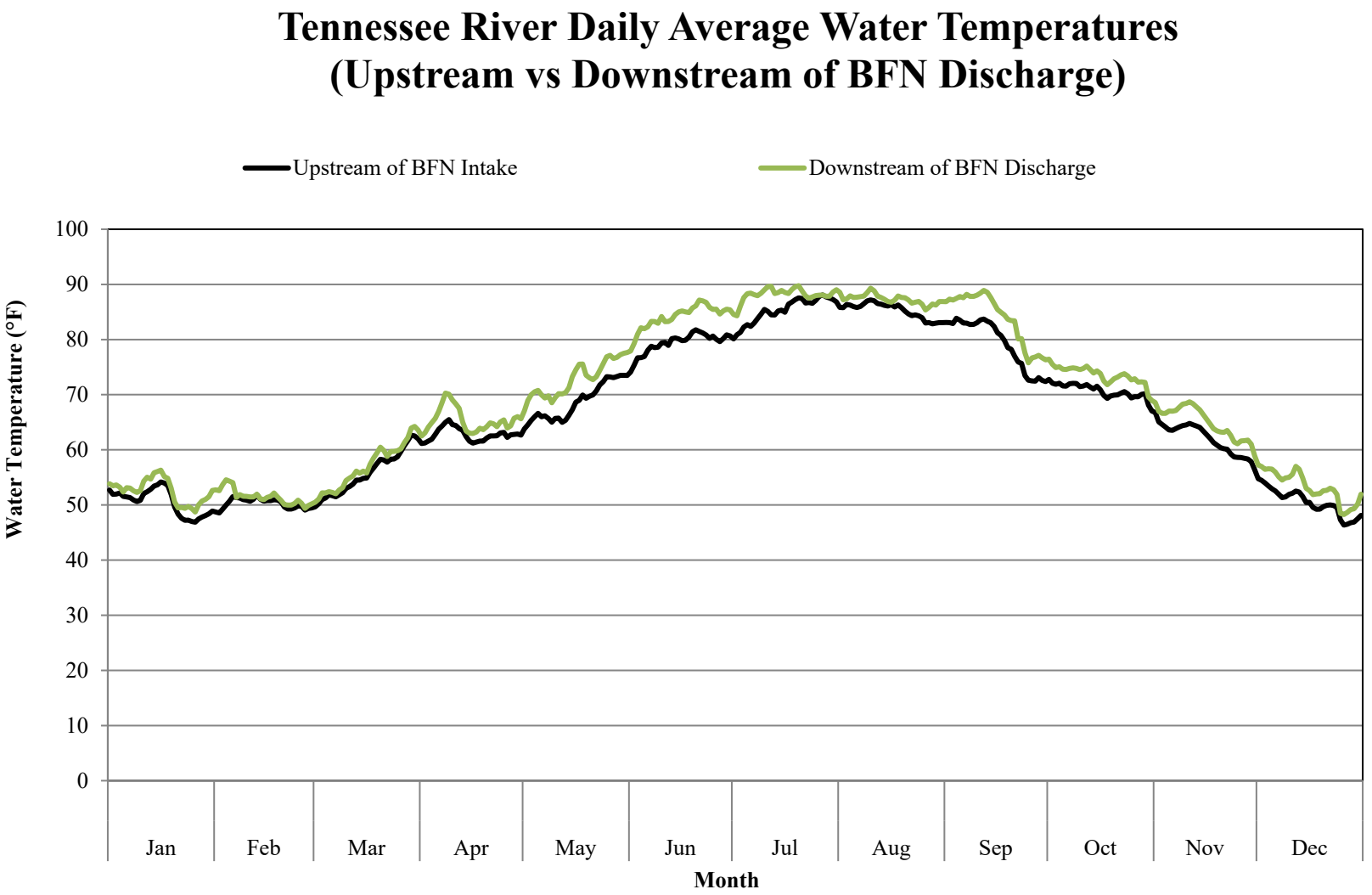


Figure 20. Substrate composition at ten equally spaced points per transect (Transects 7 and 8 shown) across the Tennessee River (Wheeler Reservoir) upstream of BFN, autumn 2020



*Averages of temperatures at depths of 3, 5, and 7 ft

Figure 21. Daily water temperatures* recorded upstream of Browns Ferry Nuclear Plant (BFN) intake and downstream of BFN discharge (see Figure A-1) during 2020

TABLES

Table 1. Seasonal Reservoir Fish Assemblage Index (RFAI) scores from fish community monitoring at sites located directly upstream and downstream of Browns Ferry Nuclear Plant (TRM 294) on Wheeler Reservoir during autumn 2000-2011, 2013, 2015, 2017, 2019 and 2020 (except for noted spring sample)

	RFAI Scores		
Year	Downstream (TRM 292.5)	Upstream (TRM 295.9)	Difference
2000	43	41	2
2001	40	37	3
2002	41	43	2
2003	43	39	4
2004	43	43	0
2005	36	46	10
2006	42	41	1
2007	44	42	2
Spring 2007	42	39	3
2008	45	42	3
2009	36	39	3
2010	38	43	5
2011	38	40	2
2013	40	46	6
2015	44	49	5
2017	42	41	1
2019	37	48	11
2020	46	49	3
Autumn 2000-2019 AVG	**41**	**42**	**3.6**

***12-21 “Very Poor”; 22-31 “Poor”; 32-40 “Fair”; 41-50 “Good”; 51-60 “Excellent”**

Table 2. Comparison of RFAI scores and select metrics (gears combined) for fish collected upstream (TRM 295.9) and downstream (TRM 292.5) of Browns Ferry Nuclear Plant during spring 2007 and autumn (AUT) 2000-2011, 2013, 2015, 2017, 2019, and 2020

Metrics	2000	2001	2002	2003	2004	2005	2006	Spring 2007	2007	2008	2009	2010	2011	2013	2015	2017	2019	2020	2000-2019 AVG	AUT RANGE
DOWNSTREAM (TRM 292.5)																				
RFAI Score	43	40	41	43	43	36	42	44	42	45	36	38	38	40	44	42	37	46	41	36 - 46
1. Number of species	23	27	26	28	27	26	27	29	26	29	26	27	27	27	31	33	23	30	27	23 - 33
2. Number of centrarchid species (excluding *Micropterus* spp.)	3	5	4	7	4	5	6	6	5	6	6	7	7	6	7	6	4	5	6	3 - 7
3. Number of benthic invertivores	6	5	5	4	6	5	4	8	5	5	3	5	4	4	5	5	4	4	5	3 - 6
4. Number of intolerant species	8	5	5	4	5	4	5	7	5	5	3	4	5	5	5	5	5	6	5	3 - 8
5. Percent tolerant individuals	29.5	45.2	50.4	44.7	25.0	19.5	14.9	45.3	48.3	35.9	41.0	40.8	58.7	38.7	30.1	29.3	18.7	26.3	35.7	14.9 - 58.7
6. Percent dominance by 1 species	26.7	26.3	23.8	25.9	34.6	60.5	64.0	24.9	35.9	47.1	41.3	43.2	34.5	33.2	31.2	41.4	34.6	32.8	37.8	23.8 - 64.0
7. Percent non-indigenous species	0.3	6.5	23.4	6.4	19.4	2.2	64.1	7.1	30.2	47.2	41.4	43.3	15.1	33.8	31.4	42.2	35.0	32.9	27.6	0.3 - 64.1
8. Number of top carnivore species	8	8	8	10	8	7	9	10	9	10	9	10	9	8	10	11	7	12	9	7 - 12
9. Percent top carnivores	24.0	18.4	14.0	17.2	12.2	6.4	14.1	31.2	10.8	14.1	12.1	7.3	5.2	7.1	6.0	12.5	8.8	25.1	11.9	5.2 - 25.1
10. Percent omnivores	34.3	34.3	28.4	37.1	15.1	18.5	12.4	15.1	42.0	21.3	30.3	36.0	38.5	23.3	22.4	28.3	16.5	15.8	27.4	12.4 - 42.0
11. Average number per run	14.4	18.1	44.9	26.8	42.7	54.6	75.6	46.0	40.9	75.3	64.4	67.6	74.8	38.8	71.0	41.4	38.5	44.2	49.4	14.4 - 75.6
12. Percent anomalies	0.0	1.2	1.1	2.7	2.0	0.2	0.4	1.8	1.1	0.4	0.5	0.4	0.3	0.8	0.3	0.8	0.5	0.8	0.8	0 - 2.7
UPSTREAM (TRM 295.9)																				
RFAI Score	41	37	43	39	43	46	41	42	39	42	39	43	40	46	49	41	48	49	42	37 - 49
1. Number of species	23	29	26	28	31	32	31	24	25	28	26	30	29	33	34	30	31	35	29	23 - 35
2. Number of centrarchid species (excluding *Micropterus* spp.)	3	7	4	6	7	6	6	5	6	7	7	7	7	8	7	7	6	6	6	3 - 8
3. Number of benthic invertivores	6	3	4	4	7	7	4	3	3	4	4	4	4	5	5	4	5	5	5	3 - 7
4. Number of intolerant species	5	6	6	5	7	6	5	5	5	5	5	5	5	6	5	5	5	5	5	5 - 7
5. Percent tolerant individuals	51.5	54.1	34.4	59.0	46.1	36.3	35.2	35.4	61.6	47.4	42.5	39.4	53.8	47.9	23.6	31.8	19.7	15.7	42.8	15.7 - 61.6
6. Percent dominance by 1 species	37.2	45.0	26.5	37.6	20.1	47.5	43.0	33.1	31.1	28.4	33.7	20.0	35.8	25.4	24.2	29.2	47.2	49.0	33.2	20.0 - 49.0
7. Percent non-indigenous species	3.7	6.9	12.6	6.7	8.5	0.3	43.2	2.7	15.9	24.7	34.2	9.9	18.9	10.8	25.0	31.3	49.1	49.4	18.9	0.3 - 49.4
8. Number of top carnivore species	9	11	8	10	11	11	11	9	8	11	10	12	11	12	11	10	11	13	10	8 - 13
9. Percent top carnivores	30.0	17.2	18.6	13.9	27.6	4.7	17.1	19.2	19.5	17.2	15.4	19.1	10.6	14.4	15.0	13.0	23.8	37.5	17.3	4.7 - 37.5
10. Percent omnivores	43.3	53.9	19.5	52.0	34.6	33.0	24.2	20.7	36.9	39.5	37.6	36.4	40.7	39.2	14.4	21.6	16.8	12.6	34.0	12.6 - 53.9
11. Average number per run	16.9	26.6	27.5	17.4	24.4	73.6	43.9	44.6	25.0	43.4	46.1	39.1	75.8	28.6	47.4	21.5	59.4	46.1	38.5	16.9 - 75.8
12. Percent anomalies	0.0	1.7	2.0	0.7	1.7	0.1	0.7	1.6	0.8	0.9	0.6	0.5	0.4	2.7	0.8	1.9	0.7	0.9	1.0	0 - 2.7

Table 3. Statistical analyses of RFAI scores, observed values for each RFAI metric, and species and abundances of trophic guilds and tolerant fish collected upstream (TRM 295.9) and downstream (TRM 292.5) of Browns Ferry Nuclear Plant during 2000 through 2020

	Mean		Standard Deviation			
	Upstream (TRM 295.9)	Downstream (TRM 292.5)	Upstream (TRM 295.9)	Downstream (TRM 292.5)	P-value	Significant Difference?
RFAI Score	42.7	40.9	3.7	3.1	0.14	No
1. Number of species	29.5	27.2	3.2	2.5	0.03	Yes
2. Number of centrarchid species (excluding *Micropterus* spp.)	6.3	5.5	1.2	1.2	0.04	Yes
3. Number of benthic invertivores	4.6	4.6	1.2	0.8	0.53	No
4. Number of intolerant species	5.4	4.9	0.6	1.0	0.05	Yes
5. Percent tolerant individuals	41.2	35.1	13.4	12.3	0.18	No
6. Percent dominance by one species	34.2	37.5	9.6	11.3	0.37	No
7. Percent non-indigenous species	20.7	27.9	15.8	17.7	0.22	No
8. Number of top carnivore species	10.6	9.0	1.3	1.4	0.002	Yes
9. Percent top carnivores	18.5	12.7	7.7	5.9	0.02	Yes
10. Percent omnivores	32.7	26.7	12.5	9.3	0.12	No
11. Average number per run	39.0	49.1	18.1	19.7	0.23	No
12. Percent anomalies	1.0	0.8	0.7	0.7	0.33	No
Number of insectivore species	7.2	6.9	1.6	1.1	0.48	No
Number of omnivore species	5.6	5.2	0.9	0.7	0.09	No
Number of planktivore species	1.1	0.9	0.7	0.3	0.35	No
Number of benthic invertivore individuals	55.2	65.8	44.3	65.2	0.82	No
Number of insectivore individuals	152.2	232.5	47.9	123.6	0.05	Yes
Number of omnivore individuals	300.7	317.9	180.4	171.9	0.59	No
Number of planktivore individuals	97.1	84.4	218.8	203.2	0.86	No
Number of top carnivore individuals	146.8	134.9	52.0	65.5	0.36	No
Total number of individuals	754.6	833.5	398.2	328.8	0.40	No
Number of tolerant species	7.5	7.2	1.6	1.5	0.58	No
Number of tolerant individuals	375.4	422.2	210.3	251.5	0.59	No

β - Comparing two population means from normally distributed independent samples. n1=n2=15, degree of freedom=n1+n2-2=28, α=0.05, tα/2=2.048. H_o: $\mu 1=\mu 2$; H_o rejected if t>tα/2.

γ - Non-parametric Wilcoxon Rank Sum test on large independent samples. α=0.05, zα/2=1.96. H_o: two sampled populations have identical probability distributions. Ho rejected if P<α or |z|>zα/2

Table 4. Numbers of indigenous species and individuals of each trophic guild represented in fish collected upstream ("U"; TRM 295.9) and downstream ("D"; TRM 292.5) of BFN during spring 2007 and autumn 2000-2011, 2013, 2015, 2017, 2019, and 2020

		Number of Species								Number of Individuals							
Year	Site	BI	HB	IN	OM	PK	PS	TC	Total	BI	HB	IN	OM	PK	PS	TC	Total
2000	D	6	--	5	4	--	--	8	23	25	--	126	136	--	--	87	374
	U	6	--	4	4	--	--	9	23	13	--	93	172	--	--	123	401
2001	D	5	1	7	5	1	--	8	27	49	1	128	149	2	--	79	408
	U	3	--	8	6	1	--	11	29	54	--	86	346	13	--	111	610
2002	D	5	--	6	6	1	--	8	26	26	--	320	319	43	--	152	860
	U	4	--	6	6	2	--	8	26	20	--	142	129	176	--	122	589
2003	D	4	1	8	4	1	--	10	28	31	1	232	247	1	--	117	629
	U	4	--	7	5	2	--	10	28	25	--	94	217	2	--	66	404
2004	D	6	--	6	5	1	1	8	27	47	--	498	155	1	1	125	827
	U	7	--	6	7	--	--	11	31	56	--	125	205	--	--	159	545
2005	D	5	1	7	5	1	--	7	26	58	2	105	264	793	--	119	1,341
	U	7	1	7	5	1	--	11	32	56	2	210	611	874	--	88	1,841
2006	D	4	--	8	5	1	--	9	27	39	--	142	240	1	--	266	688
	U	4	--	8	5	1	--	11	31	55	--	107	259	2	--	180	603
Spring 2007	D	8	--	6	4	1	--	10	29	119	--	412	175	15	--	349	1,070
	U	3	--	7	4	1	--	9	24	32	--	242	228	369	--	214	1,085
2007	D	5	--	6	5	1	--	9	26	53	--	123	439	3	--	120	738
	U	3	--	8	5	1	--	8	25	30	--	135	221	1	--	117	504
2008	D	5	1	6	5	--	--	10	29	29	1	306	416	1	--	308	1,061
	U	4	--	7	5	1	--	11	28	47	--	162	444	4	--	253	910
2009	D	3	--	8	5	1	--	9	26	45	--	190	467	16	--	187	905
	U	4	--	6	5	1	--	10	26	28	--	111	429	14	--	177	759
2010	D	5	--	6	5	--	1	10	27	28	--	201	623	--	1	127	980
	U	4	--	5	7	1	1	12	30	156	--	188	372	2	1	193	912
2011	D	4	--	6	6	1	1	9	27	46	--	485	724	240	1	108	1,604
	U	4	1	6	6	1	--	11	29	28	1	241	776	303	--	210	1,559
2013	D	4	--	9	5	1	--	8	27	80	--	257	226	12	--	71	646
	U	5	--	9	6	1	--	12	33	76	--	161	274	23	--	103	637
2015	D	5	1	8	6	1	--	10	31	197	1	212	407	305	--	110	1,232
	U	5	1	10	7	--	--	11	34	163	3	196	169	192	--	178	901
2017	D	5	--	8	7	1	1	11	33	43	--	118	263	7	1	119	551
	U	4	1	8	5	2	--	10	30	54	1	130	113	2	--	69	369
2019	D	4	--	6	5	1	--	7	23	256	--	153	157	4	--	55	625
	U	5	--	10	7	1	--	11	34	84	--	213	239	40	--	180	756
2020	D	4	--	7	6	1	--	12	30	22	--	356	173	5	--	144	700
	U	5	1	8	6	1	1	13	35	28	1	194	136	2	1	166	528
AUT AVG	D	5	1	7	5	1	1	9	27	66	1	225	327	102	1	134	842
2000-2019	U	5	1	7	6	1	1	11	29	59	2	150	311	118	1	146	769

*BI-benthic invertivore; HB-herbivore; IN-insectivore; OM-omnivore; PK-planktivore; PS-parasitic; TC-top carnivore; D-downstream; U-upstream

Table 5. Numbers of indigenous species and total mean densities per square meter (m²) of each functional feeding group[1] represented in benthic macroinvertebrates collected downstream and upstream (TRM 292.5) of BFN for years sampled, 2001-2004, 2006, 2011, 2012, 2013, 2015, 2017, and 2020

		2001		2002		2003		2004		2006		2011			2013			2015			2017			2020				
		TRM 291.7	TRM 295.9	TRM 291.7	TRM 295.9	TRM 291.7	TRM 295.9	TRM 291.7	TRM 295.9	TRM 291.7	TRM 295.9	TRM 290.4	TRM 293.2	TRM 295.9	TRM 290.4	TRM 293.2	TRM 295.9	TRM 290.4	TRM 293.2	TRM 295.9	TRM 290.4	TRM 293.2	TRM 295.9	TRM 290.4	TRM 293.2	TRM 295.9	Average	
		D	U	D	U	D	U	D	U	D	U	D	D	U	D	D	U	D	D	U	D	D	U	D	D	U	D	U
# Species	CF	3	2	2	2	2	2	3	3	5	2	3	5	4	4	1	4	4	2	3	1	4	3	5	4	3	3	3
	CG	6	6	4	6	4	4	5	3	10	7	8	23	15	5	10	8	7	14	8	9	9	7	6	6	7	8	7
	PA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0.1	0
	PR	3	4	3	5	3	7	3	5	10	7	8	9	9	8	10	11	9	11	7	7	10	6	8	9	7	7	7
	SC	6	6	5	6	3	7	5	3	6	5	3	5	1	2	5	6	4	4	5	5	3	5	6	5	7	4	5
	SH	0	1	0	0	0	1	0	0	1	1	1	2	2	0	1	2	0	2	1	2	0	1	1	2	2	1	1
	PI	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0.1	0.1
	Sum	**18**	**19**	**14**	**19**	**12**	**21**	**16**	**14**	**32**	**22**	**23**	**44**	**32**	**19**	**27**	**31**	**24**	**34**	**24**	**24**	**26**	**22**	**26**	**27**	**26**	**24**	**23**
Total Mean Density/m²	CF	62	28	15	38	155	60	70	63	60	57	150	208	265	183	233	122	107	197	345	282	470	400	152	187	218	169	160
	CG	207	152	142	115	660	235	307	120	282	160	105	440	373	608	618	437	345	468	322	678	958	300	332	413	353	438	257
	PA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0.1	0.0
	PR	212	210	248	148	133	132	170	72	335	277	280	215	322	153	367	243	355	320	293	502	352	155	328	287	223	284	208
	SC	62	40	10	73	322	57	92	48	95	140	7	13	17	10	125	75	12	28	58	32	60	33	70	55	37	66	58
	SH	0	2	0	0	0	2	0	0	18	20	3	30	107	0	3	5	0	10	65	3	0	3	2	3	10	5	21
	PI	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0.1	0.2
	Sum	**543**	**432**	**415**	**374**	**1270**	**486**	**639**	**303**	**790**	**654**	**545**	**906**	**1086**	**954**	**1346**	**882**	**819**	**1025**	**1083**	**1497**	**1840**	**891**	**884**	**947**	**841**	**961**	**703**
% Composition	% CF	11	6	4	10	12	12	11	21	8	9	28	23	24	19	17	14	13	19	32	19	26	45	17	20	26	16	20
	% CG	38	35	34	31	52	48	48	40	36	24	19	49	34	64	46	50	42	46	30	45	52	34	38	44	42	43	37
	% PA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0.0	0.0
	% PR	39	49	60	40	10	27	27	24	42	42	51	24	30	16	27	28	43	31	27	34	19	17	37	30	27	33	31
	% SC	11	9	2	20	25	12	14	16	12	21	1	1	2	1	9	9	1	3	5	2	3	4	8	6	4	7	10
	% SH	0	0.5	0	0	0	0.4	0	0	2	3	0.6	3	10	0	0.2	1	0	1.0	6	0.2	0	0.3	0.2	0.3	1	1	2
	% PI	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0.2	0	0	0	0	0	0	0	0.0	0.0

[1]Functional Feeding Groups: CF-collector/filterer; CG-collector/gatherer; PA-parasitic; PR-predator; SC-scraper; SH-shredder; PI-piercer

Microcrustaceans - Ostracoda, Copepoda, and Cladocera, and Insect family Chaoboridae as well as taxa considered to be nonindigenous are not included

Table 6. Results of Tukey's Studentized Range Test* on means select RFAI metrics (gears combined) for fish collected downstream (TRM 292.5) and upstream (TRM 295.9) of Browns Ferry Nuclear Plant during autumn 2006, spring 2007, and autumn 2007

Metrics	Downstream			Upstream		
	Autumn 2006	Spring 2007	Autumn 2007	Autumn 2006	Spring 2007	Autumn 2007
RFAI Score	42	44	42	41	42	39
Number of Indigenous Spp	11.3 A	13.1 A	10.3 A	9.3 A	10.9 A	8.3 A
Abundance (# individuals)	45.2 A	71.1 B	47.6 A	39.9 A	72.3 A	33.6 A
Number of Non-Indigenous Spp	0.1 B	0.7 A	0.9 A	0.0 B	0.6 A	0.9 A
Number of Benthic Invertivore Spp	1.4 B	2.5 A	1.3 B	1.5 A	1.4 A	1.2 A
Number of Intolerant Spp	2.3 B	3.3 A	2.3 B	1.7 A	2.2 A	1.3 A
Percent Individuals as Omnivores	14.3 B	14.5 B	45.7 A	22.7 A	31.2 A	34.0 A
Percent Individuals as Tolerant	17.9 B	48.6 A	48.0 A	34.2 A	47.9 AB	57.9 B

*Values with different letters are significantly different (alpha=0.05)

Table 7. Individual observed (Obs.) values and metric scores and overall benthic macroinvertebrate index scores (lab-processed) for upstream and downstream sampling sites near Browns Ferry Nuclear Plant, Wheeler Reservoir, autumn 2006 and spring 2007

	Upstream (TRM 295.9)				Downstream (TRM 291.7)			
	Autumn 2006		Spring 2007		Autumn 2006		Spring 2007	
Metric	**Obs**	**Rating**	**Obs**	**Rating**	**Obs**	**Rating**	**Obs**	**Rating**
1. Average number of taxa	5.9	5	6.9	5	6.2	5	5.7	5
2. Proportion of samples with long-lived organisms	0.8	5	1.0	5	1.0	5	1.0	5
3. Average number of EPT taxa	0.7	3	0.8	5	1.1	5	1.3	5
4. Average proportion of oligochaete individuals	7.0	5	10.1	5	2.3	5	10.9	5
5. Average proportion of total abundance comprised by the two most abundant taxa	75.0	5	63.3	5	77.3	5	75.5	5
6. Average density excluding chironomids and oligochaetes	348.3	3	270.0	1	272.3	1	210.0	1
7. Zero-samples – proportion of samples containing no organisms	0	5	0	5	0	5	0	5
Benthic Index Score		**31**		**31**		**31**		**31**
Ecological Health Rating		**Excellent**		**Excellent**		**Excellent**		**Excellent**

Reservoir Benthic Index Score Range: 7-12 (“Very Poor”), 13-18 (“Poor”), 19-23 (“Fair”), 24-29 (“Good”), 30-35 (“Excellent”)

Table 8. Numbers of indigenous fish species and individuals with upper incipient lethal limits (UILT) of 95 °F to 102 °F (considered "heat tolerant") collected upstream (TRM 295.9) and downstream (TRM 292.5) of Browns Ferry Nuclear Plant during autumn 2000-2011, 2013, 2015, 2017, 2019, and 2020

	Number of Species		Number of Individuals	
	Downstream	**Upstream**	**Downstream**	**Upstream**
2000	10	8	215	198
2001	11	10	261	383
2002	11	12	639	265
2003	11	13	382	295
2004	11	11	322	292
2005	11	11	384	719
2006	12	13	464	333
Spring 2007	10	10	599	475
2007	11	11	555	327
2008	11	13	792	645
2009	12	11	643	533
2010	11	12	845	547
2011	11	12	1,214	1,007
2013	10	14	476	421
2015	12	13	620	378
2017	14	14	382	222
2019	10	14	296	465
2020	13	14	464	325
Autumn AVG (2000-2019)	**11**	**12**	**531**	**439**

Note: UILTs known for 72% (41 of 57) of indigenous fish species (Table 12) collected at BFN during 2000-2020 and sourced from Yoder et al. (2006)

Table 9. Relative abundance of fish considered "heat tolerant" (upper incipient lethal limits of 95-102 °F) and "heat sensitive" (upper incipient lethal limits ≤ 91 °F) collected upstream (TRM 295.9) and downstream (TRM 292.5) of BFN during autumn 2000-2011, 2013, 2015, 2017, 2019 and 2020

	Relative Abundance of Heat-Tolerant Species		Relative Abundance of Heat-Sensitive Species	
Year	**Downstream**	**Upstream**	**Downstream**	**Upstream**
2000	57.5	49.4	17.4	19.7
2001	63.8	62.7	16.1	16.5
2002	74.3	45.0	2.3	3.6
2003	60.7	73.0	21.1	9.2
2004	38.9	53.6	45.3	18.3
2005	28.6	39.1	2.3	8.3
2006	67.4	55.2	4.9	9.6
Spring 2007	56.0	43.8	6.1	1.8
2007	75.2	64.9	1.2	2.2
2008	74.6	70.9	1.3	2.3
2009	71.0	70.2	0.2	0.9
2010	86.1	60.0	0.7	15.1
2011	75.7	64.6	1.1	1.3
2013	73.5	65.8	6.0	9.5
2015	50.3	41.8	15.2	17.9
2017	69.3	60.2	3.1	11.7
2019	47.4	62.2	33.3	6.3
2020	61.5	54.9	6.8	11.8
Autumn AVG	**63.4**	**58.7**	**10.7**	**9.5**

Table 10. List of indigenous fish species occurring in the vicinity of Browns Ferry Nuclear Plant based on sampling during 2000-2011, 2013, 2015, 2017, 2019 and 2020, upper incipient lethal limits (UILT) from Yoder et.al. (2006), and thermal tolerance designations (heat sensitive/ intermediate/ heat tolerant) used to achieve results in Tables 10 and 11

Common Name	UILT (°F)	Thermal Tolerance Designation
Logperch	87	Heat Sensitive
Spotted sucker	88	Heat Sensitive
Emerald shiner	90	Heat Sensitive
Bluntnose minnow	90	Heat Sensitive
Mooneye	90	Heat Sensitive
Northern hog sucker	91	Heat Sensitive
Sauger	91	Heat Sensitive
Walleye	91	Heat Sensitive
Warmouth	91	Heat Sensitive
White crappie	91	Heat Sensitive
Freshwater drum	92	Intermediate
Golden redhorse	92	Intermediate
Striped shiner	92	Intermediate
Central stoneroller	92	Intermediate
Smallmouth redhorse	92	Intermediate
Golden shiner	93	Intermediate
Black crappie	94	Intermediate
Mimic shiner	94	Intermediate
Largemouth bass	94	Intermediate
Redear sunfish	94	Intermediate
Skipjack herring	94	Intermediate
Smallmouth bass	94	Intermediate
Bowfin	95	Heat Tolerant
Quillback	95	Heat Tolerant
Brook silverside	95	Heat Tolerant
Gizzard shad	96	Heat Tolerant
Green sunfish	96	Heat Tolerant
Orangespotted sunfish	96	Heat Tolerant
White bass	96	Heat Tolerant
Longear sunfish	97	Heat Tolerant
Spotfin shiner	97	Heat Tolerant
Spotted bass	97	Heat Tolerant
Bigmouth buffalo	98	Heat Tolerant
Bluegill	98	Heat Tolerant
Blue catfish	99	Heat Tolerant
Smallmouth buffalo	99	Heat Tolerant
Bullhead minnow	99	Heat Tolerant
Flathead catfish	100	Heat Tolerant
Longnose gar	100	Heat Tolerant
Channel catfish	101	Heat Tolerant

Table 10. (continued)

Common Name	UILT (°F)	Thermal Tolerance Designation
Shortnose gar	102	Heat Tolerant
Black buffalo	No UILT data	
Black redhorse	No UILT data	
Chestnut lamprey	No UILT data	
Lake sturgeon	No UILT data	
Largescale stoneroller	No UILT data	
Silver redhorse	No UILT data	
Blackside snubnose darter	No UILT data	
Spotted gar	No UILT data	
Threadfin shad	No UILT data	
Yellow bass	No UILT data	
Blackspotted topminnow	No UILT data	
River redhorse	No UILT data	
Saddleback darter	No UILT data	
Silver chub	No UILT data	
River darter	No UILT data	
Stripetail darter	No UILT data	

***Heat sensitive – UILTs ≤ 91 °F; Intermediate – UILTs 92–94 °F; Heat tolerant – UILTs ≥ 95 °F**

Table 11. Numbers of non-indigenous fish species and individuals collected upstream (TRM 295.9) and downstream (TRM 292.5) of BFN during spring 2007 and autumn 2000–2011, 2013, 2015, 2017, 2019 and 2020

	Number of Species		Number of Individuals	
	Downstream	**Upstream**	**Downstream**	**Upstream**
2000	1	4	1	21
2001	3	4	27	46
2002	2	4	262	88
2003	2	4	43	29
2004	3	4	199	50
2005	2	2	29	5
2006	4	3	1,214	456
Spring 2007	3	3	82	30
2007	2	3	309	95
2008	2	4	888	268
2009	3	3	640	394
2010	2	5	731	98
2011	3	2	282	358
2013	3	3	326	74
2015	3	3	557	293
2017	2	4	402	168
2019	4	5	337	730
2020	2	2	365	576
Autumn AVG	**3**	**4**	**390**	**198**

Table 12. List of non-indigenous fish species occurring in the vicinity of BFN based on seasonal sampling during spring 2007 and autumn 2000–2011, 2013, 2015, 2017, 2019 and 2020, and associated upper incipient lethal limits (UILT) from Yoder et.al. (2006)

Common Name	UILT (°F)	Thermal Tolerance Designation
Striped bass	90	Heat Sensitive
Yellow perch	91	Heat Sensitive
Hybrid striped bass x white bass	98	Heat Tolerant
Common carp	99	Heat Tolerant
Grass carp	99	Heat Tolerant
Atlantic needlefish	No UILT data	
Mississippi silverside	No UILT data	
Redbreast sunfish	No UILT data	

***Heat sensitive – UILTs ≤ 91 °F; Heat tolerant – UILTs ≥ 95 °F**

Table 13. Records of federal and state-listed aquatic animal species known within a 10-mile radius of Browns Ferry Nuclear Plant (TRM 294)[1]

Scientific Name	Common Name	Element Rank[2]	Federal Status[3]	State Status[3]	State Rank[4]
FISH					
Hybopsis amblops	Bigeye Chub	E		TRKD	S3
Hemitremia flammea	Flame Chub	BC		TRKD	S3
Polyodon spathula	Paddlefish	H		PROT	S3
Etheostoma rufilineatum	Redline Darter	E		TRKD	S3
Moxostoma anisurum	Silver Redhorse	E		TRKD	S2
Typhlichthys subterraneus	Southern Cavefish	E		PROT	S3
Elassoma alabamae	Spring Pygmy Sunfish	A?	LT	PROT	S1
Elassoma alabamae	Spring Pygmy Sunfish	E	LT	PROT	S1
Phenacobius uranops	Stargazing Minnow	E		TRKD	S1
Etheostoma tuscumbia	Tuscumbia Darter	E		PROT	S2
AMPHIBIANS					
Cryptobranchus alleganiensis	Hellbender	E	PS	PROT	S2
MUSSELS					
Epioblasma haysiana	Acornshell	H		EXTI	SH
Lemiox rimosus	Birdwing Pearlymussel	X	LE	PROT	SX
Hemistena lata	Cracking Pearlymussel	X	LE	PROT	SX
Epioblasma brevidens	Cumberlandian Combshell	H	LE	PROT	S1
Dromus dromas	Dromedary Pearlymussel	X	LE	PROT	S1
Ptychobranchus subtentum	Fluted Kidneyshell	H	LE	PROT	SX
Toxolasma parvum	Lilliput	H		TRKD	S3
Pleurobema cordatum	Ohio Pigtoe	E		TRKD	S2
Lampsilis abrupta	Pink Mucket	E	LE	PROT	S1
Potamilus ohiensis	Pink Papershell	E		TRKD	S3
Toxolasma lividus	Purple Lilliput	E		TRKD	S2
Obovaria retusa	Ring Pink	X	LE	PROT	S1
Pleurobema plenum	Rough Pigtoe	E	LE	PROT	S1
Cumberlandia monodonta	Spectaclecase	E	LE	PROT	S1
Epioblasma torulosa torulosa	Tuberculed Blossom Pearlymussel	X	LE	PROT	SX
Lasmigona complanata	White Heelsplitter	H		TRKD	S2S3
SNAILS					
Elimia nassula	Round-rib Elimia	E		TRKD	S1
Pleurocera pyrenella	Skirted Hornsnail	E		TRKD	S2
Lithasia lima	Warty Rocksnail	H		HIST	SH
Campeloma decampi	Slender Campeloma	E	LE	PROT	S1

[1] Source: TVA Natural Heritage Database, queried on 03/25/2021

[2] Heritage Element Occurrence Rank: E=Verified extant (viability not assessed); BC=Good or fair estimated viability; A?=Possibly excellent estimated viability; H = historical record ≥25years old; X=Extirpated; Xr=Extirpated but reintroduction underway from outside of state (Georgia).

[3] Status Codes: LE or END = Listed Endangered; R = Rare, Not State-listed; D = Deemed in Need of Management; PS=Partial status (population has federal status but entire species does not-status is only in a portion of the species rang); PROT=State Protected; TRKD=Not protected by State, but tracked; EXTI=Extirpated; HIST=Historical record

[4] State Ranks: S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; SH = Of Historical occurrence in Tennessee; SX=Presumed extirpated.

Table 14. Wildlife observed during visual surveys conducted upstream (TRM 295.9) and downstream (TRM 292.5) of Browns Ferry Nuclear Plant, 2011 through 2020

	TRM 295.9 RDB				TRM 295.9 LDB				TRM 292.5 RDB				TRM 292.5 LDB			
Species Observed	**2011**	**2013**	**2015**	**2020**	**2011**	**2013**	**2015**	**2020**	**2011**	**2013**	**2015**	**2020**	**2011**	**2013**	**2015**	**2020**
Birds																
American crow	6	1	8							1						
American coot				40				75	6	4	1	25				75
American robin		1	6							2	5					
Bald eagle											1				2	
Belted kingfisher	1	4	5		2	1			1	3				2		
Blue jay		5	8				3			5	3			1		
Brown thrasher		1														
Canada goose												10				
Carolina chickadee		1									2					
Carolina wren							1									
Common flicker			2													
Common grackle									20		150					
Common snipe						1										
Double-crested cormorant	1	2		100			4	60				15			1	34
Downy Woodpecker										2						
European starling			230							10	30					
Golden eagle											3					
Great blue heron	4	6	5	2	4	2	5		6	2	5	3	5	4	4	
Least flycatcher														1		
Killdeer						2										
Mallard	5	2	1			12			7	2	2		8			
Mockingbird		1	3											2		
Osprey															1	
Pied-billed grebe														2	2	
Pileated Woodpecker						1					1					
Red-tailed hawk															1	
Ring-billed gull						1		12								
Sanderling					2											
Turkey vulture						2				2						
Unspecified perching bird	1	1	3			8			2	2	3		5	3		
White pelican				12			11									
White-breasted nuthatch										1						
Wood duck									8				4			
Reptile/Amphibian																
Map Turtle		37	22			26	29			2				69	26	
Painted turtle							1									
Unspecified turtle					20											
Mammals																
Eastern grey squirrel		2														
Total Birds	18	25	271	154	8	30	24	147	50	36	206	53	22	15	11	109
Bird Species	6	11	10	4	3	9	5	3	7	12	12	4	4	7	6	2
Total Rept/Amph	--	37	22	--	20	26	30	--	--	2	--	--	--	69	26	--
Rept/Amph Species	--	1	1	--	1	1	2	--	--	1	--	--	--	1	1	--
Total Mammals	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mammal Species	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 15. SAHI scores for shoreline habitat assessments conducted within the RFAI sample reach upstream of Browns Ferry Nuclear plant, autumn 2020

Left Descending Bank	Transects								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
SAHI Variables									
Cover	5	3	5	3	5	3	5	3	**4**
Substrate	5	5	5	5	5	5	1	5	**5**
Erosion	1	1	1	1	1	1	1	1	**1**
Canopy Cover	5	5	5	5	5	5	5	5	**5**
Riparian Zone	3	5	5	5	5	5	5	5	**5**
Habitat	5	3	5	3	5	3	3	3	**4**
Slope	5	5	5	5	5	5	5	5	**5**
Total Rating	29 Good	27 Good	31 Good	27 Good	31 Good	27 Good	25 Good	27 Good	**28 Fair**

Right Descending Bank	Transects								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
SAHI Variables									
Cover	3	5	3	1	5	1	3	1	**3**
Substrate	1	5	5	1	5	5	5	5	**4**
Erosion	5	1	3	3	1	3	3	3	**3**
Canopy Cover	5	5	3	3	5	1	3	3	**4**
Riparian Zone	3	5	1	1	5	1	1	1	**2**
Habitat	1	5	1	1	5	1	1	1	**2**
Slope	3	5	1	1	5	1	1	5	**3**
Total Rating	21 Fair	31 Good	17 Fair	11 Poor	31 Good	13 Poor	17 Fair	19 Fair	**20 Fair**

Scoring criteria: poor (7-16), fair (17-26), good (27-35)

Table 16. SAHI scores for shoreline habitat assessments conducted within the RFAI sample reach downstream of Browns Ferry Nuclear plant, autumn 2020

Left Descending Bank	Transects								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
SAHI Variables									
Cover	3	3	3	3	3	5	5	1	**3**
Substrate	3	1	1	5	5	5	5	5	**4**
Erosion	1	3	3	1	1	1	1	5	**2**
Canopy Cover	5	5	5	5	5	5	5	1	**5**
Riparian Zone	5	5	5	5	5	5	3	1	**4**
Habitat	3	1	1	1	3	5	3	1	**2**
Slope	5	5	5	5	5	5	5	1	**5**
Total Rating	25 Fair	23 Fair	23 Fair	25 Fair	27 Good	31 Good	27 Good	17 Fair	**25 Fair**

Right Descending Bank	Transects								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
SAHI Variables									
Cover	3	3	3	3	5	3	3	5	**4**
Substrate	1	3	3	1	1	3	1	5	**2**
Erosion	3	1	1	1	1	1	3	1	**2**
Canopy Cover	5	5	1	5	3	3	1	1	**3**
Riparian Zone	5	5	1	5	3	3	1	1	**3**
Habitat	1	1	3	3	3	3	1	3	**2**
Slope	5	5	4	5	1	1	1	1	**3**
Total Rating	23 Fair	23 Fair	17 Fair	23 Fair	17 Fair	17 Fair	11 Poor	17 Fair	**19 Fair**

Scoring criteria: poor (7-16), fair (17-26), good (27-35)

Table 17. Substrate percentages and average water depth (ft) per transect upstream and downstream of BFN, autumn 2020

% Substrate per transect upstream of BFN									
Substrate Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Silt	53.5	35.5	37.5	42.0	52.4	45.5	50.0	25.0	42.7
Mollusk	33.0	48.0	36.5	49.5	24.2	31.0	37.5	47.5	38.4
Gravel	2.5	16.5	10.0	5.0	3.6	5.0	6.0	1.0	6.2
Cobble	--	--	10.0	--	0.0	7.0	4.5	26.0	5.9
Bedrock	9.0	--	--	--	14.0	10.0	--	--	4.1
Detritus	2.0	--	6.0	3.5	3.3	--	0.5	--	1.9
Wood	--	--	--	--	1.2	1.5	1.5	--	0.5
Sand	--	--	--	--	1.3	--	--	--	0.2
Clay	--	--	--	--	--	--	--	0.5	0.1
Average Depth (ft)	14.7	12.6	12.2	12.2	13.6	15.7	12.4	11.5	13.1
Actual Depth Range: 3 – 44									

% Substrate per transect downstream of BFN									
Substrate Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Silt	60.5	63.0	79.5	77.0	66.5	50.5	49.0	49.5	61.9
Mollusk	27.0	31.0	16.5	17.5	30.0	43.5	45.0	30.5	30.1
Detritus	8.5	6.0	4.0	4.5	3.5	3.5	1.0	7.5	4.8
Gravel	0.5	--	--	0.5	--	2.5	3.5	5.0	1.5
Wood	3.0	--	--	0.5	--	--	1.5	4.0	1.1
Sand	--	--	--	--	--	--	--	2.0	0.3
Bedrock	0.5	--	--	--	--	--	--	1.5	0.3
Average Depth (ft)	15.2	15.2	14.8	13.4	13.4	13.5	14.8	14.3	14.3
Actual Depth Range: 3 – 26									

Table 18. Depth profiles of water temperature (°F) collected to determine the extent of the thermal plume* discharged from TVA's Browns Ferry Nuclear Plant during autumn 2020

	Transect and Profile Location (% from right descending bank)																									
	Ambient-TRM 295.2					BFN Discharge-TRM 239.9					Mid-Plume-TRM 293.0					End of Plume-TRM 291.9					Below Plume-TRM 291.0				
Depth (m)	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%
November 2020																									
0.3	65.7	64.8	64.4	64.7	64.9	72.5	71.6	69.4	64.7	64.8	68.0	69.9	68.2	64.9	66.2	67.9	68.1	68.2	66.9	66.0	67.6	67.6	67.8	67.0	65.4
1.5	65.6	64.8	64.4	64.7	64.9	71.8	68.6	68.8	64.7	64.8	67.1	67.3	67.3	64.8	65.5	67.7	68.0	68.2	66.9	65.7	67.5	67.5	67.8	67.0	65.4
2	65.4	64.8	64.4	64.7	64.9	70.0	68.3	67.2	64.7	64.8	66.8	66.9	66.9	64.8		67.6	68.0	68.2	66.6	65.7	67.5	67.4	67.7	66.9	
3	65.3		64.4	64.7	64.9	69.0	68.0	66.6			66.5	66.6	66.6	64.8		67.5	68.0	68.2	66.3	65.7	67.5	67.2	67.5	66.9	
4			64.4	64.7		69.0	67.7	66.6				66.5	66.2	64.8		67.5			66.2			66.9	67.4	66.8	
5			64.4	64.7		68.4	67.0	66.9				66.4	65.4			67.5			65.9			66.6			
6			64.4	64.7		68.0	66.5	66.8				66.4				67.5			65.8			66.6			
7			64.4	64.7			66.5	66.6								67.5									
8							67.0	66.3																	
9							66.1	66.3																	

*Shaded numbers represent temperatures 3.6 ˚F (2 °C) or greater above ambient temperature (i.e. "thermal plume").

Table 19. Water quality parameters collected during autumn 2020 along vertical depth profiles at three transects within biological sample reaches sited upstream and downstream of Browns Ferry Nuclear Plant

November 2020	LDB						Mid-Channel						RDB					
TRM 295.9	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**
Upstream Boundary	0.3	18.27	64.9	7.04	176.4	9.02	0.3	18.03	64.5	6.98	159.0	8.59	0.3	18.15	64.7	7.12	159.1	9.74
	1.5	18.22	64.8	7.04	177.2	9.01	1.5	17.99	64.4	6.99	159.3	8.54	1.09	17.92	64.3	6.92	160.2	9.30
	3	18.21	64.8	7.04	176.1	9.04	3	17.98	64.4	7.00	158.3	9.04						
	5	18.21	64.8	7.10	174.9	9.00	5	17.96	64.3	6.99	158.6	9.11						
							7	17.97	64.3	7.01	159.3	9.11						
							8	17.96	64.3	7.03	158.4	9.14						
Mid-reach	0.3	18.27	64.9	7.07	167.4	9.20	0.3	18.01	64.4	7.04	158.5	9.28	0.3	18.22	64.8	7.09	161.0	9.17
	1.5	18.25	64.9	7.08	168.4	9.17	1.5	17.99	64.4	7.04	157.9	9.27	1.5	18.21	64.8	7.07	161.0	9.20
	2.5	18.24	64.8	7.11	167.4	9.16	3	17.96	64.3	7.05	158.6	9.25	3	18.21	64.8	7.08	160.7	9.22
							5	18.00	64.3	7.05	157.9	9.30	3.5	18.21	64.8	7.14	160.8	9.22
							7	17.96	64.3	7.06	158.5	9.26						
							8	17.96	64.3	7.12	158.5	9.29						
Downstream Boundary	0.3	18.23	64.8	7.12	163.9	9.34	0.3	18.05	64.5	7.06	158.4	9.28	0.3	18.77	65.8	7.67	160.6	10.50
	1.5	18.21	64.8	7.11	164.2	9.32	1.5	18.02	64.4	7.06	158.7	9.27	1.5	18.74	65.7	7.67	160.3	10.47
	2.5	18.20	64.8	7.14	163.5	9.28	3	17.99	64.4	7.06	158.9	9.24	2.8	18.72	65.7	7.63	160.0	10.44
							5	17.99	64.4	7.06	159.0	9.26						
							7	17.99	64.4	7.08	158.1	9.26						
TRM 292.5	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**
Upstream Boundary	0.3	18.92	66.1	7.16	161.1	9.25	0.3	21.29	70.3	7.34	161.8	9.48	0.3	21.73	71.1	7.34	161.2	9.47
	1.5	18.71	65.7	7.15	160.9	9.23	1.5	20.13	68.2	7.28	160.3	9.49	1.5	20.24	68.4	7.30	160.8	9.51
	2	18.61	65.5	7.18	160.7	9.23	3	19.54	67.2	7.28	159.7	9.56	3	19.29	66.7	7.24	160.1	9.44
							5	19.22	66.6	7.26	159.6	9.53	5	19.12	66.4	7.24	160.7	9.44
							7	19.10	66.4	7.26	158.9	9.53	6	19.13	66.4	7.26	160.5	9.43
							9	19.07	66.3	7.26	159.6	9.54						
Mid-reach	0.3	18.55	65.4	7.22	171.7	9.25	0.3	19.49	67.1	7.17	160.3	9.28	0.3	19.8	67.7	7.3	159.9	9.6
	1.5	18.54	65.4	7.20	171.3	9.15	1.5	19.19	66.5	7.16	159.8	9.31	1.5	19.81	67.7	7.27	159.8	9.56
	3	18.50	65.3	7.19	170.9	9.15	3	18.88	66.0	7.15	159.3	9.26	3	19.80	67.6	7.28	159.8	9.51
	3.5	18.51	65.3	7.21	170.9	9.19	5	18.78	65.8	7.15	160.7	9.22						
							7	18.70	65.7	7.15	160.9	9.25						
							7.6	18.70	65.7	7.17	161.1	9.21						
Downstream Boundary	0.3	18.73	65.7	7.28	171.3	9.49	0.3	19.28	66.7	7.18	159.9	9.31	0.3	19.96	67.9	7.22	159.6	9.27
	1.5	18.69	65.6	7.27	170.6	9.49	1.5	19.29	66.7	7.18	160.3	9.31	1.5	19.96	67.9	7.2	160.0	9.3
	3	18.63	65.5	7.26	170.7	9.47	3	19.23	66.6	7.17	159.9	9.28	3	19.77	67.6	7.2	160.2	9.16
	3.6	18.62	65.5	7.26	169.7	9.46	5	19.19	66.5	7.16	160.5	9.31	3.8	19.63	67.3	7.18	160.2	9.1
							7	19.17	66.5	7.18	160.4	9.31						

Abbreviations: °C – Temperature (degrees Celsius), °F – Temperature (degrees Fahrenheit), Cond – Conductivity, DO – Dissolved Oxygen

APPENDICES

Appendix A. Field study design, sampling methods, and Reservoir Fish Assemblage Index methodology used by TVA to monitor biological communities in the vicinity of Browns Ferry Nuclear Plant during the period 2000-2011, 2013, 2015, 2017, 2019 and 2020

Evaluation of Plant Operating Conditions

Data describing the operation of BFN during the course of biological monitoring—specifically daily averages of power generation, water temperatures at the CCW system intake and discharge, and the flow rate of water through the CCW system—were collected, compiled, analyzed and compared to available historical operations data to assist in the interpretation of thermal plume characteristics and biological community information.

Aquatic Habitat in the Vicinity of BFN

Shoreline and river bottom habitat data presented in this report were collected during winter 2021 and autumn 2020, respectively. TVA assumes habitat data to be valid for five years, barring any major changes to the river/reservoir (e.g. major flood event). No significant changes have occurred in the river system from the initial characterization, but in the event of such a change, habitat will be re-evaluated during the following sample period.

Shoreline Aquatic Habitat Assessment

An integrative multi-metric index (Shoreline Aquatic Habitat Index or SAHI), including several habitat parameters important to resident fish species, was used to measure existing fish habitat quality in the vicinity of BFN. Using the general format developed by Plafkin et al. (1989), seven metrics were established to characterize selected physical habitat attributes important to reservoir resident fish populations which rely heavily on the littoral (shoreline) zone for reproductive success, juvenile development, and adult feeding (Table A-1). Habitat Suitability Indices (U.S. Fish and Wildlife Service), along with other sources of information on biology and habitat requirements (Etnier and Starnes 1993), were consulted to develop "reference" criteria or "expected" conditions from a high quality environment for each parameter. Some generalizations were necessary in setting up scoring criteria to cover the various requirements of all species into a single index.

When possible, the quality of shoreline aquatic habitat was assessed while traveling parallel to the shoreline in a boat and evaluating the habitat within 10 vertical feet of full pool. At each transect, near-shore aquatic habitat was assessed along sections of shoreline corresponding to the left descending bank (LDB) and right descending bank (RDB). For each shoreline section (16 upstream and 16 downstream of BFN), percentages of aquatic macrophytes in the littoral areas were estimated, then each section was scored by comparing the observed conditions associated with each individual metric to the "reference" conditions and assigning the observations a corresponding value: "Good" – 5; "Fair" – 3; or "Poor" – 1 (Table A-1). The scores for each of the seven metrics were summed to obtain the SAHI value for the shoreline section, and this value was assigned a habitat quality descriptor based on trisecting the range of potential SAHI values ("Poor", 7-16; "Fair", 17-26; and "Good", 27-35).

River Bottom Habitat

Along each transect described above, a benthic grab sample was collected with a Ponar dredge at each of ten points equally spaced from the LDB to the RDB. Transects were established across the width of Wheeler Reservoir within the fish community sampling reaches upstream and downstream of BFN (Figure 9). Substrate material collected with the Ponar was emptied into a screen, and percent composition of each substrate was estimated to determine existing benthic habitat across the width of the river. Water depths (feet) at each sample location were recorded (Figure 9). If no substrate was collected after multiple Ponar drops, it was assumed that the substrate was bedrock. For example, when the Ponar was pulled shut, collectors could feel substrate consistency. If it shut easily and was not embedded in the substrate on numerous drops within the same location, the substrate was recorded as bedrock.

Fish Community Sampling Methods and Data Analysis for Sites Upstream and Downstream of BFN

Thermal discharge from BFN enters Wheeler Reservoir in the Tennessee River at TRM 294.0 (Figure 2). To evaluate the fish community in the vicinity of BFN, two sample sites were selected. One site was centered in the transition zone of Wheeler Reservoir at TRM 295.9, upstream of the plant's intake (Figure 4), and served as a reference site unaffected by the thermal discharge. The second site was centered in the transition zone at TRM 292.5, downstream of the cooling water discharge (Figure 5). TVA's REH program monitors three additional sample areas on Wheeler Reservoir: Forebay, TRM 277.0; Inflow, TRM 348.0; and Elk River Embayment, ERM 6.0 (Figure 1).

Fish sampling methods utilized include boat electrofishing and gill netting (Hubert 1996; Reynolds 1996). Electrofishing methodology consisted of fifteen boat electrofishing runs near the shoreline, each 300 meters long and of approximately 10 minutes duration. The total near-shore area sampled was approximately 4,500 meters (15,000 feet).

Experimental gill nets (so called because of their use for research as opposed to commercial fishing) were used as an additional gear type to collect fish from deeper habitats not effectively sampled by electrofishing. Each experimental gill net consists of five 6.1 meter panels for a total length of 30.5 meters (100.1 feet). The distinguishing characteristic of experimental gill nets is mesh size that varies between panels. For this application, each net has panels with mesh sizes of 2.5, 5.1, 7.6, 10.2, and 12.7 cm. Experimental gill nets are typically set perpendicular to river flow, extending from near-shore to the main channel of the reservoir. Ten experimental gill nets were set overnight in each sample reach.

Fish collected were identified by species, counted, and examined for anomalies (such as disease, deformations, parasites or hybridization). The resulting data were analyzed using RFAI methodology.

The RFAI uses 12 fish community metrics from four general categories: Species Richness and Composition; Trophic Composition; Abundance; and Fish Health. Individual species can be utilized for more than one metric, though hybrid species and non-indigenous species are excluded from metrics counting numbers of individual species. Together, these 12 metrics provide a balanced evaluation of fish community integrity. The individual metrics are shown below, grouped by category:

Species Richness and Composition

(1) **Total number of species** – Greater numbers of species are considered representative of healthier aquatic ecosystems. As conditions degrade, numbers of species at an area decline.

(2) **Number of centrarchid species** – Sunfish species (excluding black basses) are invertivores and a high diversity of this group is indicative of reduced siltation and suitable sediment quality in littoral areas.

(3) **Number of benthic invertivore species** – Due to the special dietary requirements of this species group and the limitations of their food source in degraded environments, numbers of benthic invertivore species increase with better environmental quality.

(4) **Number of intolerant species** – A category of species that are particularly intolerant of physical, chemical, and thermal habitat degradation. Higher numbers of intolerant species suggest the presence of fewer environmental stressors.

(5) **Percentage of tolerant individuals** (excluding young-of-year) – An increased proportion of individuals tolerant of degraded conditions signifies poorer water quality.

(6) **Percent dominance by one species** – Ecological quality is considered reduced if one species inordinately dominates the resident fish community.

(7) **Percentage of non-indigenous species** – Based on the assumption that non-indigenous species reduce the quality of resident fish communities.

(8) **Number of top carnivore species** – Higher diversity of piscivores is indicative of the availability of diverse and plentiful forage species and the presence of suitable habitat.

Trophic Composition

(9) **Percent top carnivores** – A measure of the functional aspect of top carnivores which feed on major planktivore populations.

(10) **Percent omnivores** – Omnivores are less sensitive to environmental stresses due to their ability to vary their diets. As trophic links are disrupted due to degraded conditions, specialist species such as insectivores decline while opportunistic omnivorous species increase in relative abundance.

Abundance

(11) **Average number per run** (number of individuals) – Based on the assumption that high quality fish assemblages support large numbers of individuals.

Fish Health

(12) Percent anomalies – Incidence of diseases, lesions, tumors, external parasites, deformities, blindness, and natural hybridization is noted for all fish collected, with higher incidence indicating less favorable environmental conditions.

RFAI methodology addresses all four attributes or characteristics of a "balanced indigenous population" (BIP), defined by the CWA as described below:

(1) A biotic community characterized by diversity appropriate to the ecoregion: Diversity is addressed by the metrics in the Species Richness and Composition category, especially metric 1 – "Number of species." Determination of reference conditions based on the transition zones of lower mainstem Tennessee River reservoirs (as described below) ensures appropriate species expectations for the ecoregion.

(2) The capacity for the community to sustain itself through cyclic seasonal change: TVA uses an autumn data collection period for biological indicators, both REH and upstream/downstream monitoring. Autumn monitoring is used to document community condition or health after being subjected to the wide variety of stressors throughout the year.

One of the main benefits of using biological indicators is their ability to integrate stressors through time. Examining the condition or health of a community at the end of the "biological year" (i.e., autumn) provides insights into how well the community has dealt with the stresses through an annual seasonal cycle. Likewise, evaluation of the condition of individuals in the community (in this case, individual fish as reflected in Metric 12) provides insights into how well the community can be expected to withstand stressors through winter. Further, multiple sampling years during the permit renewal cycle add to the evidence of whether the autumn monitoring approach has correctly demonstrated the ability of the community to sustain itself through repeated seasonal changes.

(3) The presence of necessary food chain species: Integrity of the food chain is measured by the Trophic Composition metrics, with support from the Abundance metric and Species Richness and Composition metrics. A healthy fish community is comprised of species that utilize complex feeding mechanisms extending into multiple levels of the aquatic food web. Three dominant fish trophic levels exist within Tennessee River reservoirs: insectivores, omnivores, and top carnivores. To determine the presence of necessary food chain species, these three groups should be well represented within the overall fish community. Other fish trophic levels include benthic invertivores, planktivores, herbivores, and parasitic species. Insectivores include most sunfish, minnows, and silversides. Omnivores include gizzard shad, common carp, carpsuckers, buffalo, and channel and blue catfish. Top carnivores include bass, gar, skipjack herring, crappie, flathead catfish, sauger, and walleye. Benthic invertivores include freshwater drum, suckers, and darters. Planktivores include alewife, threadfin shad, and paddlefish. Herbivores include largescale stonerollers. Lampreys in the genus *Ichthyomyzon* are the only parasitic species occurring in Tennessee River reservoirs.

To establish expected proportions of each trophic guild and the expected number of species included in each guild occurring in transition zones in lower mainstem Tennessee River reservoirs (Kentucky, Pickwick, Wilson, Wheeler, and Guntersville reservoirs), data collected from 1993 to 2020 were analyzed for each reservoir zone (inflow, transition, forebay). Samples collected in the downstream vicinity of thermal discharges were not included in this analysis so that accurate expectations could

be calculated with the assumption that these data represent what should occur in lower mainstem Tennessee River reservoirs absent from point source effects (i.e. power plant discharges). Data from 1,245 electrofishing runs (a total of 560,250 meters of shoreline sampled) and from 830 overnight experimental gill net sets were included in this analysis. From these data, the range of proportional values for each trophic level and the range of the number of species included in each trophic level were trisected. These trisections were intended to show less than expected, expected, and above expected values for trophic level proportions and species occurring within each reservoir zone in lower mainstem Tennessee River reservoirs. The data were also averaged and bound by confidence intervals (95%) to further evaluate expectations for proportions of each trophic level and the number of species representing each trophic level (Table A-2).

(4) A lack of domination by pollution-tolerant species: Domination by pollution-tolerant species is determined by metrics 3 ("Number of benthic invertivore species"), 4 ("Number of intolerant species"), 5 ("Percent tolerant individuals"), 6 ("Percent dominance by one species"), and 10 ("Percent omnivores").

Scoring categories are based on "expected" fish community characteristics in the absence of human-induced impacts other than impoundment of the reservoir. These categories were developed from historical REH fish assemblage data representative of transition zones from lower mainstem Tennessee River reservoirs (Hickman and McDonough, 1996). Attained values for each of the 12 metrics were compared to the scoring criteria and assigned scores to represent relative degrees of degradation: least degraded (5); intermediately degraded (3); and most degraded (1). Scoring criteria for lower mainstem Tennessee River reservoirs are shown in Table A-3.

If a metric was calculated as a percentage (e.g., "Percent tolerant individuals"), the data from electrofishing and gill netting were scored separately and allotted half the total score for that individual metric. Individual metric scores for a sampling area (i.e., upstream or downstream) were summed to obtain the RFAI score for the area.

TVA uses RFAI results to determine maintenance of BIP using two approaches. One is "absolute" in that it compares the RFAI scores and individual metrics to predetermined values. The other is "relative" in that it compares RFAI scores attained downstream to scores at the upstream control site. The "absolute" approach is based on Jennings et al. (1995) who suggested that favorable comparisons of the RFAI score attained from the potential impact zone to a predetermined criterion can be used to identify the presence of normal community structure and function, and hence existence of BIP. For multi-metric indices, TVA uses two criteria to ensure a conservative screening of BIP. First, if an RFAI score reaches 70% of the highest attainable score of 60 (adjusted upward to include sample variability as described below), and second, if fewer than half of RFAI metrics receive a low (1) or moderate (3) score, then community structure and function are considered normal, indicating that BIP had been maintained and no further evaluation would be needed.

RFAI scores range from 12 to 60. Ecological health ratings (12-21 "Very Poor", 22-31 "Poor", 32-40 "Fair", 41-50 "Good", or 51-60 "Excellent") are then applied to scores. As discussed in detail below, the average variation for RFAI scores in TVA reservoirs is 6 (± 3). Therefore, any location that attains a RFAI score of 45 (75% of the highest score) or higher would be considered to have BIP. It must be stressed that scores below this threshold do not necessarily reflect an adversely impacted fish community. The threshold is used to serve as a conservative screening level; i.e., any fish community that meets these criteria is obviously not adversely impacted. RFAI scores below this

level require a more in-depth look to determine if BIP exists. An inspection of individual RFAI metric results and species of fish used in each metric are an initial step to help identify if operation of BFN is a contributing factor. This approach is appropriate because a validated multi-metric index is being used and scoring criteria applicable to the zone of study are available.

A comparison of RFAI scores from the area downstream of BFN to those from the upstream (control) area is one basis for determining if operation of the plant has had any impacts on the resident fish community. The definition of "similar" is integral to accepting the validity of these interpretations. The Quality Assurance (QA) component of the VS monitoring program deals with how well the RFAI scores can be repeated and is accomplished by collecting a second set of samples at 15%-20% of the areas each year. Comparison of paired-sample QA data collected over seven years shows that the difference in RFAI index scores ranges from 0 to 18 points. The mean difference between these 54 paired scores is 4.6 points with 95% confidence limits of 3.4 and 5.8. The 75th percentile of the sample differences is 6, and the 90th percentile is 12. Based on these results, a difference of 6 points or less in the overall RFAI scores is the value selected for defining "similar" scores between upstream and downstream fish communities. That is, if the downstream RFAI score is within 6 points of the upstream score and if there are no major differences in overall fish community composition, then the two locations are considered similar. It is important to bear in mind that differences greater than 6 points can be expected simply due to method variation (25% of the QA paired sample sets exceeded that value). An examination of the 12 metrics (with emphases on fish species used for each metric) is conducted to analyze any difference in scores and the potential for the difference to be thermally related.

Statistical Analyses

In addition to RFAI analyses, data were analyzed using traditional statistical methods. Data from the survey were used to calculate catch per unit effort (CPUE), expressed as number of fish per electrofishing run or fish per net night. CPUE values were calculated by pollution tolerance, trophic guilds (e.g., benthic invertivores, top carnivores, etc.), thermal sensitivity (Yoder et al. 2006), and indigenousness. CPUE, species richness, and diversity values were computed for each electrofishing effort (to maximize sample size; n = 30) and compared upstream and downstream to assess potential effects of power plant discharges.

Diversity was quantified using two commonly used diversity indices: Shannon diversity index (Shannon 1948) diversity index. This index accounts for the number of species present, as well as the relative abundance of each species.

Shannon diversity index values were computed using the formula:

$$H' = -\sum_{i=1}^{S} \left(\frac{n_i}{N}\right) \ln \left(\frac{n_i}{N}\right)$$

where:
S = total number of species
N = total number of individuals
n_i = total number of individuals in the i^{th} species.

An independent two-sample *t*-test was used to test for differences in CPUE, species richness, and diversity values upstream and downstream of BFN ($\alpha = 0.05$). Before statistical tests were performed using this method, data were analyzed for normality using the Shapiro-Wilk test (Shapiro and Wilk, 1965) and homogeneity of variance using Levene's test (Levene 1960). Non-normal data or data with unequal variances were transformed using either square root conversion or the ln(x+1) transformation. Transformed data were reanalyzed for normal distribution and equal variances. If transformation normalized the data or resulted in homogeneous variances, transformed data were tested using an independent two-sample *t*-test. If transformed data were not normally distributed or had unequal variances, statistical analysis was conducted using the Wilcoxon-Mann-Whitney test (Mann and Whitney, 1947; Wilcoxon, 1945).

Benthic Macroinvertebrate Community Sampling Methods and Data Analysis for Sites Upstream and Downstream of BFN

To assess the benthic macroinvertebrate community in the vicinity of BFN from 2000 to 2010, data were collected along transects established across the full width of Wheeler reservoir at two sites in the transition zone—one at TRM 295.9 upstream of the intake and one at TRM 291.7 downstream of the BFN discharge. Prior to this time, a sampling site in the forebay zone of Wheeler Reservoir (TRM 277) was used as the downstream comparison site. Because other factors unrelated to influence from BFN depressed benthic communities at both the forebay site and in the Elk River embayment (Wheeler Reservoir, Elk River Mile [ERM] 6 – between BFN and the forebay site), the downstream site was moved into the transition zone two miles downstream from the BFN diffuser at TRM 291.7 in 2000. Benthic scores and community composition from this site were used through 2010 for downstream comparisons to the upstream benthic site at TRM 295.9.

Beginning in 2011, samples were collected in the reservoir's transition zone along transects established across the full width of the reservoir at three sites. One site upstream of the plant intake was maintained at TRM 295.9 (Figure 4). To more accurately assess any possible effects of the BFN discharge on the benthic communities downstream, two sites were selected: one at TRM 293.2, within the thermal plume from the BFN discharge, and a second at TRM 290.4, downstream of the thermal plume (Figure 5).

During autumn 2020, benthic macroinvertebrate data were collected along these three transects. The upstream transect was used as a control site for comparison to the downstream benthic communities potentially affected by the BFN thermal effluent. A Ponar dredge (area per sample 0.06 m^2) was used to collect benthic samples at ten points equally spaced along each transect. When heavier substrate was encountered, a Peterson dredge (area per sample 0.11 m^2) was used. Sediments from each sample were washed on a 533µ screen, and organisms were picked from the screen and from any remaining substrate. Samples were fixed in formalin and sent to an independent consultant who identified each organism collected to the lowest possible taxonomic level.

Benthic samples were evaluated using seven metrics that represent characteristics of the benthic community. Results for each metric were assigned a rating of 1, 3, or 5, based on comparison to reference conditions developed for REH reservoir transition sample sites (Table 4). For each sample site, the ratings for the seven metrics were then summed to produce an RBI score. Potential RBI scores ranged from 7 to 35. Ecological health ratings derived from the range of potential values (7-12 "Very Poor", 13-18 "Poor", 19-23 "Fair", 24-29 "Good", or 30-35 "Excellent") were then applied to scores (Table A-4). The individual metrics are described below:

(1) Average number of taxa — Calculated by averaging the total number of taxa present in each sample at a site. Greater taxa richness indicates better conditions than lower taxa richness

(2) Proportion of samples with long-lived organisms — A presence/absence metric that is evaluated based on the proportion of samples with at least one long-lived organism (*Corbicula, Hexagenia*, mussels, or snails) present. The presence of long-lived taxa is indicative of conditions that allow long-term survival.

(3) Average number of EPT taxa — Calculated by averaging the number of *Ephemeroptera* (mayfly), *Plecoptera* (stonefly), and *Trichoptera* (caddisfly) taxa present in each sample at a site. Higher diversity of these taxa indicates good water quality and better habitat conditions.

(4) Percentage of oligochaetes — Calculated by averaging the percentage of oligochaetes in each sample at a site. Oligochaetes are considered tolerant organisms, so a higher proportion indicates poorer water quality.

(5) Percentage as dominant taxa — Used as an evenness indicator, this metric is calculated by selecting the two most abundant taxa in a sample, summing the number of individuals in those two taxa, dividing that sum by the total number of animals in the sample, and converting to a percentage for that sample. The percentages are then averaged for the 10 samples at each site. Because the most abundant taxa often differ among the 10 samples at a site, this approach allows more discretion to identify imbalances at a site than developing an average for a single dominant taxon for all samples at a site. Dominance of one or two taxa indicates poor conditions.

(6) Average density excluding chironomids and oligochaetes — Calculated by first summing the number of organisms – excluding chironomids and oligochaetes – present in each sample and then averaging these densities for the 10 samples at a site. This metric examines the community, excluding taxa which often dominate under adverse conditions. Higher abundance of taxa other than chironomids and oligochaetes indicates good water quality conditions.

(7) Zero-samples: Proportion of samples containing no organisms — For each site, the proportion of samples in which no organisms are present. "Zero-samples" indicate living conditions unsuitable to support aquatic life (i.e. toxicity, unsuitable substrate, etc.). A site with no zero samples was assigned a score of five. Any site with one or more zero samples was assigned a score of one.

A similar or higher benthic index score at the downstream sites compared to the upstream site was used as the basis for determining absence of impact on the benthic macroinvertebrate community related to BFN's thermal discharge. The QA component of REH monitoring compared benthic index scores from 49 paired sample sets collected over seven years. Differences between these paired sets ranged from 0 to 14 points; the 75th percentile was four points, the 90th percentile was six points. The mean difference between these 49 paired scores was 3.1 points with 95% confidence limits of 2.2 and 4.1. Based on these results, a difference of four points or less was the value selected for defining "similar" scores between upstream and downstream benthic communities. That is, if benthic scores at the downstream sites are within four points of the upstream score, the communities are considered similar. However, differences greater than four points can be expected simply due to method variation (25% of the QA paired sample sets exceeded that value). Any difference in scores of four points or

greater between communities is examined on a metric-by-metric basis to determine what caused the difference in scores and the potential for the difference to be thermally related.

Visual Encounter Survey (Wildlife Observations)

Permanent survey sites were established on both the right and left descending banks at one location upstream of the BFN thermal discharge, centered at TRM 295.9 (Figure 4), and at a second location downstream of the discharge, centered at TRM 292.5 (Figure 5). Each survey site spanned a distance of 2,100 m along the shoreline, and the beginning and ending points were marked using a global positioning system unit for relocation.

Surveys were conducted by steadily traversing the site by boat, at approximately 30 m offshore and parallel to the shoreline, and simultaneously recording observations of wildlife. The sampling frame of each survey generally followed the strip or belt transect concept: from the center-line of each transect landward to an area that included the shoreline and riparian zone (i.e., belt width generally averages 60 m where vision is not obscured), all individuals observed were enumerated. Wildlife observed visually or detected audibly was identified to the lowest taxonomic trophic level, and a direct count of individuals observed per trophic level was recorded. If a flock of a species or a mixed flock of a group of species was observed, numbers of individuals present of each species were estimated. Time was recorded at the start and end points of each survey to provide a general measure of effort expended. Variation of observation times among surveys was primarily due to the difficulty of approaching some wildlife species without inadvertently flushing them from basking or perching sites.

The principal objective of the surveys was to provide a preliminary set of observations to verify that trophic levels of birds, mammals and reptiles were not affected by thermal effects from the BFN discharge. If expected trophic levels were not represented, further investigation will be used to target particular species or species groups (guilds) in an attempt to determine the cause.

Wheeler Reservoir Flow and BFN Temperature

Total daily average discharge from Guntersville Dam was used to describe the amount of water flowing past BFN and was obtained from TVA's River Operations database.

Water temperature data were also obtained from TVA's River Operations database. Locations of water temperature monitoring stations used to compare water temperatures upstream of BFN intake and downstream of BFN discharge are depicted in Figure A-1. Ambient temperatures upstream of the BFN intake were measured at Station 4, located at TRM 297.8. Upstream daily mean temperatures were calculated by averaging temperatures collected at depths of 3, 5, and 7 feet. Temperatures downstream of BFN discharge were measured at Stations 1, 16, and 17, all located at TRM 293.5. Downstream temperatures were calculated by first averaging temperatures at each site across depths of 3, 5, and 7 feet. The resultant values from each site were then averaged together to obtain overall mean daily water temperatures downstream of BFN.

Thermal Plume Characterization

Physical measurements to characterize and map the BFN thermal plume were collected concurrent with biological field sampling. The plume was characterized under representative thermal maxima

and seasonally-expected low flow conditions. Measurements were collected during periods of normal operation of BFN, as reasonably practicable, to capture the thermal plume under existing river flow/reservoir elevation conditions. This effort evaluated potential impacts on recreation and water supply uses and allowed general delineation of the "Primary Study Area" – per the EPA (1977) draft guidance defined as the "*entire geographic area bounded annually by the locus of the 2 °C above ambient surface isotherms as these isotherms are distributed throughout an annual period*" – ensuring placement of the biological sampling locations within thermally influenced areas.

However, it is important to emphasize that the ≥2ºC isopleth boundary is not a bright line; it is dynamic, changing geometrically in response to changes in ambient river flows and temperatures and BFN operations. As such, samples collected outside of, but generally proximate to the Primary Study Area boundary cannot be considered free of thermal influence and thus should not be discounted. Every effort was made to collect biological samples in thermally affected areas as guided by the Primary Study Area definition.

Depth profiles of temperature from the river surface to the bottom were collected at points along transects crossing the plume. One transect was located proximate to the thermal discharge point; subsequent downstream transects were concentrated in the near field area of the plume where the change in plume temperature was expected to be most rapid. The distance between transects in the remainder of the Primary Study Area increased with distance downstream (or away from the discharge point). The farthest downstream transect was just outside of the Primary Study Area. A transect upstream of the discharge, in an area not affected by the thermal plume, was included for determining ambient temperature conditions. The total number of transects needed to fully characterize and delineate the plume was determined in the field.

Collection of temperature profiles along a given transect began at or near the shoreline from which the discharge originated and continued until the far shore was reached. Measurements across a transect were typically conducted at points 10%, 30%, 50%, 70%, and 90% from the originating shoreline, though the number of measurement points along transects was sometimes increased in proportion to the magnitude of the temperature change across a given transect. The distances between transects, and between points of measurement along each transect, depended on the size of the discharge plume.

Temperature data were compiled and analyzed to present the horizontal and vertical dimensions of the BFN thermal plume using spatial analysis techniques to yield plume cross-sections, which can be used to demonstrate the existence of a zone of passage for fish and other aquatic species under or around the plume.

Water Quality Parameters at Fish Sampling Sites during RFAI Samples

Water quality conditions were measured using a Hydrolab® that provided readings for water temperature (°C), conductivity (µS/cm), dissolved oxygen (mg/L), and pH. Within each of the electrofishing sample reaches upstream and downstream of BFN, transects were established across the river at the most upstream boundary, at mid-reach, and at the most downstream boundary. Along each transect, samples were collected at the RDB, in mid-channel, and at the LDB by recording readings at one- to two-meter intervals along a vertical gradient from just above the bottom of the river to approximately 0.3 meters from the surface.

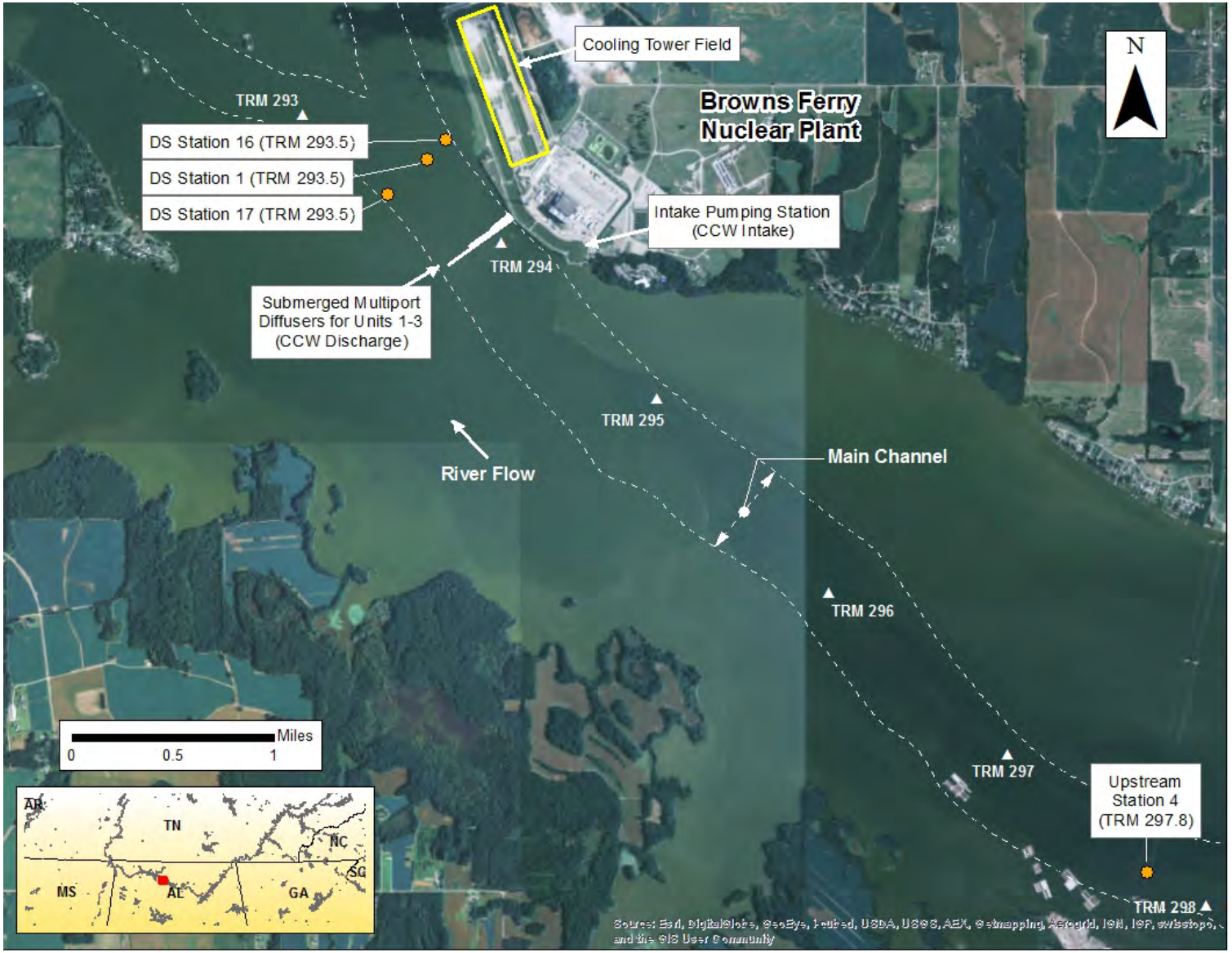


Figure A-1. Locations of water temperature monitoring stations used to compare water temperatures upstream of Browns Ferry Nuclear Plant (BFN) intake and downstream of BFN discharge

Table A-1. Shoreline Aquatic Habitat Index (SAHI) metrics and scoring criteria

Metric	Scoring Criteria	Score
Cover	Stable cover (boulders, rootwads, brush, logs, aquatic vegetation, artificial structures) in 25 to 75% of the drawdown zone	5
	Stable cover in 10 to 25% or > 75% of the drawdown zone	3
	Stable Cover in < 10% of the drawdown zone	1
Substrate	Percent of drawdown zone with gravel substrate > 40	5
	Percent of drawdown zone with gravel substrate between 10 and 40	3
	Percent substrate gravel < 10	1
Erosion	Little or no evidence of erosion or bank failure. Most bank surfaces stabilized by woody vegetation.	5
	Areas of erosion small and infrequent. Potential for increased erosion due to less desirable vegetation cover (grasses) on > 25% of bank surfaces.	3
	Areas of erosion extensive, exposed or collapsing banks occur along > 30% of shoreline.	1
Canopy Cover	Tree or shrub canopy > 60% along adjacent bank	5
	Tree or shrub canopy 30 to 60% along adjacent bank	3
	Tree or shrub canopy < 30% along adjacent bank	1
Riparian Zone	Width buffered > 18 meters	5
	Width buffered between 6 and 18 meters	3
	Width buffered < 6 meters	1
Habitat	Habitat diversity optimum. All major habitats (logs, brush, native vegetation, boulders, gravel) present in proportions characteristic of high quality, sufficient to support all life history aspects of target species. Ready access to deeper sanctuary areas present.	5
	Habitat diversity less than optimum. Most major habitats present, but proportion of one is less than desirable, reducing species diversity. No ready access to deeper sanctuary areas.	3
	Habitat diversity is nearly lacking. One habitat dominates, leading to lower species diversity. No ready access to deeper sanctuary areas.	1
Gradient	Drawdown zone gradient abrupt (> 1 meter per 10 meters). Less than 10% of shoreline with abrupt gradient due to dredging.	5
	Drawdown zone gradient abrupt. (> 1 meter per 10 meters) in 10 to 40% of the shoreline resulting from dredging. Rip-rap used to stabilize bank along > 10% of the shoreline.	3
	Drawdown zone gradient abrupt in > 40 % of the shoreline resulting from dredging. Seawalls used to stabilize bank along > 10 % of the shoreline.	1

Table A-2. Expected trophic guild proportions* and expected numbers of species* of all species in lower mainstem Tennessee River reservoir transition zones, compared to values observed during autumn 2020 monitoring at Browns Ferry Nuclear Plant

	Lower Mainstem Tennessee River Transition Zones								2020			
	Proportion (%)				Number of species				Observed Downstream of BFN (TRM 292.5)		Observed Upstream of BFN (TRM 295.9)	
	Trisected range [a]			Average [b]	Trisected range [a]			Average [b]				
Trophic Guild	-	Expected	+		-	Expected	+		Proportion (%)	Number of Species	Proportion (%)	Number of Species
Benthic Invertivore	< 5.9	5.9 to 11.9	> 11.9	5.0 ± 0.9	< 3	3 to 6	> 6	5 ± 1	2.1	4	2.5	5
Insectivore	< 26.8	26.8 to 53.6	> 53.6	37.6 ± 3.9	< 3	3 to 6	> 6	6 ± 1	67.7	10	69.5	10
Top Carnivore	< 15.4	15.4 to 30.8	> 30.8	18.7 ± 2.0	< 4	4 to 9	> 9	9 ± 1	13.5	12	15.0	13
Omnivore	>45.5	22.7 to 45.5	<22.7	27.8 ± 2.9	> 5	3 to 5	< 3	5 ± 1	16.2	6	12.6	7
Planktivore	< 28.4	28.4 to 56.7	>56.7	12.4 ± 4.6	0	1	> 1	1 ± 1	0.5	1	0.2	1
Parasitic	< 0.1	0.1 to 0.2	> 0.2	0.2 ± 0.04	0	1	> 1	1 ± 0	--	--	0.1	1
Herbivore	<1.8	1.8 to 3.5	>3.5	0.7 ± 0.4	0	1	> 1	1 ± 0	--	--	0.1	1

**Expected values were calculated from data collected over 1,245 electrofishing runs and 830 overnight experimental gill net sets in transition areas of lower mainstem Tennessee River reservoirs.*

[a] Trisected ranges are intended to show below expected (-), expected, and above expected (+) values for trophic level proportions and species occurring within the transition zones in lower mainstem Tennessee River reservoirs.

[b] Average expected values are bound by 95% confidence intervals.

Table A-3. RFAI scoring criteria (2002) for inflow, transition, and forebay sections of lower mainstem reservoirs* in the Tennessee River system.

		Scoring Criteria								
		Inflow			Transition			Forebay		
Metric	**Gear**	**1**	**3**	**5**	**1**	**3**	**5**	**1**	**3**	**5**
1. Total species	Combined	< 14	14-27	> 27	< 16	16-30	>30	< 14	14-27	> 27
2. Number of centrarchid species	Combined	< 2	2-4	> 4	< 2	2-2	> 2	< 2	2-3	> 3
3. Number of benthic invertivores	Combined	< 4	4-7	> 7	< 4	4-7	> 7	< 4	4-6	> 6
4. Number of intolerant species	Combined	< 3	3-6	> 6	< 3	3-4	> 4	< 2	2-4	> 4
5. Percent tolerant individuals	Electrofishing	>51%	26-51%	< 26%	>54%	27-54%	< 27%	> 61%	30-61%	< 30%
	Gill netting				>30%	15-30%	< 15%	>46%	22-46%	< 22%
6. Percent dominance by one species	Electrofishing	>47%	24-47%	< 24%	>58%	29-58%	< 29%	>59%	30-59%	< 30%
	Gill netting				>34%	17-34%	< 17%	>43%	21-43%	< 21%
7. Percent non-indigenous species	Electrofishing	>4%	2-4%	< 2%	>2%	1-2%	< 1%	>2%	2-2%	< 2%
	Gill netting				>2%	1-2%	< 1%	>2%	1-2%	< 1%
8. Number of top carnivore species	Combined	< 4	4-7	>7	< 4	4-7	>7	< 4	4-7	>7
9. Percent top carnivores	Electrofishing	< 15%	15-29%	>29%	< 5%	5-10%	>10%	< 6%	6-12%	>12%
	Gill netting				< 20%	20-39%	>39%	< 25%	25-49%	>49%
10. Percent omnivores	Electrofishing	>48%	24-48%	< 24%	>48%	24-48%	< 24%	>59%	30-59%	< 30%
	Gill netting				>33%	16-33%	< 16%	>49%	24-49%	< 24%
11. Average number per run	Electrofishing	< 68	68-136	>136	< 243	243-487	>487	< 170	170-341	>341
	Gill netting				< 11	11-22	>22	< 20	20-40	>40
12. Percent anomalies	Electrofishing	>5%	2-5%	< 2%	>5%	2-5%	< 2%	>5%	2-5%	< 2%
	Gill netting				>5%	2-5%	< 2%	>5%	2-5%	< 2%

**Lower mainstem Tennessee River reservoirs include Guntersville, Wheeler, Wilson, Pickwick, and Kentucky.*

Transition scoring criteria were used to score sites upstream and downstream of BFN.

Table A-4. Scoring criteria for laboratory-processed benthic macroinvertebrate community samples from inflow, transition, and forebay zones of mainstem Tennessee River reservoirs

Benthic Community Metrics	Scoring Criteria								
	Inflow			Transition			Forebay		
	1	3	5	1	3	5	1	3	5
1. Average number of taxa	<4.2	4.2-8.3	>8.3	<3.3	3.3-6.6	>6.6	<2.8	2.8-5.5	>5.5
2. Proportion of samples with long-lived organisms	<0.6	0.6-0.8	>0.8	<0.6	0.6-0.9	>0.9	<0.6	0.6-0.8	>0.8
3. Average number of EPT taxa	<0.9	0.9-1.9	>1.9	<0.6	0.6-1.4	>1.4	<0.6	0.6-0.9	>0.9
4. Average proportion of oligochaete individuals	>23.9	23.9-12.0	<12.0	>21.9	21.9-11.0	<11.0	>41.9	41.9-21.0	<21.0
5. Average proportion of total abundance comprised by the two most abundant taxa	>86.2	86.2-73.1	<73.1	>87.9	87.9-77.8	<77.8	>90.3	90.3-81.7	<81.7
6. Average density excluding chironomids and oligochaetes	<400.0	400.0-799.9	>799.9	<305.0	305.0-609.9	>609.9	<125.0	125.0-249.9	>249.9
7. Zero Samples: proportion of samples containing no organisms	>0	-	0	>0	-	0	>0	-	0

Transition scoring criteria were used to score sites upstream and downstream of BFN.

Appendix B. Evaluation of Brown Ferry Nuclear plant operating conditions during 2014-2020

Evaluation of Plant Operating Conditions

Relevant plant operational data—mean daily temperatures at the CCW intake and discharge, mean daily flow through the CCW system, and mean daily power generation by the three nuclear units at BFN—were compiled from 2014 through 2020.

Biological monitoring was conducted upstream and downstream of BFN on November 10 and 11, 2020. Daily mean generation for these two days respectively was 3,651 MW and 3,662 MW, respectively, which were slightly higher than the historical average (3,325 MW). Daily mean intake temperatures for these dates were 67.5 ˚F and 67.8 ˚F for both days, which was about 8 degrees warmer than the November average for 2014-2019 (59.5 ˚F). Daily mean discharge temperatures were 97.0 and 97.3 ˚F, respectively, from 15 degrees warmer than the historical November mean (82.6 ˚F). Daily flow rates were 3,050 mgd for both sample dates, which was about 300 mgd higher than historical average of 2,784 mgd (Table B-1, Figure B-1).

During 2020, daily mean generation ranged from 983 to 3,914 MW, with an annual daily average of 3,326 MW. Mean daily CCW flow during 2020 ranged from 1,386 to 3,050 mgd and averaged 2,753 mgd (Figure B-3). Daily mean intake and discharge temperatures in 2020 averaged 67.0 ˚F and 97.9 ˚F, respectively. The daily averages in 2020 were similar to 2014-2019 daily averages, except for average flow past BFN. The 2020 average flow past BFN was about 27,000 cfs less than the 2014-2019 average (Table B-1, Figure B-2).

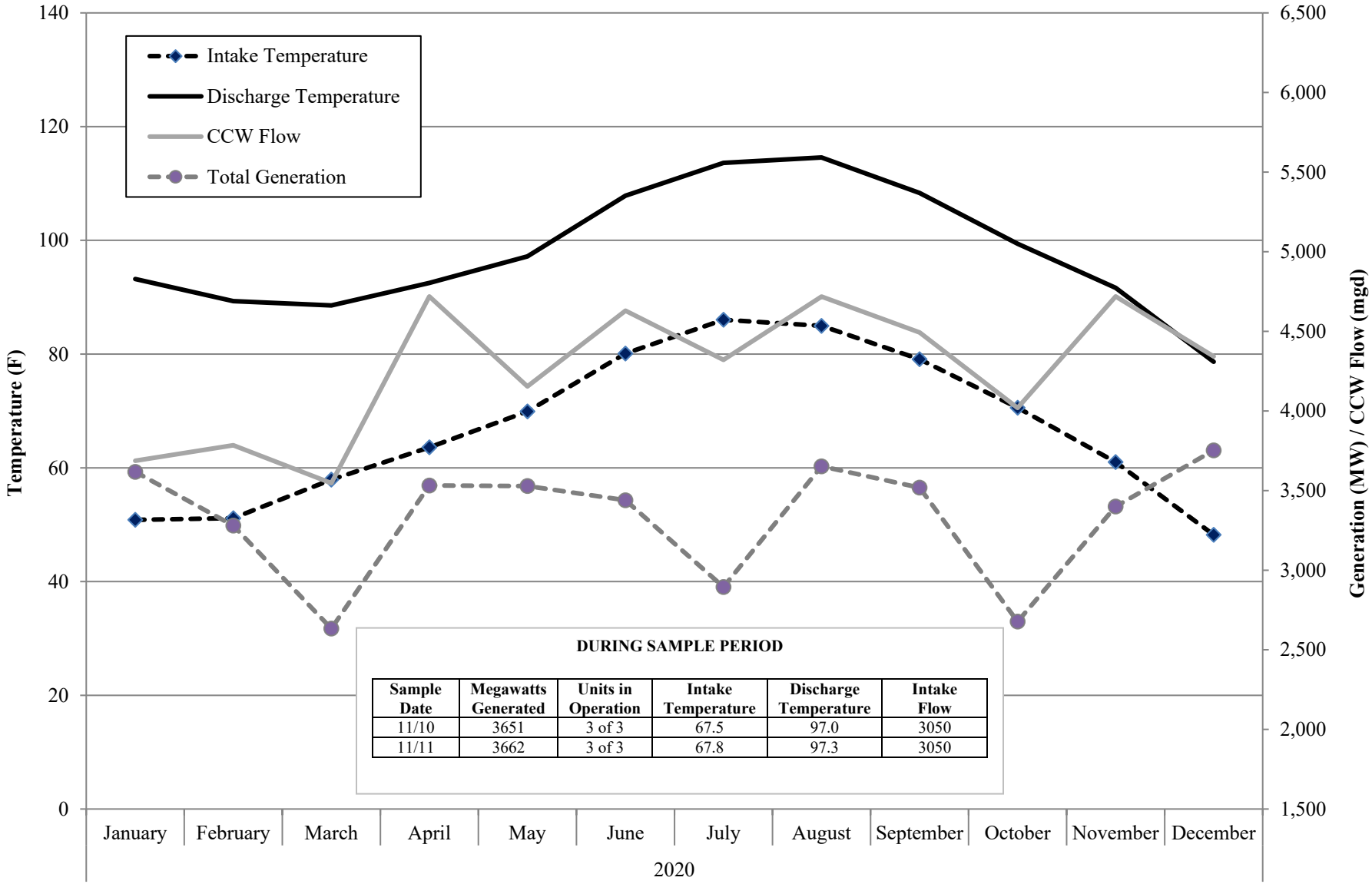


Figure B-1. Megawatts generated, water temperatures of the intake and discharge and flow through the condenser cooling water (CCW) system at Browns Ferry Nuclear Plant during 2020

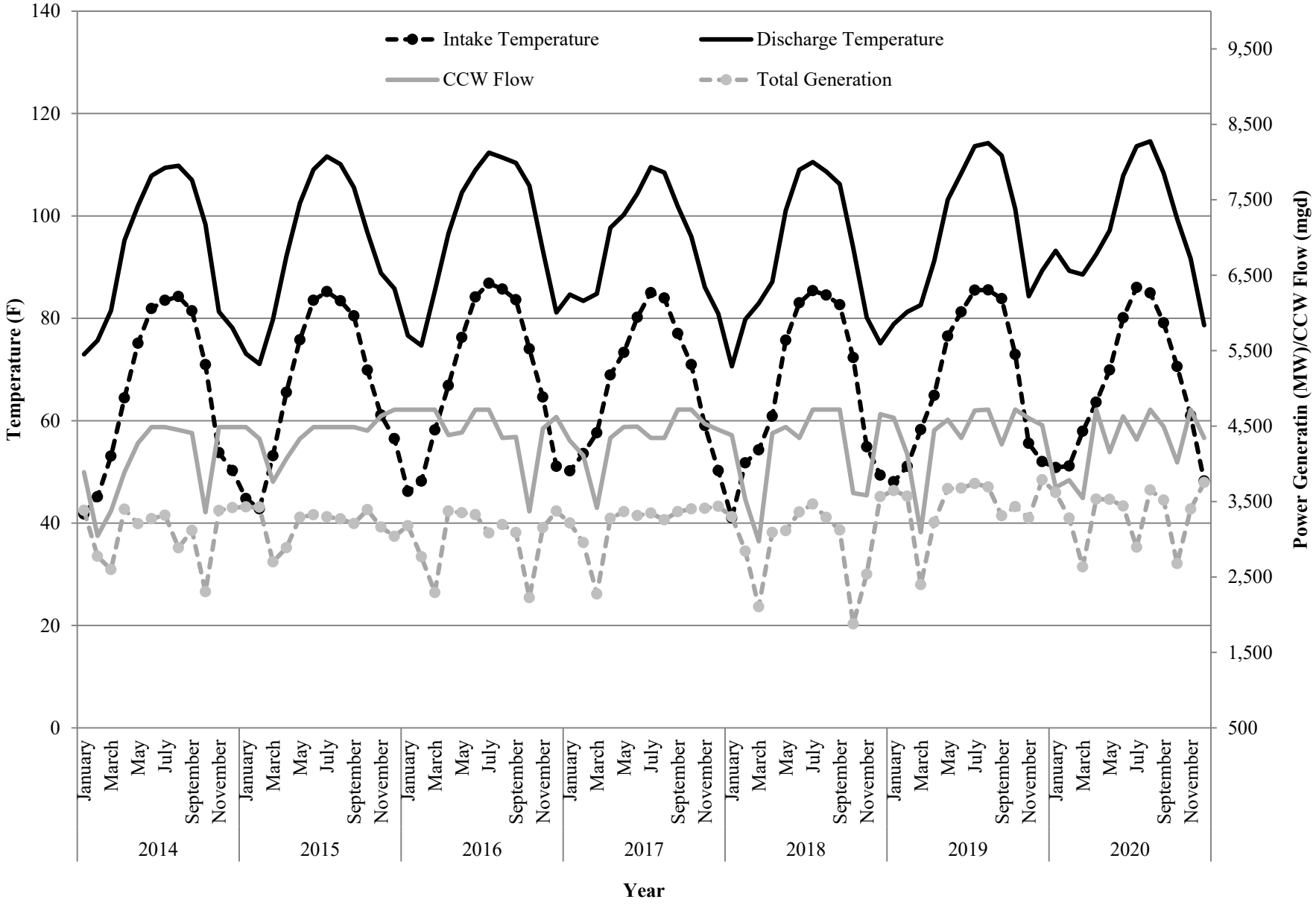


Figure B-2. Megawatts generated, water temperatures of the intake and discharge and flow through the condenser cooling water (CCW) system at Browns Ferry Nuclear Plant during the five years prior to the survey (2014-2019) and during the survey year (2020)

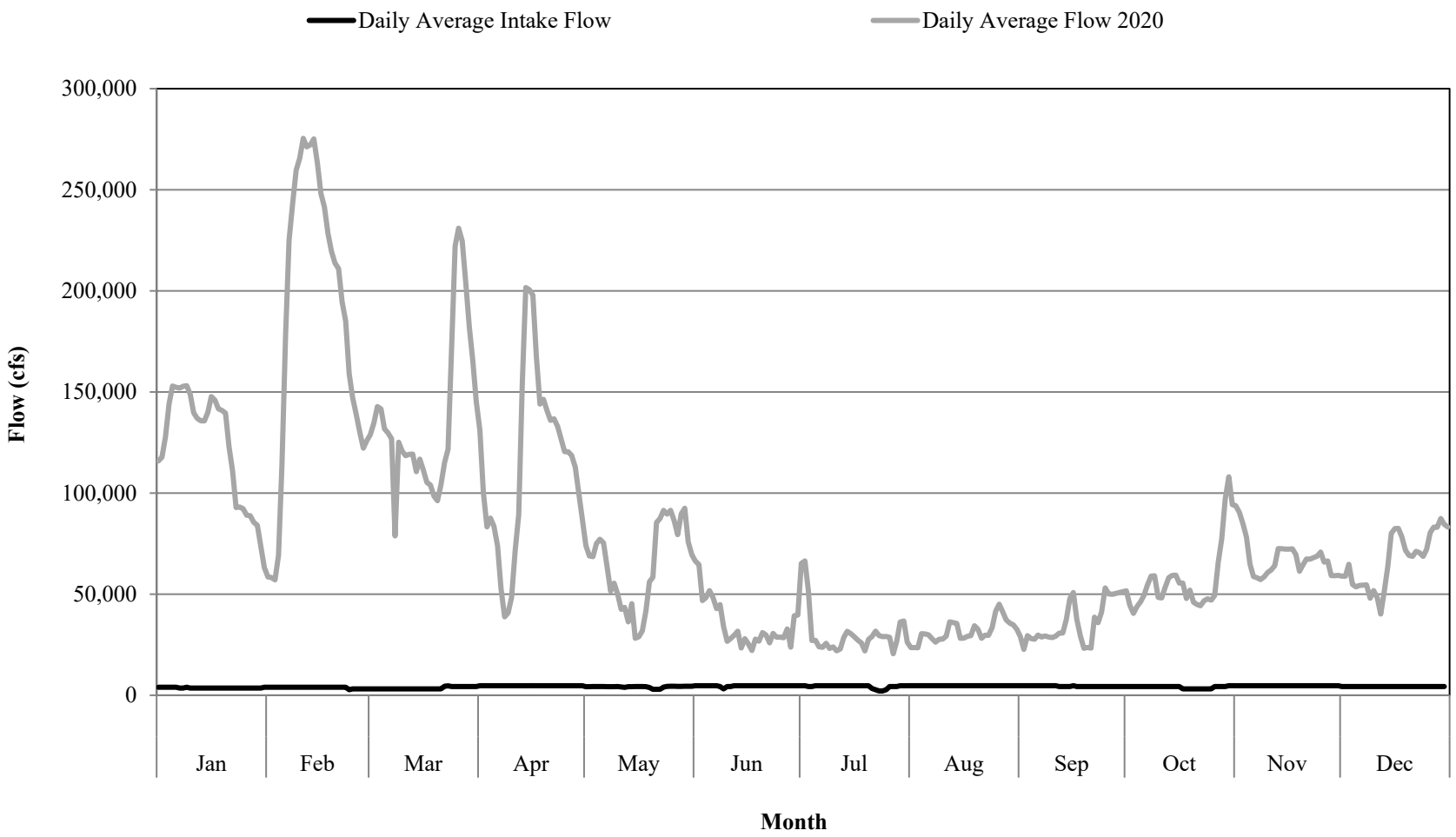


Figure B-3. Comparison of Tennessee River flows to Browns Ferry Nuclear (BFN) plant condenser cooling water withdrawals during 2020

Table B-1. Daily average intake and discharge water temperatures (°F), megawatts generated, and flow* (mgd) of the condenser circulating water (CCW) system at Browns Ferry Nuclear Plant during 2014 through 2020

Year	Month	Intake Temperature (°F)	Discharge Temperature (°F)	Total Generation	CCW Flow	Flow past BFN
2014	January	43.1	79.1	3,383	2,514	79,670
	February	42.7	78.9	2,773	2,038	76,405
	March	56.5	84.2	2,598	2,181	40,439
	April	65.8	101.4	3,398	2,514	30,980
	May	76.8	103.3	3,205	2,763	20,437
	June	83.4	108.0	3,272	2,899	26,386
	July	84.8	109.8	3,318	2,899	22,365
	August	85.4	110.8	2,887	2,875	28,911
	September	82.7	107.4	3,117	2,848	28,989
	October	71.6	95.9	2,304	2,170	47,982
	November	55.1	83.0	3,381	2,899	48,912
	December	51.4	76.7	3,419	2,899	52,570
	AVG	**68.3**	**96.2**	**3,088**	**2,628**	**42,004**
2015	January	45.9	71.1	3,429	2,899	63,781
	February	43.9	68.6	3,425	2,899	47,768
	March	54.2	78.1	2,700	2,432	77,737
	April	66.6	93.2	2,887	2,628	55,555
	May	77.1	102.5	3,291	2,800	17,722
	June	84.8	110.2	3,324	2,899	21,090
	July	86.3	112.6	3,297	2,899	45,493
	August	84.6	110.1	3,271	2,899	33,312
	September	81.8	107.3	3,207	2,899	23,507
	October	71.1	96.0	3,392	2,868	40,286
	November	62.2	87.6	3,161	2,994	53,010
	December	57.7	83.7	3,038	3,049	139,303
	AVG	**68.2**	**93.5**	**3,201**	**2,847**	**51,547**
2016	January	47.4	76.3	3,179	3,049	100,779
	February	48.6	73.7	2,768	3,049	118,141
	March	63.4	85.2	2,294	3,049	55,408
	April	68.2	102.9	3,373	2,831	19,847
	May	77.9	112.5	3,352	2,853	10,841
	June	85.6	109.2	3,325	3,049	14,795
	July	88.1	112.5	3,082	3,049	15,301
	August	86.9	112.0	3,194	2,806	25,885
	September	84.9	109.2	3,089	2,814	16,886
	October	74.6	104.3	2,226	2,177	15,766
	November	66.1	95.3	3,153	2,887	15,548
	December	52.2	78.0	3,373	2,986	31,021
	AVG	**71.5**	**99.3**	**3,033**	**2,882**	**36,685**
2017	January	50.2	54.2	3,215	2,783	53,279
	February	53.6	58.1	2,956	2,751	37,676
	March	57.6	61.3	2,274	2,207	41,645
	April	68.9	72.0	3,276	2,806	54,603
	May	72.9	76.6	3,366	2,900	60,711
	June	79.6	83.9	3,314	2,903	40,513
	July	84.8	87.5	3,346	2,806	38,180
	August	84.3	87.0	3,258	2,806	34,749
	September	77.0	81.5	3,365	3,050	28,818
	October	72.1	76.3	3,401	3,050	35,668
	November	60.3	64.0	3,410	2,928	49,185
	December	51.3	55.6	3,437	2,877	40,254
	AVG	**67.8**	**71.6**	**3,219**	**2,822**	**42,940**

Table B-1. (continued)

Year	Month	Intake Temperature (°F)	Discharge Temperature (°F)	Total Generation	CCW Flow	Flow past BFN
2018	January	42.2	71.6	3,299	2,830	27,935
	February	49.1	74.3	2,842	2,360	117,206
	March			2,106	1,921	90,108
	April	62.2	88.9	3,091	2,847	59,686
	May	76.8	105.9	3,115	2,900	40,256
	June	84.2	114.3	3,361	2,806	53,954
	July	86.5	113.6	3,466	3,050	33,137
	August	85.7	113.2	3,289	3,050	33,303
	September	83.9	111.3	3,121	3,050	51,016
	October	75.1	97.5	1,877	2,334	46,304
	November	55.7	83.0	2,537	2,315	82,415
	December	50.6	77.8	3,565	3,010	121,659
	AVG	**69.2**	**96.6**	**2,973**	**2,708**	**63,082**
2019	January	49.2	80.3	3,646	2,979	144,488
	February	51.9	81.2	3,570	2,763	171,489
	March	56.3	87.9	2,398	1,998	159,686
	April	66.1	93.4	3,225	2,872	55,642
	May	77.7	105.1	3,671	2,963	51,358
	June	82.5	109.9	3,677	2,806	40,007
	July	86.8	115.0	3,738	3,042	33,943
	August	86.8	115.2	3,693	3,050	31,166
	September	85.2	113.5	3,312	2,752	25,959
	October	74.3	102.5	3,431	3,050	25,073
	November	57.7	82.5	3,282	2,976	48,651
	December	53.5	86.0	3,787	2,916	100,858
	AVG	**69.6**	**98.4**	**3,452**	**2,848**	**74,027**
2020	January	52.9	92.7	3,617	2,383	123,135
	February	54.2	94.1	3,280	2,445	188,000
	March	65.9	81.8	2,633	2,292	137,068
	April	64.9	90.0	3,532	3,050	114,884
	May	71.1	98.7	3,528	2,685	64,882
	June	81.4	109.5	3,439	2,991	35,212
	July	87.0	115.2	2,894	2,792	30,598
	August	86.2	115.3	3,652	3,049	31,586
	September	80.3	112.3	3,518	2,903	35,565
	October	71.1	100.0	2,677	2,597	56,604
	November	62.1	91.9	3,400	3,050	68,036
	December	49.3	79.3	3,752	2,806	67,079
	AVG	**69.5**	**99.7**	**3,326**	**2,753**	**79,387**
2014-2019	Range	35.0 - 89.5	63.4 - 118.7	1,119 - 3,885	1,386 - 3,050	984 - 351,504
	Average	67.2	94.7	3,161	2,789	51,525
2020	Range	40.4 - 89.2	72.9 - 118.2	983 - 3,914	1,386 - 3,050	20,532 - 275,437
	Average	67.0	97.9	3,326	2,753	78,955

Appendix C. Pages 25 and 36 from EPA Region 1. 2011. Draft NPDES Permit for the PSNH Merrimack Station; Clean Water Act NPDES Permitting Determinations for the Thermal Discharge and Cooling Water Intake Structures at Merrimack Station in Bow, New Hampshire NPDES Permit No. NH 0001465

> *[t]he Congress intended that there be a very limited waiver for those major sources of thermal effluents which could establish beyond any question the lack of relationship between federally established effluent limitations and that water quality which assures the protection of public water supplies and the protection and propagation of a balanced, indigenous population of fish, shellfish, and wildlife, and allows recreational activities, in and on the water.*

Congressional Research Service, "A Legislative History of the Water Pollution Control Act Amendments of 1977," Vol. IV, 95th Cong., 2nd Session, (cited hereinafter as the "1977 Legislative History"), at 642 (Senate Report); *see also id.* at 457.

EPA has not, however, interpreted § 316(a) to require absolute certainty before a variance could be granted. *Seabrook*, 1977 EPA App. LEXIS 16, at *32. In reality, achieving absolute certainty about a § 316(a) determination is likely to be impossible. *See id.* EPA has stated, however, that "[t]he greater the risk, the greater the degree of certainty that should be required." *Id.* *See also* 44 Fed. Reg. at 32,894.

The above material suggests that EPA should take a conservative approach to assessing variance applications in order to ensure that the standard of assuring the protection and propagation of the BIP is satisfied. Such an approach is also appropriate in light of the fact that the applicant for a § 316(a) variance is asking to be excused from the otherwise applicable limitations, and given the CWA's overarching goal of restoring and maintaining the "biological integrity of the Nation's waters," 33 U.S.C. § 1251(a), and attaining "water quality which provides for the protection and propagation of fish, shellfish and wildlife." 33 U.S.C. § 1251(a)(2).

While the variance applicant's burden is a stringent one, EPA's NPDES permit decisions are subject to the "arbitrary and capricious" standard of review under the Administrative Procedures Act. 5 U.S.C. §§ 701–706. Thus, EPA decisions regarding whether a permit applicant has carried its burden in seeking a § 316(a) variance, and in setting the thermal discharge limits included in the permit, must have a rational basis and be consistent with applicable law.

With respect to the question of how much evidence is needed to support a § 316(a) variance, EPA has explained that, "no hard and fast rule can be made as to the amount of data that must be furnished . . . and much depends on the circumstances of the particular discharge and receiving waters." *Seabrook*, 1977 EPA App. LEXIS 16, at *31. At the same time, information requirements are likely to increase to the extent that there is greater reason for concern over the protection and propagation of the BIP. As EPA stated in the preamble to its current § 316(a)-related regulations in 40 C.F.R. Part 125, Subpart H:

> *Section 125.72 accordingly gives the Director the flexibility to require substantially less information in the case of renewal requests. This does not mean, however, that the Director may not require a full demonstration for a*

Table 5-2. Species identified by Merrimack Station as being representative of the fish community in Hooksett Pool

1. Alewife (Alosa pseudoharengus)
2. American shad (Alosa sapidissima)
3. Atlantic salmon *(Salmo salar)*
4. Fallfish (Semotilus corporalis)
5. Largemouth bass (*Micropterus salmoides*)
6. Pumpkinseed (*Lepomis gibbosus*)
7. Smallmouth bass (*Micropterus dolomieu*)
8. White sucker (Catostomus commersoni)
9. Yellow perch (*Perca flavescens*)

EPA agrees that the species listed were part of the balanced, indigenous fish community in 1967. Merrimack Station's data and analyses of these species are an important component of EPA's assessment of thermal impacts. However, while it is appropriate to identify and focus on representative important species for "predictive" § 316(a) demonstrations, non-predictive (*i.e.*, retrospective, or "Type I") demonstrations, which are designed to assess prior appreciable harm, should not be restricted to assessing the status of representative important species. In fact, EPA's Draft 1977 316(a) Technical Guidance recommends that references to Representative Important Species be eliminated from Type I demonstrations (EPA 1977a). Merrimack Station's § 316(a) demonstration is largely retrospective (Type I). Therefore, EPA's assessment of the balanced, indigenous fish community of Hooksett Pool encompassed all species present in 1967. This does not mean that every species of fish present in 1967 requires an in-depth review, but when assessing community-wide impacts, there is no reason to exclude any resident species that was present prior to the increase in discharges of heated effluent to Hooksett Pool.

5.3.2 Other Aquatic Communities

Assessing changes in the resident fish community of a water body often provides the most conspicuous evidence of impacts to the overall aquatic community, but a complete §316(a) variance demonstration is not limited to fish. Planktonic organisms (*e.g.* phytoplankton, zooplankton, meroplankton), macroinvertebrates (*e.g.*, shellfish), habitat formers (*e.g.*, subaquatic vegetation), and wildlife are all supposed to be assessed at the level of detail appropriate to the facility's potential to impact these communities. EPA provides specific guidance for facilities developing demonstrations in its Draft 1977 316(a) Technical Guidance.

Merrimack Station does not assess impacts to aquatic communities other than fish in the Fisheries Analysis Report. However, it does state that the Station's past and current operations have resulted in no appreciable harm to the balanced, indigenous populations of fish and other aquatic organisms in the segment of the Merrimack River receiving the Station's thermal discharge. Merrimack Station bases this conclusion on all reports, past and present, prepared by

Appendix D. Results from fish community monitoring upstream (TRM 295.9) and downstream (TRM 292.5) of Browns Ferry Nuclear Plant during autumn 2020

Table D-1. Individual Metric Scores and the Overall RFAI Scores Downstream (TRM 292.5) and Upstream (TRM 295.9) of (Browns Ferry Nuclear plant), Autumn 2020.

Autumn 2020		TRM 292.5		TRM 295.9	
Metric		Obs	Score	Obs	Score
A. Species richness and composition					
1. Number of indigenous species (Tables D-2 and D-3)	Combined	**30**	**3**	**35**	**5**
2. Number of centrarchid species (less *Micropterus*)	Combined	**5** Black crappie Bluegill Green sunfish Longear sunfish Redear sunfish	**5**	**6** Black crappie Bluegill Green sunfish Longear sunfish Redear sunfish Warmouth	**5**
3. Number of benthic invertivore species	Combined	**4** Freshwater drum Logperch Silver redhorse Spotted sucker	**3**	**5** Freshwater drum Golden redhorse Logperch Northern hog sucker Spotted sucker	**3**
4. Number of intolerant species	Combined	**6** Brook silverside Longear sunfish Rock bass Skipjack herring Smallmouth bass Spotted sucker	**5**	**5** Longear sunfish Northern hog sucker Skipjack herring Smallmouth bass Spotted sucker	**5**

Table D-1. (Continued)

Autumn 2020 Metric		TRM 292.5 Obs		Score	TRM 295.9 Obs		Score
5. Percent tolerant individuals	Electrofishing	**40.1%**			**23.5%**		
		Bluegill	3.9%		Bluegill	3.2%	
		Bluntnose minnow	0.5%		Common carp	0.3%	
		Gizzard shad	12.6%	**1.5**	Gizzard shad	10.1%	**2.5**
		Green sunfish	1.5%		Golden shiner	0.2%	
		Largemouth bass	6.2%		Green sunfish	1.3%	
		Redbreast sunfish	0.1%		Largemouth bass	5.7%	
		Spotfin shiner	15.3%		Spotfin shiner	2.7%	
	Gill Netting	**6.2%**			**10.8%**		
		Gizzard shad			Bluegill	0.9%	
				2.5	Gizzard shad	3.6%	**2.5**
					Golden shiner	0.9%	
					Largemouth bass	0.9%	
					Longnose gar	0.9%	
6. Percent dominance by one species	Electrofishing	**36.4%**			**57.6%**		
		Mississippi silverside		**1.5**	Mississippi silverside		**1.5**
	Gill Netting	**26.2%**			**32.7%**		
		Sauger		**1.5**	Sauger		**1.5**
7. Percent non-indigenous species	Electrofishing	**36.5%**			**57.9%**		
		Mississippi silverside	36.4%	**0.5**	Common carp	0.30%	**0.5**
		Redbreast sunfish	0.1%		Mississippi silverside	57.6%	
	Gill Netting	**NA**		**2.5**	**NA**		**2.5**

Table D-1. (Continued)

Autumn 2020 Metric		TRM 292.5 Obs		Score	TRM 295.9 Obs		Score
8. Number of top carnivore species	Combined	**12**			**13**		
		Black crappie			Black crappie		
		Flathead catfish			Bowfin		
		Largemouth bass			Flathead catfish		
		Rock bass			Largemouth bass		
		Sauger			Longnose gar		
		Skipjack herring		**5**	Sauger		**5**
		Smallmouth bass			Skipjack herring		
		Spotted bass			Smallmouth bass		
		Spotted gar			Spotted bass		
		Walleye			Spotted gar		
		White bass			Walleye		
		Yellow bass			White bass		
					Yellow bass		
B. Trophic composition							
9. Percent top carnivores	Electrofishing	**10.3%**			**8.7%**		
		Black crappie	0.3%		Black crappie	0.4%	
		Flathead catfish	0.5%		Bowfin	0.2%	
		Largemouth bass	6.2%		Flathead catfish	0.3%	
		Rock bass	0.1%	**2.5**	Largemouth bass	5.7%	**1.5**
		Smallmouth bass	2.9%		Sauger	0.1%	
		Spotted gar	0.2%		Smallmouth bass	0.2%	
		Yellow bass	0.1%		Spotted bass	0.2%	
					Spotted gar	1.4%	
					Yellow bass	0.1%	
	Gill Netting	**63.1%**			**72.7%**		
		Flathead catfish	1.5%		Flathead catfish	4.5%	
		Sauger	26.2%		Largemouth bass	0.9%	
		Skipjack herring	9.2%		Longnose gar	0.9%	
		Smallmouth bass	3.1%		Sauger	32.7%	
		Spotted bass	6.2%	**2.5**	Skipjack herring	10.9%	**2.5**
		Walleye	4.6%		Smallmouth bass	0.9%	
		White bass	6.2%		Spotted bass	4.5%	
		Yellow bass	6.2%		Spotted gar	0.9%	
					Walleye	2.7%	
					White bass	10.0%	
					Yellow bass	3.6%	

Table D-1. (Continued)

Autumn 2020 Metric		TRM 292.5 Obs		Score	TRM 295.9 Obs		Score
10. Percent omnivores	Electrofishing	**15.2%**			**12.0%**		
		Black buffalo	0.1%		Channel catfish	1.0%	
		Bluntnose minnow	0.5%		Common carp	0.3%	
		Channel catfish	1.9%	**2.5**	Gizzard shad	10.1%	**2.5**
		Gizzard shad	12.6%		Golden shiner	0.2%	
		Smallmouth buffalo	0.1%		Smallmouth buffalo	0.4%	
					Channel catfish	1.0%	
	Gill Netting	**32.3%**			**18.2%**		
		Blue catfish	6.2%		Black buffalo	0.9%	
		Channel catfish	20.0%		Channel catfish	9.1%	
		Gizzard shad	6.2%	**1.5**	Gizzard shad	3.6%	**1.5**
					Golden shiner	0.9%	
					Quillback	1.8%	
					Smallmouth buffalo	1.8%	
C. Fish abundance and health							
11. Average number per run	Electrofishing	**66.7**		**0.5**	**66.3**		**0.5**
	Gill Netting	**6.5**		**0.5**	**11.0**		**1.5**
12. Percent anomalies	Electrofishing	**0.6%**		**2.5**	**0.8%**		**2.5**
	Gill Netting	**1.5%**		**2.5**	**0.0%**		**2.5**
Overall RFAI Score				**46 Good**			**49 Good**

*12-21 “Very Poor”; 22-31 “Poor”; 32-40 “Fair”; 41-50 “Good”; 51-60 “Excellent”

Table D-2. Species collected, ecological and recreational designation and corresponding electrofishing (EF) and gill net (GN) catch per unit effort downstream (TRM 292.5) of Browns Ferry Nuclear Plant discharge – autumn 2020

Common Name	Scientific name	Trophic level	Native species	Tolerance	Heat Sensitive Species	Comm. Valuable Species	Rec. Valuable Species	EF Catch Per Run	EF Catch Per Hr	Total Fish EF	GN Catch Per Net Night	Total Fish GN	Total fish Combined	Percent Composition
Gizzard shad	*Dorosoma cepedianum*	OM	X	TOL	.	X	.	8.40	31.74	126	0.40	4	130	12.2
Spotfin shiner	*Cyprinella spiloptera*	IN	X	TOL	.	.	.	10.20	38.54	153	.	.	153	14.4
Bluntnose minnow	*Pimephales notatus*	OM	X	TOL	X	X	.	0.33	1.26	5	.	.	5	0.5
Redbreast sunfish	*Lepomis auritus*	IN	.	TOL	.	.	X	0.07	0.25	1	.	.	1	0.1
Green sunfish	*Lepomis cyanellus*	IN	X	TOL	.	.	X	1.00	3.78	15	.	.	15	1.4
Bluegill	*Lepomis macrochirus*	IN	X	TOL	.	.	X	2.60	9.82	39	.	.	39	3.7
Largemouth bass	*Micropterus salmoides*	TC	X	TOL	.	.	X	4.13	15.62	62	.	.	62	5.8
Skipjack herring	*Alosa chrysochloris*	TC	X	INT	.	X	.	.	.	.	0.60	6	6	0.6
Spotted sucker	*Minytrema melanops*	BI	X	INT	X	X	.	0.27	1.01	4	.	.	4	0.4
Rock bass	*Ambloplites rupestris*	TC	X	INT	.	.	X	0.07	0.25	1	.	.	1	0.1
Longear sunfish	*Lepomis megalotis*	IN	X	INT	.	.	X	4.60	17.38	69	0.10	1	70	6.6
Smallmouth bass	*Micropterus dolomieu*	TC	X	INT	.	.	X	1.93	7.30	29	0.20	2	31	2.9
Brook silverside	*Labidesthes sicculus*	IN	X	INT	.	X	.	0.07	0.25	1	.	.	1	0.1
Spotted gar	*Lepisosteus oculatus*	TC	X	.	.	X	.	0.13	0.50	2	.	.	2	0.2
Threadfin shad	*Dorosoma petenense*	PK	X	.	.	X	.	0.33	1.26	5	.	.	5	0.5
Emerald shiner	*Notropis atherinoides*	IN	X	.	X	.	.	0.60	2.27	9	.	.	9	0.8
Smallmouth buffalo	*Ictiobus bubalus*	OM	X	.	.	X	.	0.07	0.25	1	.	.	1	0.1
Black buffalo	*Ictiobus niger*	OM	X	.	.	X	.	0.07	0.25	1	.	.	1	0.1
Silver redhorse	*Moxostoma anisurum*	BI	X	.	.	X	.	0.07	0.25	1	.	.	1	0.1
Blue catfish	*Ictalurus furcatus*	OM	X	.	.	X	X	.	.	.	0.40	4	4	0.4
Channel catfish	*Ictalurus punctatus*	OM	X	.	.	X	X	1.27	4.79	19	1.30	13	32	3.0
Flathead catfish	*Pylodictis olivaris*	TC	X	.	.	X	X	0.33	1.26	5	0.10	1	6	0.6
White bass	*Morone chrysops*	TC	X	.	.	.	X	.	.	.	0.40	4	4	0.4
Yellow bass	*Morone mississippiensis*	TC	X	.	.	.	X	0.07	0.25	1	0.40	4	5	0.5
Redear sunfish	*Lepomis microlophus*	IN	X	.	.	.	X	4.53	17.13	68	0.10	1	69	6.5
Spotted bass	*Micropterus punctulatus*	TC	X	.	.	.	X	.	.	.	0.40	4	4	0.4
Black crappie	*Pomoxis nigromaculatus*	TC	X	.	.	.	X	0.20	0.76	3	.	.	3	0.3
Logperch	*Percina caprodes*	BI	X	.	X	.		0.80	3.02	12	.	.	12	1.1
Sauger	*Sander canadensis*	TC	X	.	X	.	X	.	.	.	1.70	17	17	1.6
Walleye	*Sander vitreus*	TC	X	.	X	.	X	.	.	.	0.30	3	3	0.3
Freshwater drum	*Aplodinotus grunniens*	BI	X	.	.	X	.	0.27	1.01	4	0.10	1	5	0.5
Mississippi silverside	*Menidia audens*	IN	.	.	.	X	.	24.27	91.69	364	.	.	364	34.2
Total			30		6	15	17	66.68	251.89	1,000	6.50	65	1,065	
Number Samples								15			10			
Species Collected								26			14			

An asterisk (*) denotes aquatic nuisance species. Trophic level: benthic invertivore (BI), herbivore (HB), insectivore (IN), omnivore (OM), planktivore (PK), parasitic (PS), specialized insectivore (SP), top carnivore (TC); Tolerance: tolerant species (TOL), intolerant species (INT);Comm.-Commercially, Rec.-Recreationally. All species are considered representative important species. No species collected have a Federal Threatened or Endangered status.

Table D-3. Species collected, ecological and recreational designation and corresponding electrofishing (EF) and gill net (GN) catch per unit effort upstream (TRM 295.9) of Browns Ferry Nuclear Plant discharge – autumn 2017

Common Name	Scientific name	Trophic level	Native species	Tolerance	Heat Sensitive Species	Comm. Valuable Species	Rec. Valuable Species	EF Catch Per Run	EF Catch Per Hr	Total Fish EF	GN Catch Per Net Night	Total Fish GN	Total fish Combined	Percent Composition
Longnose gar	*Lepisosteus osseus*	TC	X	TOL	.	X	.	.	.	.	0.10	1	1	0.1
Gizzard shad	*Dorosoma cepedianum*	OM	X	TOL	.	X	.	6.67	24.51	100	0.40	4	104	9.4
Common carp	*Cyprinus carpio*	OM	.	TOL	.	X	.	0.20	0.74	3	.	.	3	0.3
Golden shiner	*Notemigonus crysoleucas*	OM	X	TOL	.	X	.	0.13	0.49	2	0.10	1	3	0.3
Spotfin shiner	*Cyprinella spiloptera*	IN	X	TOL	.	.	.	1.80	6.62	27	.	.	27	2.4
Green sunfish	*Lepomis cyanellus*	IN	X	TOL	.	.	X	0.87	3.19	13	.	.	13	1.2
Bluegill	*Lepomis macrochirus*	IN	X	TOL	.	.	X	2.13	7.84	32	0.10	1	33	3.0
Largemouth bass	*Micropterus salmoides*	TC	X	TOL	.	.	X	3.80	13.97	57	0.10	1	58	5.3
Skipjack herring	*Alosa chrysochloris*	TC	X	INT	.	.	X	.	.	.	1.20	12	12	1.1
Northern hog sucker	*Hypentelium nigricans*	BI	X	INT	X	.	.	0.07	0.25	1	.	.	1	0.1
Spotted sucker	*Minytrema melanops*	BI	X	INT	X	X	.	0.87	3.19	13	.	.	13	1.2
Longear sunfish	*Lepomis megalotis*	IN	X	INT	.	.	X	5.40	19.85	81	.	.	81	7.3
Smallmouth bass	*Micropterus dolomieu*	TC	X	INT	.	.	X	0.13	0.49	2	0.10	1	3	0.3
Blackside snubnose darter	*Etheostoma duryi*	SP	X	INT	.	.	.	0.13	0.49	2	.	.	2	0.2
Spotted gar	*Lepisosteus oculatus*	TC	X	.	.	X	.	0.93	3.43	14	0.10	1	15	1.4
Bowfin	*Amia calva*	TC	X	.	.	X	.	0.13	0.49	2	.	.	2	0.2
Threadfin shad	*Dorosoma petenense*	PK	X	.	.	X	.	0.13	0.49	2	.	.	2	0.2
Largescale stoneroller	*Campostoma oligolepis*	HB	X	.	.	.	.	0.07	0.25	1	.	.	1	0.1
Quillback	*Carpiodes cyprinus*	OM	X	.	.	X	.	.	.	.	0.20	2	2	0.2
Smallmouth buffalo	*Ictiobus bubalus*	OM	X	.	.	X	.	0.27	0.98	4	0.20	2	6	0.5
Black buffalo	*Ictiobus niger*	OM	X	.	.	X	.	.	.	.	0.10	1	1	0.1
Golden redhorse	*Moxostoma erythrurum*	BI	X	.	.	X	.	.	.	.	0.10	1	1	0.1
Channel catfish	*Ictalurus punctatus*	OM	X	.	.	X	X	0.67	2.45	10	1.00	10	20	1.8
Flathead catfish	*Pylodictis olivaris*	TC	X	.	.	X	X	0.20	0.74	3	0.50	5	8	0.7
Blackstripe topminnow	*Fundulus notatus*	IN	X	.	.	.	.	0.07	0.25	1	.	.	1	0.1
White bass	*Morone chrysops*	TC	X	.	.	.	X	.	.	.	1.10	11	11	1.0
Yellow bass	*Morone mississippiensis*	TC	X	.	.	.	X	0.07	0.25	1	0.40	4	5	0.5
Warmouth	*Lepomis gulosus*	IN	X	.	.	.	X	0.20	0.74	3	.	.	3	0.3
Redear sunfish	*Lepomis microlophus*	IN	X	.	.	.	X	2.00	7.35	30	0.30	3	33	3.0
Hybrid sunfish	Hybrid *Lepomis* spp.	IN	.	.	.	.	X	0.07	0.25	1	.	.	1	0.1
Spotted bass	*Micropterus punctulatus*	TC	X	.	.	.	X	0.13	0.49	2	0.50	5	7	0.6
Black crappie	*Pomoxis nigromaculatus*	TC	X	.	.	.	X	0.27	0.98	4	.	.	4	0.4
Logperch	*Percina caprodes*	BI	X	.	X	.	.	0.47	1.72	7	.	.	7	0.6
Sauger	*Sander canadensis*	TC	X	.	X	.	X	0.07	0.25	1	3.60	36	37	3.4
Walleye	*Sander vitreus*	TC	X	.	X	.	X	.	.	.	0.30	3	3	0.3
Freshwater drum	*Aplodinotus grunniens*	BI	X	.	.	X	.	0.07	0.25	1	0.50	5	6	0.5
Mississippi silverside	*Menidia audens*	IN	.	.	.	X	.	38.20	140.44	573	.	.	573	51.9
Chestnut lamprey	*Ichthyomyzon castaneus*	PS	X	.	.	.	.	0.07	0.25	1	.	.	1	0.1
Total			35		5	16	17	66.29	243.68	994	11.00	110	1,104	
Number Samples								15			10			
Species Collected								31			21			

Asterisk (*) denotes aquatic nuisance species. Trophic level: benthic invertivore (BI), herbivore (HB), insectivore (IN), omnivore (OM), planktivore (PK), parasitic (PS), specialized insectivore (SP), top carnivore (TC); Tolerance: tolerant species (TOL), intolerant species (INT);Comm.-Commercially, Rec.-Recreationally. All species are considered representative important species. No species collected have a Federal Threatened or Endangered status.

Table D-4. Spatial statistical comparisons of numbers of species, mean electrofishing catch per unit effort values (number/run), tolerance designations, trophic levels, and non-indigenous individuals, including species richness and Simpson and Shannon diversity values, for samples collected near Browns Ferry Nuclear Plant, autumn 2020.

	Mean		Standard Deviation					
Parameter	**Upstream (TRM 295.9)**	**Downstream (TRM 292.5)**	**Upstream (TRM 295.9)**	**Downstream (TRM 292.5)**	**t-test Statistic β**	**z-test Statistic γ**	**P-value**	**Significant Difference?**
Species (per run)								
Total (species richness)	10.4	10.8	4.3	3.6	0.28	--	0.78	No
Benthic invertivores	0.9	0.9	0.8	0.9	--	-0.11	0.91	No
Insectivores	3.7	4.3	1.7	1.6	0.88	--	0.39	No
Omnivores	2.2	2.3	1.1	0.7	--	0.33	0.74	No
Top carnivores	2.4	3.4	1.3	1.8	--	1.50	0.13	No
Non-indigenous	1.1	0.9	0.5	0.5	--	-1.36	0.17	No
Tolerant	2.7	2.6	1.2	0.9	--	-0.17	0.86	No
Intolerant	1.4	2.1	1.1	0.7	--	2.15	0.04	Yes
Heat Sensitive	1.6	1.6	1.1	1.6	--	-0.34	0.73	No
CPUE (per effort)								
Total	2.9	3.5	2.0	2.3	--	0.81	0.42	No
Benthic invertivores	0.1	0.1	0.2	0.1	--	-0.51	0.61	No
Insectivores	3.4	3.2	2.9	2.0	--	0.04	0.97	No
Omnivores	0.7	0.8	0.8	0.7	--	1.12	0.27	No
Top carnivores	1.2	0.9	0.7	0.5	--	-0.87	0.39	No
Non-indigenous	2.6	1.6	2.5	1.7	--	-0.73	0.47	No
Tolerant	0.8	1.3	0.7	1.4	--	0.52	0.60	No
Intolerant	0.5	0.6	0.7	0.6	--	1.39	0.16	No
Heat Sensitive	0.4	0.3	0.3	0.4	--	-1.56	0.12	No
Simpson Diversity Index	0.7	0.7	0.2	0.2	--	0.46	0.65	No
Shannon Diversity Index	5.4	5.9	2.4	2.5	0.66	--	0.51	No

β - Comparing two population means from normally distributed independent samples. $n_1=n_2=15$, degree of freedom=$n_1+n_2-2=28$, $\alpha=0.05$, $t_{\alpha/2}=2.048$. H_o: $\mu_1=\mu_2$; H_o rejected if $t>t_{\alpha/2}$.

γ - Non-parametric Wilcoxon Rank Sum test on large independent samples. $\alpha=0.05$, $z_{\alpha/2}=1.96$. H_o: two sampled populations have identical probability distributions. H_o rejected if $P<\alpha$ or $|z|>z_{\alpha/2}$.

Table D-5. Comparison of RBI metric ratings and total scores for laboratory-processed samples collected upstream and downstream of Browns Ferry Nuclear Plant, Wheeler Reservoir, autumn 2020

	Downstream TRM 290.4		Downstream TRM 293.2		Upstream TRM 295.9	
Metric	**Obs**	**Rating**	**Obs**	**Rating**	**Obs**	**Rating**
1. Average number of taxa	10.4	5	9.4	5	10.0	5
2. Proportion of samples with long-lived organisms	1.0	5	0.9	3	1.0	5
3. Average number of EPT taxa	1.2	3	1.1	3	1.4	3
4. Average proportion of oligochaete individuals	7.7	5	10.3	5	11.1	3
5. Average proportion of total abundance comprised by the two most abundant taxa	63.2	5	66.2	5	64.7	5
6. Average density excluding chironomids and oligochaetes	678	5	635	5	1,040	5
7. Zero-samples – proportion of samples containing no organisms	0	5	0	5	0	5
Benthic Index Score		**33**		**31**		**31**
Ecological Health Rating		**Excellent**		**Excellent**		**Excellent**

Reservoir Benthic Index Score Range: 7-12 (“Very Poor”), 13-18 (“Poor”), 19-23 (“Fair”), 24-29 (“Good”), 30-35 (“Excellent”)

Table D-6. Ecological designations and mean densities per square meter of benthic macroinvertebrate taxa collected in samples downstream (TRMs 290.4 and 293.2) and upstream (TRM 295.9) of Browns Ferry Nuclear Plant during autumn 2020

Phylum (sub ph) Class	Order	Family (Subfamily)	Scientific Name	Estimated Mean Density (per m^2) DS TRM 290.4	DS TRM 293.2	US TRM 295.9	FFG[1]	Invasive Species
Annelida								
Hirudinea	Rhynchobdellida	Glossiphoniidae	*Actinobdella* sp.	2	---	---	PR	---
			Helobdella elongata	---	3	---	PR	---
			Helobdella stagnalis	3	2	---	PR	---
			Helobdella triserialis	---	2	---	PA	---
Oligochaeta	Haplotaxida	Naididae (Naidinae)		---	2	---	CG	---
			Dero sp.	12	10	----	CG	---
			Nais communis	---	---	13	CG	---
		(Tubificinae whc)	immature Tubificinae whc	10	13	15	CG	---
			Aulodrilus pigueti	---	3	2	CG	---
			Branchiura sowerbyi	13	7	---	CG	X
		(Tubificinae wohc)	immature Tubificinae wohc	58	70	58	CG	---
	Lumbriculida	Lumbriculidae		2	---	---	CG	---
Arthropoda (Crustacea)								
Malacostraca	Amphipoda	Corophiidae	*Apocorophium lacustre*	70	37	428	CF	X
		Gammaridae	*Gammarus* sp.	3	2	3	CG	---
		Talitridae	*Hyalella azteca*	---	---	2	CG	---
Insecta (Hexapoda)	Diptera	Chironomidae	*Ablabesmyia annulata*	28	8	2	PR	---
			Ablabesmyia mallochi	---	2	---	PR	---
			Chironomus sp.	---	3	3	CG	---
			Coelotanypus sp.	245	247	168	PR	---
			Cricotopus (Isocladius) sylvestris gp.	---	---	2	SH	---
			Cricotopus sp.	---	2	2	SH	---
			Cryptochironomus sp.	22	18	27	PR	---
			Dicrotendipes simpsoni	2	10	25	CG	---
			Dicrotendipes sp.	23	---	7	CG	---
			Glyptotendipes sp.	---	---	7	SH	---
			Polypedilum halterale gp.	2	2	---	SH	---
			Procladius sp.	8	3	8	PR	---
			Rheotanytarsus sp.	3	---	---	CF	---
	Ephemeroptera	Ephemeridae	*Hexagenia* sp. <10mm	53	148	127	CG	---
			Hexagenia sp. >10mm	168	152	98	CG	---
		Heptageniidae		---	---	2	SC	---
	Trichoptera	Leptoceridae	*Oecetis* sp.	3	2	10	PR	---
		Polycentropodidae	*Cyrnellus fraternus*	8	2	48	CF	---

Table D-6. (Continued)

Phylum (sub ph) Class	Order	Family (Subfamily)	Scientific Name	Estimated Mean Density (per m^2) DS TRM 290.4	DS TRM 293.2	US TRM 295.9	FFG[1]	Invasive Species
Mollusca								---
Bivalvia	Unionoida	Unionidae	*Truncilla donaciformis*	3	3	12	CF	---
			Truncilla truncata	---	2	---	CF	---
	Veneroida	Corbiculidae	*Corbicula fluminea* <10mm	47	8	20	CF	X
			Corbicula fluminea >10mm	93	37	88	CF	X
		Sphaeriidae	*Eupera cubensis*	2	---	---	CF	---
			Musculium transversum	135	180	158	CF	---
Gastropoda	Architaenioglossa	Viviparidae	*Campeloma decisum*	2	12	2	SC	---
			Lioplax sulculosa	---	---	2	SC	---
			Viviparus subpurpureus	20	12	7	SC	---
	Basommatophora	Ancylidae	*Ferrissia rivularis*	7	---	---	SC	---
	Neotaenioglossa	Hydrobiidae	*Amnicola limosa*	15	12	10	SC	---
			Somatogyrus sp.	13	17	5	SC	---
		Pleuroceridae	*Pleurocera canaliculata*	13	3	10	SC	---
Nemertea				---	---	2	PR	---
Platyhelminthes								---
Trepaxonemata	Neoophora	Planariidae	*Girardia tigrina*	17	2	7	PR	---
Number of Samples				**10**	**10**	**10**		
Mean Density/ meter²				**1107**	**1035**	**1378**		
Taxa Richness				**28**	**30**	**28**		
Total area sampled (m²)				**0.6**	**0.6**	**0.6**		

[1]Functional Feeding Group (FFG): assigned using the Ecological Tables at the end of each taxonomic chapter in An Introduction to the Aquatic Insects of North America (Merritt et. al, 2019) and Appendix B of EPA's Rapid Bioassessment protocols. CG=collector/gatherer; CF=collector/filterer; PA=parasite; PR=predator; SC=scraper; SH=shredder; PI=piercer

Table D-7. Ecological designations and mean densities per square meter of benthic macroinvertebrate taxa collected but not included in individual RBI metrics or total scores for sites downstream (TRMs 290.4 and 293.2) and upstream (TRM 295.9) of Browns Ferry Nuclear Plant during autumn 2020

Phylum (sub ph) Class	Order	Family (Subfamily)	Scientific Name	Estimated Mean Density (per m^2) DS TRM 290.4	DS TRM 293.2	US TRM 295.9	FFG[1]
Arthropoda (Chelicerata)							
Arachnida	Trombidiformes	Arrenuridae	*Arrenurus* sp.	7	---	2	PR
Arthropoda (Crustacea)							
Branchiopoda	Diplostraca	Sididae	*Sida crystallina*	---	---	15	---
Maxillopoda	Cyclopoida	Cyclopidae	*Mesocyclops edax*	---	---	2	---
Number of Samples				**10**	**10**	**10**	
Mean Density/ meter²				**7**	**---**	**19**	
Taxa Richness				**1**	**---**	**3**	
Total area sampled (m^2)				**0.6**	**0.6**	**0.6**	

[1]Functional Feeding Group (FFG): assigned using the Ecological Tables at the end of each taxonomic chapter in An Introduction to the Aquatic Insects of North America (Merritt et. al, 2019) and Appendix B of EPA's Rapid Bioassessment protocols. CG=collector/gatherer; CF=collector/filterer; PA=parasite; PR=predator; SC=scraper; SH=shredder; PI=piercer

Appendix E. Letter dated August 11, 2011 from Christopher B. Thomas, Chief, Pollution Control & Implementation Branch, Water Protection Branch, EPA Region 4 to Paul E. Davis, Director, Division of Water Pollution Control, TDEC, regarding EPA review and comments on the draft NPDES permit for TVA's Gallatin Fossil Plant (NPDES TN0005428)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

AUG 1 1 2011

Mr. Paul E. Davis
Director, Division of Water Pollution Control
Tennessee Department of Environment
and Conservation
6th Floor, L & C Annex
401 Church Street
Nashville, Tennessee 37243-1534

Dear Mr. Davis:

On May 19, 2011, the Environmental Protection Agency received for renewal the draft National Pollutant Discharge Elimination System (NPDES) permit for the Tennessee Valley Authority (TVA) Gallatin Fossil Plant, NPDES permit number TN0005428, which expired on November 29, 2009, and is being administratively continued. In a letter to you dated June 14, 2011, we requested up to 90 days to review the proposed permit in accordance with Section IV.B.6.c. of the Tennessee/EPA Memorandum of Agreement. We have completed our review and offer the following comments:

1. Technology-Based Limits for the Ash Pond

The NPDES permit must include numeric technology-based effluent limits (TBELs) for the ash pond (outfall 001) as required by the Clean Water Act (CWA) and implementing regulations. The CWA Section 301(a)(1) requires that permits include limitations based on the application of statutorily prescribed levels of treatment ("technology-based effluent limitations"). Where the EPA has not promulgated technology-based effluent guidelines for a particular class or category of industrial discharger, or where the technology-based effluent guidelines do not address all waste streams or pollutants discharged by the industrial discharger, the permitting authority must establish TBELs on a case-by-case basis in individual NPDES permits, based on its best professional judgment or "BPJ."

In October 2009, the EPA completed a study of wastewater discharges from both Flue Gas Desulfurization (FGD) and Coal Combustion Residuals (CCR) impoundments (i.e., ash ponds). Findings indicate the need for revised effluent guidelines (EGL) for these wastestreams to due to the potential for metals to exist in relatively high concentrations. The Agency plans to promulgate a revised EGL in 2013. In order to address these discharges during the interim period, on June 7, 2010, the EPA issued guidance entitled "*National Pollutant Discharge Elimination System (NPDES) Permitting of Wastewater Discharges from Flue Gas Desulfurization (FGD) and Coal Combustion Residuals (CCR) Impoundments at Steam Electric Power Plants.*" The record for the 1982 ELG indicates that Best Available Technology (BAT) was not established for fly ash or bottom ash transporter water in the final

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1982 rule. These wastewaters discharge from CCR impoundments. Thus, BAT-based limits would currently need to be established through BPJ for discharges from CCR impoundments.

Based on our review of the fact sheet, it does not appear that the Tennessee Department of Environment and Conservation (TDEC) examined pollutants expected to be present in the discharge from the CCR impoundment (i.e., ash pond) to establish appropriate TBELs as required by CWA § 301(a)(1) and applicable federal regulations at 40 Code of Federal Regulations (CFR) § 125.3 (applicable to state NPDES permit programs per 40 CFR § 125.25). Therefore, TDEC should reconsider the guidance and the obligations under CWA § 301 in this permit reissuance by evaluating the costs for TVA to install, at a minimum, chemical precipitation or biological treatment for the ash pond discharge in order to reduce the effluent discharge of metals. If the revised analysis still concludes that the existing pond is BAT, TDEC could establish TBELs that reflect the performance of the pond using reported effluent characteristic data for metals contained in the facility's Discharge Monitoring Reports and/or recent permit application.

2. Section 316(a) Report and the Study Plan for the Subsequent Permit

The draft permit lacks detail and does not generate information sufficient to support a CWA Section 316(a) variance determination for the next permit cycle. The EPA's comments are submitted in order to ensure that the study plan to be developed during the next permit cycle will generate information sufficient to support a determination of whether the TVA Gallatin Plant's thermal variance under Section 316(a) of the CWA can be approved.

The EPA recognizes that, under 40 CFR § 125.73(c), existing sources seeking variance renewal are not typically required to conduct the same detailed, comprehensive studies required under § 125.72(a) and (b). Also, under § 125.73, existing sources can base their demonstration on a lack of appreciable harm instead of completing predictive studies. However, under § 125.72(c), the type of detailed studies contemplated under § 125.72(a) and (b) can be required whenever determined to be necessary. After examining the record of prior 316(a) variance determinations for the TVA Gallatin Plant, the EPA has concerns regarding the need for a more thorough examination and definition of the Balanced and Indigenous Population (BIP), the identification of Representative Important Species (RISs), and a closer examination of whether the variance is protective. Given the thinness of the available record to justify prior variance determinations, the EPA believes a more focused study is needed. The EPA acknowledges that TVA has in the past collected a substantial amount of data in support of its variance. TVA may use existing data in completing its study and may incorporate the existence of such data into the study plan design; however, the existing data needs to be evaluated and presented in the context of a BIP definition that the existing record does not adequately provide.

Section 316(a) of the CWA contains the term "BIP" but does not define it. However, 40 CFR § 125.71(c) defines the term "balanced, indigenous community"[1] as:

> "A biotic community typically characterized by diversity, the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species and by a lack of domination

[1] "Balanced, indigenous community" and BIP are equivalent terms.

by pollution tolerant species. Such a community may include historically non-native species introduced in connection with a program of wildlife management and species whose presence or abundance results from substantial, irreversible environmental modifications. Normally, however, such a community will not include species whose presence is attributable to the introduction of pollutants that will be eliminated by compliance by all sources with section 301(b)(2) of the Act: and may not include species whose presence or abundance is attributable to alternative effluent limitations imposed pursuant to section 316(a)."

The Environmental Appeals Board stated in its decision in In Re Dominion Energy Brayton Point, LLC, 12 Environmental Appeals Decision (E.A.D.) 490 (2006)("Brayton Point"), "this definition clearly envisions a consideration of more than the population of organisms currently inhabiting the water body. In this vein, although it permits inclusion of certain 'historically non-native species' that are currently present, it explicitly excludes certain currently present species whose presence or abundance is attributable to avoidable pollution or previously-granted section 316(a) variances."

Page 557 of the Brayton Point E.A.D. goes on to further state that a BIP "can be the indigenous population that existed prior to the impacts of pollutants, not solely the current populations of organisms."

To the question of how a permittee should identify a BIP in an area that has been altered by impacts from an existing thermal discharge, the Brayton Point E.A.D. points out that it may be appropriate to use a nearby water body unaffected by the existing thermal discharge as a reference area. Examination of an appropriate reference area may be applicable in this case.

The definition of "balanced, indigenous community" at 40 CFR § 125.71(c) contains several key elements. To be consistent with the regulations, each of these key elements should be specifically addressed in the demonstration, and the Study Plan should be designed to generate information relevant to these elements. Those elements include: (1) "a population typically characterized by diversity at all trophic levels;" (2) "the capacity to sustain itself through cyclic seasonal changes;" (3) "presence of necessary food chain species;" (4) "non-domination of pollution-tolerant species;" and (5) "indigenous." Each of these elements is discussed in more detail below:

a. "A population typically characterized by diversity at all trophic levels" means that all of the major trophic levels present in the unaffected portion of the water body should be present in the heat-affected portions. The EPA recognizes that community structure differences will occur, however, the number of species represented in each trophic level in the unaffected portions should be reasonably similar in the heat-affected portions of the water body. Sampling and analysis of fish and invertebrate communities should be done such that the major trophic levels are identified and represented by reasonably similar species distributions. Also, the study plan should be expanded to include some observations of wildlife (i.e., water fowl, mammals, amphibians, etc.) both upstream and immediately downstream of the discharge point that may be impacted by the thermal discharge.

In keeping with the requirements of CWA Section 316, the plant needs to address the BIP's of the phyletic groups (amphibians, reptiles, birds, mammals) in the "wildlife" category. This group should be restricted to animals that are dependent on the receiving waters. For example, the blackbird population needs to be included but waterfowl or Kingfishers might be. Mammals that only drink from the receiving waters (i.e., whitetail deer) don't need to be included, but the beaver population might be. Once those BIPs are identified, the permittee should come up with a list of the wildlife species from all phyletic groups that may be affected by the temp changes in the receiving waters. The effects could be either direct or indirect depending on their dependence on the receiving water for habitat, food, etc. There may be several species of turtles present but some may be highly vulnerable and others not as much. The U.S. Fish and Wildlife Service and state wildlife agency can supply most, or all, of the information. Specifically, the plant should describe what effects the temperature changes might have on organisms that have habitats located near the point of discharge and depend on the receiving water body for survival. For example, amphibians can be affected directly in terms of survival and development of eggs and early life stages that are water dependent. Later, juvenile stages and adults could be affected by changes in prey items (food distribution) in the thermal affected area. All stages could be affected by increases in predation if warmer areas attract more predators. So for species for each group, the permittee needs to discuss the effects the thermal variance might have in regards to maintain a BIP of these organisms.

b. "The capacity to sustain itself through cyclic seasonal changes" means that any additional thermal stress will not cause significant community instability during times of natural extremes in environmental conditions. Community data should be collected during normal seasonal extremes as well as during optimal seasonal conditions. Data should be compared between heat affected and unaffected portions of the receiving water body to account for normal community changes corresponding with a change in season.

c. "Presence of necessary food chain species" means that the necessary food webs remain intact so that communities will be sustaining. We believe that exhaustive food web studies are not necessary provided that invertebrate, fish and wildlife communities are otherwise healthy, i.e., represented by sufficiently high species diversity and abundance (appropriate for that portion of the receiving water body) for the identified trophic levels and sustaining through normal seasonal changes.

d. "Non-domination of pollution-tolerant species" means that in the case of a thermal effluent, community assemblages in heat affected portions of the water body dominated by heat-tolerant species do not constitute a BIP. The EPA recognizes that because all species have varying levels of thermal tolerance, communities in the heat affected portions of the receiving water body may possess altered assemblages in terms of species present and abundance. All community data should be collected, analyzed and presented to clearly demonstrate that affected communities have not shifted to primarily heat tolerant assemblages.

e. "Indigenous" has been further clarified in the regulations: "Such a community may include historically non-native species introduced in connection with a program of wildlife management and species whose presence or abundance results from substantial, irreversible environmental modifications. Normally, however, such a community will not include species whose presence is attributable to the introduction of pollutants that will be eliminated by compliance by all sources with section 301(b)(2) of the Act and may not include species whose presence or abundance is attributable to alternative effluent limitations imposed pursuant to section 316(a)." The EPA recognizes that non-indigenous species are present in most aquatic systems in the United States. All community data should be analyzed and presented to demonstrate that community assemblages in the heat-affected portions of the receiving water body are not significantly different from non-affected communities with regard to the number of non-indigenous species in the assemblages.

In addition to the foregoing components of the BIP definition, the Study Plan should also include provisions for the identification of RIS (e.g., a list of threatened, endangered, thermally sensitive, or commercially or recreationally valuable species up- and downstream of the study area), as contemplated in 40 CFR § 125.72(b). 40 CFR § 125.71(b) defines RIS as "species which are representative, in terms of their biological needs, of a balanced, indigenous community of shellfish, fish and wildlife in the body of water into which a discharge of heat is made."

The following EPA comments should be specifically addressed in the study plan prior to TVA commencing sampling. The plan should:

i) include available information on wildlife in the receiving water body areas based on communications with the state's wildlife agency. See item a) above.

ii) include a diagram depicting the thermal plume under the worst case scenario and address the presence or absence of a zone of passage for which fish can travel around the thermal plume.

iii) provide information of which fish collected are either heat-sensitive or nuisance species. See item d) above.

iv) provide a list of any receiving water body species that are endangered or threaten in accordance with federal and state regulations.

v) select more appropriate sampling locations in order to avoid data that is difficult to interpret.

vi) analyze and present data to clearly demonstrate that affected communities have not shifted to primarily heat tolerant assemblages.

vii) analyze and present all data to demonstrate that community assemblages in the heat-affected portions of the receiving water body are not significantly different from non-affected communities with regard to the number of non-indigenous species in the assemblages.

viii) include recent data or information on benthic macroinvertebrates. See item a) above.

To reiterate, in order to ensure that TVA's future Study Plan is adequate to demonstrate that the Gallatin Plant should get continuance of a Section 316(a) variance during the term of its next NPDES permit, the EPA requests the opportunity to review a draft 316(a) plan prior to TVA commencing the study. Note that the above study elements are required for all facilities subject to a thermal variance. If you have any questions, please contact Ms. Karrie-Jo Shell of my staff at (404) 562-9308.

Sincerely,

Christopher B. Thomas, Chief
Pollution Control and Implementation Branch
Water Protection Division

cc: Ms. Linden P. Johnson
Manager, Water Permitting and Compliance
TVA - Environmental Affairs

Pinson, Theo

From: Phillips, Craig Lee <clphillips@tva.gov>
Sent: Thursday, March 20, 2025 3:40 PM
To: Pinson, Theo; Johnson, Chris L; Jackson, Scott A
Cc: Pearman, Paul Jonathan
Subject: Revised cover letter for TVA BFN MWAT Proposal
Attachments: MWAT Application cover_3 20 2025 - external.pdf

Theo,

As requested, see attached revised cover letter that better explains what BFN is requesting.

Thanks,

Craig L. Phillips
Specialist, Water Permits, Compliance, & Monitoring
Regulatory Environmental Programs

TENNESSEE VALLEY AUTHORITY

M. 865-599-6183 **E.** clphillips@tva.gov
400 West Summit Hill Drive, Knoxville, TN 37902

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TENNESSEE VALLEY AUTHORITY

1101 Market Street, BR 2C, Chattanooga, Tennessee 37402

Sent Via Electronic Submittal

March 20, 2025

Mr. Scott Jackson, Chief (scott.jackson@adem.alabama.gov)
Industrial Section, Water Division
Alabama Department of
Environmental Management
Permits and Services Division
1400 Coliseum Boulevard
Montgomery, Alabama 36110-2059

Dear Mr. Jackson:

TENNESSEE VALLEY AUTHORITY (TVA) – BROWNS FERRY NUCLEAR PLANT (BFN) – NPDES PERMIT NO. AL0022080 – MAXIMUM WEEKLY AVERAGE TEMPERATURE (MWAT) – PERMIT RENEWAL SUPPLEMENTAL INFORMATION

On November 14, 2024, TVA submitted a request to modify the calculation of BFN's NPDES permit 24-hour maximum discharge temperature limit to a MWAT limit. TVA would like to provide clarify to the original request. Current permitted thermal discharge limitations specify the hourly average maximum temperature is not to exceed 93° F (33.9 °C) and the 24-hour average maximum temperature is not to exceed 90° F (32.2 °C) at the end of the mixing zone (Part I, Page 1, NPDES permit AL0022080). The proposed MWAT is intended only as a calculation-based change from the current 90° F (32.2 °C) 24-hour average permit limit to a 7-day running average. The hourly average maximum temperature limit of 93° F (33.9 °C) would remain unchanged.

The MWAT approach offers predictability of a 7-day running average. Rather than causing an urgent plant derating due to one day's excessive high temperature, the MWAT lets operators observe an approaching period of ambient conditions that may reach or exceed the 90° F (32.2 °C) permit limit and better plan for needed operational changes (i.e., increased cooling tower use or plant derating). MWAT was first identified by the Environmental Protection Agency (EPA) in their Water Quality Criteria Blue Book (1972) for setting water quality standards and remails acceptable criteria by the EPA today.

If you have questions or need any additional information concerning this request, please contact Craig Phillips at (865) 599-6183 or by e-mail at clphillips@tva.gov.

Sincerely,



Paul Pearman
Senior Manager
Water Permits, Compliance, and Monitoring

cc (Electronic Distribution):

Mr. Chris Johnson (cljohnson@adem.alabama.gov)
Chief, Water Quality Branch
Water Division
Alabama Department of
Environmental Management
1400 Coliseum Boulevard
Montgomery, Alabama 36110-2059

Mr. Theo Pinson (tpinson@adem.alabama.gov)
Industrial Section
Industrial/ Municipal Branch
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Pinson, Theo

From: Figgures, Sharon Mclin <sdmclin@tva.gov>
Sent: Thursday, November 14, 2024 9:05 AM
To: Jackson, Scott A
Cc: Pinson, Theo; Phillips, Craig Lee; Pearman, Paul Jonathan
Subject: TVA - BFN MWAT Permit Renewal Supplemental Information
Attachments: MWAT Application cover_2024 - external.pdf

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Please find attached your copy of the subject.

Thanks

Sharon Figgures
Business Support Representative
Regulatory Environmental Programs

TENNESSEE VALLEY AUTHORITY

W. 423-751-7235 **M.** 706-639-7223 **E.** sdmclin@tva.gov
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TENNESSEE VALLEY AUTHORITY

1101 Market Street, BR 2C, Chattanooga, Tennessee 37402

Sent Via Electronic Submittal

November 14, 2024

Mr. Scott Jackson, Chief (scott.jackson@adem.alabama.gov)
Industrial Section, Water Division
Alabama Department of Environmental
Management
Permits and Services Division
P.O. Box 301463
Montgomery, Alabama 36130-1463

Dear Mr. Jackson:

TENNESSEE VALLEY AUTHORITY (TVA) – BROWNS FERRY NUCLEAR PLANT (BFN) – NPDES PERMIT NO. AL0022080 – MAXIMUM WEEKLY AVERAGE TEMPERATURE (MWAT) PERMIT RENEWALSUPPLEMENTAL INFORMATION

TVA requests to modify the calculation of BFN's NPDES permit 24-hour average maximum discharge temperature limit to a MWAT limit. Currently permitted thermal discharge limitations specify that the daily maximum temperature is not to exceed 93 °F (33.9 °C) at the end of the mixing zone (Part I, Page 1, NPDES permit AL0022080). The proposed MWAT is not a request to change the temperature limit; it is intended only as a calculation-based change to the current permit limit. The MWAT approach offers predictability of a 7-day running average of monitored temperature. Rather than causing an urgent plant derating due to one day's excessive high temperature, the MWAT lets operators observe an approaching period of ambient conditions that may reach or exceed it's permit limits and better plan for needed operational changes (i.e., cooling tower use or plant derating) under the existing permit temperature limits. MWAT was first identified by the Environmental Protection Agency (EPA) in their Water Quality Criteria Blue Book (1972) for setting water quality standards and remails acceptable criteria by the EPA today.

Enclosed is a report that provides additional information on this request. If you have any questions, or need any additional information concerning this request, please contact Craig Phillips at (865) 599-6183 or by e-mail at clphillips@tva.gov.

Sincerely,



Paul Pearman
Senior Manager
Water Permits, Compliance, and Monitoring

Enclosure

Enclosure
cc (Electronic Distribution w/ Enclosure):
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Industrial Section
Industrial/ Municipal Branch
Water Division
Alabama Department of Environmental Management
Post Office Box 301463
Montgomery, Alabama 36130-1463

TENNESSEE VALLEY AUTHORITY

Maximum Weekly Average Temperature Request for Thermal Compliance at Browns Ferry Nuclear Plant NPDES permit AL0022080

Limestone County, Alabama



Tennessee Valley Authority

November 12, 2024

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EXECUTIVE SUMMARY

This document sets forth a request by the Tennessee Valley Authority (TVA) to modify Browns Ferry Nuclear Plant's (BFN) NPDES permit (AL0022080) 24-hour average maximum discharge temperature limit to a Maximum Weekly Average Temperature (MWAT) limit. Over the last 15 years, Wheeler Reservoir has experienced several environmental events that have resulted in operational derates at Browns Ferry. Although infrequent, these events have the potential to increase in frequency due to factors outside of BFN's control. TVA, as a member of the Electric Power Research Institute (EPRI), reached out for assistance in identifying options for BFN given the challenge of fluctuations in Wheeler Reservoir. EPRI identified MWAT as a viable option for BFN's upcoming NPDES permit reissuance (see Attachment A). Furthermore, the EPA lists MWAT calculation as a criterion for discharge temperature when establishing water quality parameters and has issued multiple NPDES permits across EPA regions using this method. Since BFN began full operations in 1977, TVA has conducted extensive studies related to §316(a) which have consistently demonstrated that Wheeler Reservoir has maintained a balanced indigenous aquatic community. TVA believes the MWAT approach offers operational relief from the predictability of a 7-day running average of monitored temperature. Rather than causing an urgent plant derating due to one day's excessive high temperature, the MWAT lets operators observe an approaching period of ambient conditions that may reach or exceed its permit limits and better plan for needed operational changes (i.e., cooling tower use or plant derating, under the existing permit temperature limits).

1.0 Purpose and Need

Revising the current NPDES permit from a 24-hour average maximum discharge temperature to a maximum weekly average discharge temperature provides TVA Browns Ferry Nuclear Plant (BFN) and TVA River Operations with operational flexibility and prevents unnecessary derates during times of peak loading on the grid where critical infrastructure could be impacted.

TVA will not and cannot adjust operations to provide more power from this change. BFN Technical Specifications allow the plant units to generate a maximum of 3952 MWth per unit, which is monitored closely by the Unit Operators and strictly regulated by the Nuclear Regulatory Commission (NRC). BFN operates slightly below 3952 MWth per unit at all times, unless a condition in the plant interferes with this goal.

In the past, BFN has performed required derates due to NPDES discharge temperature limitations in 2007, 2010, and 2022. As the summer climate has been trending hotter, these derates have the potential to occur more frequently for longer periods of time.

TVA Nuclear and River Hydrothermal Teams monitor and model river temperatures and adjust river flows as necessary in order to stay within the bounds of the existing NPDES permit requirements. Changing weather patterns can move the predictor rapidly, and in these cases both TVA Nuclear and River Operations have to act quickly to prevent a derate.

- Nuclear Operations will respond to rising river temperatures by placing additional cooling towers in service, if available. The time periods where the NPDES restrictions would be applicable are associated with peak temperatures in the summer when all cooling towers are typically already in service. If available, maneuvering of plant equipment during these periods of high demand increases the risk associated with equipment failure or human error, that could result in a further de-rate or plant trip.

- If all available cooling towers are in service, Nuclear Operations will coordinate with the River Hydrothermal Team to evaluate the effectiveness of increased river flows past the plant. This option is typically limited, and frequently unavailable based on upstream lake levels. If river flows past the plant are increased, this can challenge the River Management team with maintaining lake levels to support recreational, commercial navigation, and environmental obligations later in the summer operating period.

If neither of these options are available, the plant will derate its power output to the grid in order to lower discharge temperatures.

Typically, if the daily permit limits for the downstream river temps are challenged, the grid is in a period of high energy demand due to elevated temperatures across the Tennessee Valley. Lowering power at the plant can place the enterprise into a power supply alert or even challenge grid stability

depending on the available generation versus demand. During these periods of high demand due to extreme temperatures, it is TVA's mission to supply reliable power to the people that we serve.

By altering the permit to a weekly average, there will be less frequent times when maneuvering the plant is necessary, which will increase the reliability to the grid, and modeling can more accurately predict and provide more time to ensure actions necessary to comply with the permit can be achieved.

From the Institute of Nuclear Power Operations (INPO) Tier 1 Principles Document 24-003, "Resiliency":

Critical infrastructure are the basic physical and organizational elements considered essential for a functioning society and deserving of special protection. They are critical in that their incapacitation or destruction would have a debilitating effect on national security, economic security, public health and safety, or combinations of these. Although elements of critical infrastructure may vary slightly from country to country, critical infrastructure sectors generally include those shown in Figure 1.

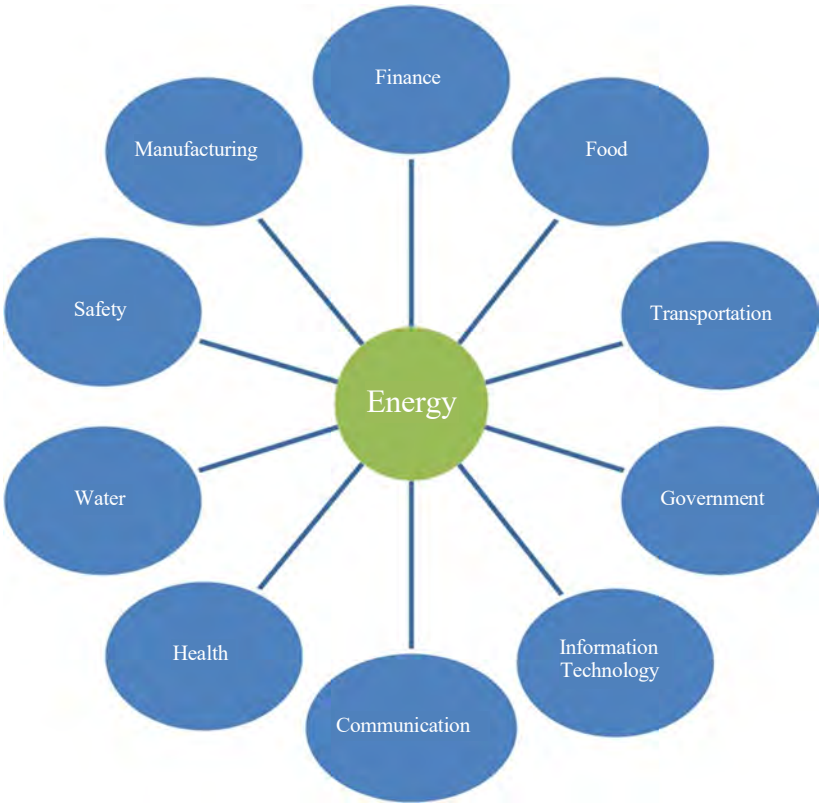


Figure 1. Critical Infrastructure Sectors

Energy is generally considered a *lifeline function* because it enables the functionality of all other critical infrastructure sectors. *Electricity* is a subsector of the energy sector, which also includes oil and gas industries. The electrical grid encompasses the entire network of electricity *generation* sources, including coal, oil, natural gas, nuclear, and renewables; *transmission* of bulk electricity over

longer distances from the generation sources to substations; and *distribution* of electricity over shorter distances from substations to consumers.

A significant or extended loss of the electricity subsector — regionally or nationally — would severely inhibit the capabilities of nearly all other critical infrastructure sectors. For example, the 2003 blackout that affected the northeastern U.S. and southern Canada was caused by the cascading loss of 508 electricity generating units. While some essential services remained online, cellular communications became congested and unreliable; water systems lost pressure, causing potential contaminations; airports, highway checkpoints, gas stations, and train stations halted operations; and affected factories shut down completely, while those in surrounding areas slowed production to reduce energy consumption. Tragically, up to 100 deaths were attributed to the blackout.

Because of our society's strong dependence on electricity in daily life and in enabling other essential functions, the grid network must be highly reliable and especially resilient in the face of external threats that, by affecting the electricity subsector, could disrupt multiple critical infrastructure sectors at once. This is being complicated by ever-increasing demands for electricity world-wide, especially carbon-free generation, such that grid operators everywhere are challenged with managing expansion while maximizing grid reliability. For example, in the U.S., the North American Electric Reliability Corporation (NERC) is tasked with the effective and efficient reduction of risks to the reliability and security of the grid under the oversight of the Federal Energy Regulatory Commission (FERC). To that end, NERC sets and enforces standards for all bulk power system owners, operators, and users that address, among other concerns, resiliency threats — examples include Critical Infrastructure Protection standards for physical and cyber security and requirements to protect assets against extreme weather.

Among electricity generating sources within the energy sector, nuclear power is already uniquely resilient. Its high energy density supports long-duration, uninterrupted, large-scale generation that is not subject to the availability of sunlight, wind or off-site fuel supplies. Regulatory requirements for the design of nuclear power plants ensure they can safely withstand the impacts from more severe external forces than other electricity generation sources. Although these characteristics provide the nuclear industry a unique advantage, ongoing challenges to the grid and the future threat landscape demand new, unified efforts to ensure operating margins and recovery capabilities are maintained.

2.0 Regulatory Basis

2.0.1 Permitted Conditions

Currently permitted thermal discharge limitations for BFN specify that the daily maximum temperature is not to exceed 93 °F (33.9 °C) at the end of the mixing zone (Part I, Page 1, NPDES permit AL0022080). This mixing zone criterion is based on a previous demonstration by TVA, in accordance with CWA §316(a) and ADEM Rule 335-6-10-.09 noted above, that a balanced

indigenous population (BIP) of fish, shellfish, and wildlife is supported in the Tennessee River potentially affected by the thermal discharge. The mixing zone criteria, as supported by the biological studies, also encompass other components of the ADEM temperature criteria, specifically the change in temperature from ambient/upstream conditions and the maintenance of daily and seasonal temperature variations. BFN has maintained a good compliance record with its mixing zone criteria throughout each NPDES permit term since first authorized in the late-1970s; ongoing biological monitoring has consistently demonstrated that the mixing zone criteria are protective of aquatic communities in the river near the facility.

2.1 Previous §316(a) demonstration study

Prior to construction and operation of BFN, TVA conducted comprehensive studies of fish populations in Wheeler Reservoir, initially to determine an inventory of the fish community and subsequently to monitor the status of the community. Since BFN began full operation in 1977, TVA has conducted extensive studies related to §316(a) demonstration, including:

- analysis of the effects of thermal variance on aquatic communities (conducted jointly with EPA) (TVA 1998)
- analysis and monitoring of the freshwater mussel community (TVA 1992)
- biological and environmental effects of physical changes made to the plant (TVA 2005, 2006)
- an overview of the conditions of Wheeler Reservoir (TVA 1990)
- hydrothermal modeling of proposed extended power uprates at the plant (TVA 2005)
- evaluation of water quality
- continued monitoring of the fish community (TVA 1978)
- monitoring of periphyton, phytoplankton, aquatic macrophytes, zooplankton, and benthic macroinvertebrates (TVA 2010)
- a supplemental §316(a) demonstration study of the BFN thermal effluent (TVA 1983)

Major findings of these studies included:

- Wheeler Reservoir behaves more like a large river, with comparatively high flow rates generally keeping water in the channel well-mixed with little stratification.

- Water temperature patterns in Wheeler Reservoir are constantly changing in response to varying meteorology and hydrology of the area. Spatial variations in water temperature occur between the main channel and the overbanks, with the overbanks more susceptible to extreme water temperatures.

- The reservoir has a notable gradient in dissolved oxygen (DO) concentration, decreasing from the surface to the bottom. Low DO concentrations are particularly evident during summer and fall seasons.

- Uprate of power production at BFN to 120% of original design capacity of units 2 and 3 was determined to have no significant thermal impact on the aquatic community of Wheeler Reservoir.

- Wheeler Reservoir contains diverse communities of phytoplankton, zooplankton, and benthic macroinvertebrates. Species richness in the benthic macroinvertebrate communities during pre-operational and operational monitoring was similar.

- Both diversity and abundance of freshwater mussels historically identified in Wheeler Reservoir, particularly of riverine species, have decreased significantly since impoundment of the Tennessee River. Species found currently include four endangered species, and the mussel community has diverged into two groups: those species that inhabit the old river channel and those that have colonized the overbanks. Two sections of Wheeler Reservoir upstream of BFN are currently maintained as mussel sanctuaries.

- Analysis of data for occurrence and abundance of fish species indicated no significant impacts due to operation of BFN, and avoidance of the plume was not detected for any species of fish.

- One study found that sauger (*Sander canadensis*) were not concentrated in the thermal plume during winter months nor inhibited from movement past BFN. Results of gonadal inspections indicate that the heated discharge did not adversely affect reproduction of cool-water fish.

- Phytoplankton, zooplankton and benthic macroinvertebrate communities downstream of BFN have been similar to those upstream during most years of operation, or if differences were noted, they were not attributable to operation of BFN.

2.2 Contemporary Studies

This section of the document is intended to provide an executive summary of conclusions of TVAs most recent summer sampling event (August 2024) to further demonstrate, in the context of EPA's interpretation of the regulatory definition of a BIP, that a BIP has been maintained for decades up to and including this most recent sampling event. Concluding that reasonable assurance that a BIP will be supported moving forward with the proposed calculation adjustment and continuance of the thermal variance for the plant discharge (Outfall DSN001).

This summer's sampling event was recently performed with intentions of developing a complete BIP report for submittal to ADEM for the next permit cycle. However, TVA feels a summer sample indicative of the most extreme thermal scenarios compared to historic autumn samples will aid in ADEM's current review process. TVA is still in process of a full analysis of the data collected, however, high level comparative conclusions from the data that is currently available can be supplemental to the proposal as it suggest a continued BIP.

Fish Community

TVA's multi-metric Reservoir Fish Assemblage Index (RFAI) attempts to address characteristics of a BIP in a holistic manner by measuring 12 population "metrics", scoring the metrics based on expectations of healthy populations in the region, and summing the scores to arrive at an overall RFAI score and subsequent rating. The maximum RFAI score attainable is 60. Ecological health ratings are then applied to the scoring ranges: 12-21 "Very Poor", 22-31 "Poor", 32-40 "Fair", 41-50 "Good", or 51-60 "Excellent".

It has generally been accepted that an RFAI rating of "Fair" or better in the thermally affected area can be considered demonstration of a BIP, particularly where RFAI scores for unaffected upstream areas are similar. A difference of six points or less between the thermally affected area and unaffected upstream area indicates statistical similarity of the fish communities between the two sites.

Evaluating the selected fish community metrics of the RFAI (Table 1), it is apparent that the fish community structure at the thermally affected downstream reach was similar to that of the thermally unaffected upstream reach in 2024. Additionally, there has been no significant shift in fish community structure at the downstream reach in summer 2024 when compared to the 2000-2022 Autumn sampling years (Table 2 and Figure 6).

Macroinvertebrate Community

The Same general assessment that was made in TVA's 2021 BIP, can also be made after including summer 2024 data. That is, the downstream reaches have scored in the "Excellent" range during eight of 13 sample years, and both "Good" and "Excellent" in an additional three sample years, including summer 2024 (Table 4). In addition, the status of the macroinvertebrate community structure, based on specific metrics regarding BIP Elements 1 (diversity at all trophic levels), 2 (sustainment through seasonal changes), and 3 (food chain species), demonstrates a seasonally abundant and diverse macroinvertebrate community present at both downstream and upstream reaches.

In summary, ecological conditions of benthic macroinvertebrate communities, when compared among the downstream and upstream reaches, have been "similar" since initiation of sampling and lab-processing of data in 2001. Results support the general conclusion that the BFN thermal effluent has had no adverse environmental impact on the benthic macroinvertebrate community downstream of the plant.

Zone of Passage

TVA collected depth profiles of temperature from the river bottom to the surface at points along transects to characterize and map the BFN thermal plume on the day fish community sampling occurred. Transects were located upstream of the discharge in an area not affected by the thermal plume (ambient), proximate to the thermal discharge point, and at various locations downstream of the discharge concentrated in the near field area of the plume where the change in plume temperature was expected to be most rapid. The total number of transects needed to fully characterize and delineate the plume was determined in the field.

On the date of the Summer 2024 survey, ambient water temperature profiles were collected approximately 4 river miles upstream of the BFN plant at TRM 297.8, and profiles to represent thermal discharge temperatures were collected at TRM 293.9. Profiles were also collected at TRM 293.2, TRM 292.3 and at TRM 291.2. These data indicated that the thermal plume (water temperatures greater than 2 °C or 3.6 °F above ambient temperatures) extended horizontally about halfway across the river from the discharge channel at TRM 294 and downstream to TRM 293.2. Data indicated that the thermal plume, as defined above, did not extend past TRM 293.2 and extended down to a maximum depth of 5 m at the discharge transect. In general, plume temperatures and elevated temperatures below the defined plume of 2 °C or 3.6 °F are limited to a depth of 1.5 m and extend to TRM 291.2.

All profiles used to characterize the thermal plume (Table 3) make clear that it is confined to the upper strata of the Tennessee River, indicating that an adequate zone of passage exists in the lower strata for fish to traverse the area of the reservoir around the plant.

Results of the permit monitoring work and TVA's ongoing Vital Signs monitoring (TVA, 2021) have consistently demonstrated that fish and macroinvertebrate assemblages of Wheeler Reservoir within and downstream of the BFN thermal discharge are similar to those of upstream locations, as well as to established mainstem reservoir reference conditions for the area. Because BFN's daily maximum temperature limits of 93 °F (33.9 °C) would not increase, TVA believes that fish and macroinvertebrate assemblages of Wheeler Reservoir within and downstream of the BFN thermal discharge would continue to be similar to those of upstream schedules

2.3 Studies/Permits with Maximum Weekly Average Approved by EPA

- EPA's 2021 Temperature Fact Sheet Temperature (epa.gov)

- EPA's "Well designed" Case studies included in *EPA's Thermal Discharges in NPDES Permits* manual - https://www.epa.gov/system/files/documents/2023-07/Thermal-Discharges-Report.pdf [epa.gov] (see example from SJEC (Section 5.3.4).

- Merrimack Station's NPDES Authorization (2024) - https://www3.epa.gov/region1/npdes/merrimackstation/pdfs/2024finalmod/finalnh0001465permitmodification-2024.pdf [epa.gov]

- Dresden Final 316(a) Demonstration Appendix B (003 Final DNS 316(a) Demonstration Appendix B 1. (nrc.gov) [nrc.gov])

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Technical Memorandum

October 1, 2024

TO: Mr. D. Scott Acselrod (TVA)

FROM: Mr. Doug Bradley (EPRI)

SUBJECT: **316(a) REPORTING PERIOD: BASIS FOR A SEVEN DAY ROLLING AVERAGE**

This memo concerns a proposed alternative temperature calculation that would be environmentally protective and provide additional flexibility for Tennessee Valley Authority (TVA) at the Browns Ferry Nuclear Plant (BFN) given the challenge of fluctuations in Wheeler Reservoir water temperatures.

1) BFN's current (2018) NPDES permit includes a continuation of its thermal variance, approved by EPA June 30, 1977. The variance grants the following conditions for BFN Outfall DSN00l,
    a) 10°F difference (ΔT) in the upstream ambient river temperature and the downstream river temperature,
    b) Maximum 24-hr average downstream temperature limit of 90°F and the daily downstream temperature shall not exceed 93°F (90/93°F),
    c) Compliance with downstream river temperature and temperature rise limitations shall be applicable at the edge of the mixing zone.
2) Over the last 15 years, Wheeler Reservoir has experienced several environmental events that have resulted in operational derates at BFN. Although infrequent, the perfect storm for these events occurs in the summer and includes long periods of reduced rain and the subsequent low river flows, and extended periods of high ambient temperatures. TVA has been working with EPRI and its consultants (Drs. Charles Coutant and Chris Yoder) to identify options under this 2018 NPDES permit review period that might provide marginal operational relief for the plant during these unusual but increasingly common weather events. These optional considerations should also,
    a) Adhere to the temperature limits of the ADEM permit and its thermal variance,
    b) Continue to maintain and support the aquatic life within Wheeler Reservoir, and
    c) Meet the intent of EPA's 316(a) guidance.
3) TVA, in working with the EPRI team, have identified a potential approach for providing operational flexibility under the increasingly frequent weather conditions. The following approach is intended only as a calculation-based change to its Maximum Average

Downstream Temperature to better plan and prepare BFN for such environmental operating conditions, without changing impacts to the aquatic biota.

a) Maximum Weekly Average Temperature (MWAT)
   i) Background – MWAT was first identified by EPA in their Water Quality Criteria Blue Book (1972) for setting water quality standards. It was included as a running average option in the WQ Standards tool kit and remains acceptable criteria by EPA.
   ii) More recently, EPA (2021) published its factsheet and recommends two types of maximum limit temperatures, *maximum temperature* for short-term exposure, and *maximum weekly average temperature* (MWAT) for one of the following,
      (1) *Protect against mortality in cooler months,*
      (2) *Protect for physiologically optimum temperature in warmer months,*
      (3) *Protect for successful migration, spawning, egg incubation, fry rearing, and other reproductive functions in reproductive seasons,*
      (4) *Preserve normal species diversity.*
   iii) The MWAT has also been used recently in 316(a) demonstrations to develop thermal limits (see Dresden Nuclear Station, 316(a) demonstration, 2016 [link]).
   iv) Note: This approach does not propose to change the existing max temperature limits (90/93°F), it's simply a change in the calculation of the existing collected monitoring data and how its reported.

b) BFN Representative Important Species Assessment
   i) The selection and assessment of representative important species (RIS) was then conducted using species documented in TVA's Balanced Indigenous Population (BIP) monitoring and reporting program for BFN (TVA 2018). From this dataset, the top 100 RIS were selected by Dr. Charles Coutant. Dr. Chris Yoder (MBI) then conducted an evaluation of key thermal metrics against the RIS thermal data using the Fish Temperature Modeling System (FTMS; Yoder 2008). FTMS assessed the species against three key, species-specific thermal metrics (Thermal Optimum (a measure of thermal affect related to growth), UAT (Upper Avoidance Temperature), UILT (Upper Incipient Lethal Temperature).Thermal metric temperatures were then established for the RIS to understand temperature thresholds related to both long- and short-term survival (Appendix A). These thermal metrics were also applied to the mainstem of the Ohio River (Yoder and Emery 2003).
   ii) The key results of this trial analysis found summer average temperatures for long-term survival of 86.9°F, and short-term max temperature of 90.5°F (Table 1).

Table 1. *Results of the Fish Temperature Modeling System (FTMS) for the Wheeler Reservoir Representative Important Species (RIS). Table shows the temperatures at which 50, 75, 90, or 100 percent of species would be protected using data at the lower extent of the existing mixing zone.*

	Temperature in °C (°F) at which a			
Category	**100%**	**90%**	**75%**	**50%**
Optimum	21.9 (71.4)	24.6 (76.3)	27.8 (82.0)	29.1 (84.4)
Growth (MWAG)	26.1 (79.0)	27.85 (82.2)	29.9 (85.8)	31.4 (88.5)
Avoidance (UAT)	28.8 (83.8)	30.5 (86.9)	30.95 (87.7)	32.2 (89.96)
Survival (LT)	**30.5[a] (86.9)**	31.2 (88.2)	32.4 (90.3)	33.95 (93.1)
Survival (ST)	**32.5[b] (90.5)**	33.2 (91.8)	34.4 (93.9)	35.95 (96.7)

[a] Summer period average. This long-term survival target for this parameter is at least 1:10 ratio of stress hrs (1) to recovery hrs (10). Stress hours are ≥ short term survival temperatures (ST).
[b] Summer period daily maximum. Using the stress-recovery concept, RIS would be protected 100% of the time, when summer maximum daily temperatures remain at or below 90.5°F (32.5C) for a 24hr period. RIS would further be protected for short duration exceedances (i.e., 3% or 129 minutes) that remain within 3 degrees above the summer daily maximum temperature (93.5°F).

iii) TVA then conducted analysis comparing its existing 24hr limit to a maximum weekly average temperature (MWAT) limit approach.
iv) Ten summer periods were identified and assessed comparing 24hr Ave Max and MWAT Max limits (Figures 1 and 2) These ten years were the hottest, driest years on record. Figures and tables showing temperature data for 2005-2023 are provided in Appendix B.
v) The long-term and short-term survival limits (Table 1) were then assessed against the 2005-2023 datasets. Among the 18-year dataset, only 7 total hrs (2 hrs in 2008 and 5 hrs in 2010) exceeded the maximum 93.5°F threshold for the daily maximum temperature within the edge of the mixing zone (Appendix B). Using the 1:10 (stress:recovery) ratio of exposure to recovery described in Bevelhimer and Bennett (2000) and Bevelhimer and Coutant (2007; see Appendix A), only one year (2010) fell below the 1:10 value. The year 2010 was unusually hot and had low precipitation within the Tennessee River Valley.
vi) TVA believes the 7-day running average approach offers operational relief. The operational relief comes from the predictability of a 7-day running average of monitored temperatures. Rather than causing an urgent plant derating due to one day's excessive high temperature, the 7-day running average lets operators observe an approaching period of ambient conditions that may reach or exceed its permit limits and better plan for needed operational changes (i.e., cooling tower use or plant derating, under the existing permit temperature limits).
vii) Based on the review of historical temperature data, this averaging adjustment continues to support the thermal protection needs of the RIS (Figures 1 and 2).

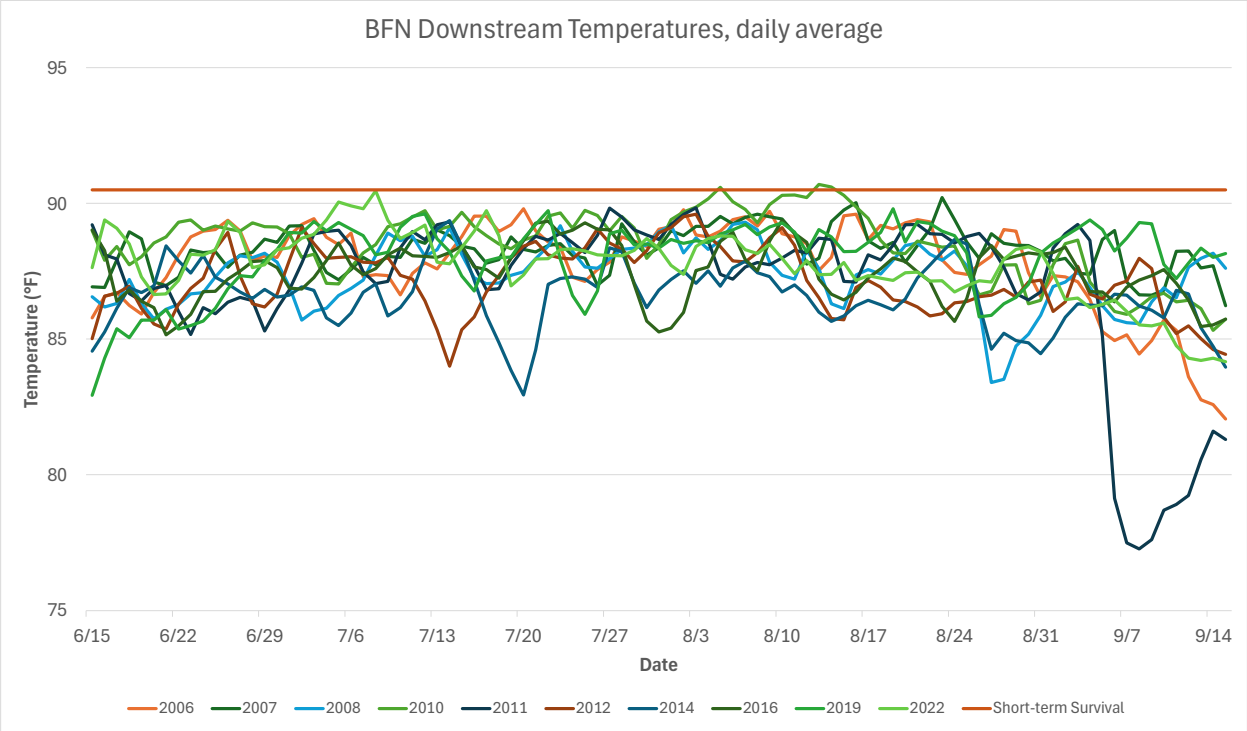


Figure 1. *The 24-hour average temperature (°F) at the edge of the BFN discharge plume during the summer of the hottest, driest years of record. The rust orange horizontal line indicates the short-term survival exposure maximum for all RIS species (90.5 °F).*

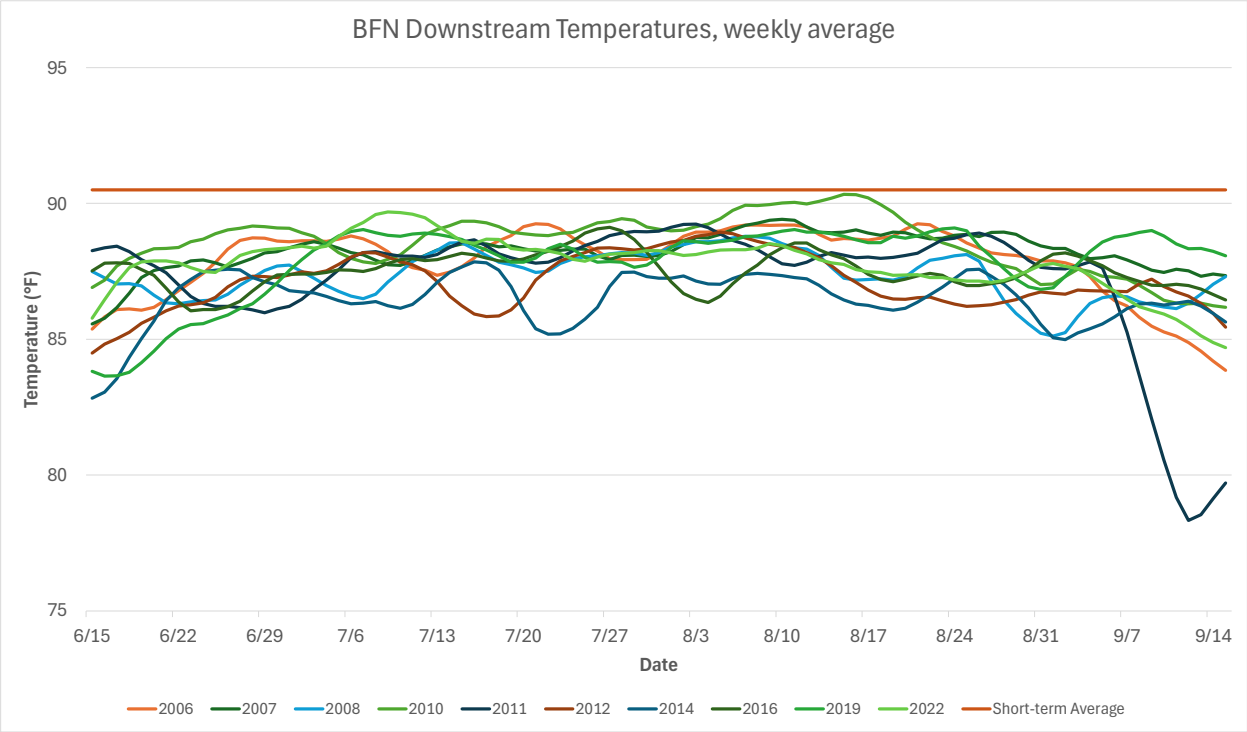


Figure 2. *The 7-day rolling average temperature (°F) at the edge of the BFN discharge plume during the summer of the hottest, driest years of record. The rust orange horizontal line indicates the short-term survival exposure maximum for all RIS species (90.5 °F).*

APPENDIX A
Fish Temperature Modeling

The Fish Temperature Modeling System (FTMS; Yoder 2008) was used to derive biologically protective temperature thresholds for Wheeler Reservoir. The FTMS was designed to provide summer average and maximum temperatures that are protective of short and long-term survival requirements of the most sensitive of Representative Important Species (RIS) that are specific to a region, a river or stream, or a reach of a river or stream, or other waterbody type. It incorporates endpoints for the protection of chronic behavioral and physiological thresholds such as avoidance and growth of selected RIS. The FTMS approach was first used to develop river and basin-specific monthly and bi-monthly average and maximum temperature criteria for Ohio rivers and streams in 1978. Examples of use include the Lower Des Plaines River (IL) in 2003, the Ohio River (ORSANCO) in 2005, the Connecticut River (MA) in 2012, and by Marathon Petroleum to execute a successful 316(a) Demonstration for their Robinson, IL refinery in 2016.

The FTMS is supported by a comprehensive thermal effects database compiled from the technical literature. The database includes laboratory and field studies and predominantly includes fish as they have long been determined to be the most sensitive aquatic assemblage to thermal stress. This database consists of seven thermal thresholds that include preferred/optimum, growth, avoidance, and lethal temperature endpoints for cold and warmwater fish species and selected macroinvertebrates. The four primary FTMS thermal tolerance variables (optimum, mean weekly average for growth, upper avoidance temperature, and upper incipient lethal temperatures) are used from the database as the primary FTMS input variables for determining protective temperature criteria for a set of RIS. Two additional variables are then calculated as measures of long-term survival and short-term survival (Yoder and Emery 2003), as defined below.

> **Optimum** – the temperature at which an organism can most efficiently perform a specific physiological or ecological function;
> **Growth** – the mean weekly average temperature for acceptable growth (MWAG);
> **Upper Avoidance Temperature (UAT)** – a sharply defined upper temperature at which an organism that a given acclimation temperature will avoid;
> **Upper Incipient Lethal Temperature (UILT)** – at a given acclimation temperature this is the maximum temperature beyond which an organism cannot survive for an indefinite period of time;
> **Long Term Survival** – This temperature is calculated by subtracting UILT - 2°C;
> **Short Term Survival** – This threshold temperature is equal to the UILT.

The selection of thermal tolerance endpoints is then made for each RIS based on geographical relevance and experimental variables such as the acclimation temperature of a tolerance endpoint using summer data. Non-summer (i.e., spring and fall) season criteria are not based on RIS tolerance endpoints because fish can tolerate temperatures that are well in-excess of non-summer season ambient temperatures. Criteria for these months are set to be consistent with the seasonal temperature regime allowing for seasonal acclimation (i.e., recovery) during the spring and fall periods. Table A1 defines the key terms used in the FTMS and temperature data analysis.

Table A1. *Key FTMS Terms*

Total Summer Period Hrs	Total hourly averaged measurements across the June 15-Sept 15 (summer) period.

Total Annual Hrs	Total hourly averaged measurements across the year, Jan 1- Dec 31
Summer daily average T (°F)	Average daily temperature for the summer period (from the permit monitoring data at the edge of the mixing zone)
Summer daily maximum T (°F)	Maximum daily temperature for the summer period (from the permit monitoring data at the edge of the mixing zone)
Hours ≤ 86.9°F	Hrs less than or equal to the long-term survival temperature. This is the mean annual weekly temperature for growth for the most thermally sensitive RIS. I.e., the average temperature (across the year) required for optimum growth for sensitive RIS. **These are the recovery period hours.**
Hours > 86.9°F	Hrs above the long-term survival temperature. This includes acceptable hrs of temperature exposure above the long-term survival temperature but below the upper avoidance temperature, as well as those above the upper avoidance temperatures.
Hours ≥ 90.5°F but ≤ 93.5°F	Hrs above the avoidance (maximum daily average temperature for the RIS) but below the upper incipient lethal temperatures (defined as 3°. above avoidance temperature). **These are the stress period hrs**
Hours >93.5°F	Hours above the incipient lethal temperatures
Ratio of Recovery:Stress	Ratio across the year of recovery hours (i.e. ≤ 86.9°F) to summer stress hrs (≥ 90.5°F but ≤ 93.5°F). This does not include temperatures above the upper incipient lethal temps assuming fishes are completely avoiding these temperatures in an open water environment.
Recovery:Stress Ratio < 10	Below target (10:1) ratio of annual recovery exposure hrs to stress exposure hrs
Recovery_Stress Ratio ≥ 10	Meeting or exceeding target (10:1) ratio of annual recovery exposure hrs to stress exposure hrs
Recovery_Stress Ratio ≥ 20	Meeting or exceeding target (20:1) ratio of annual recovery exposure hrs to stress exposure hrs. This value is included to depict the frequency of an order-of-magnitude above target recovery.

We used historical data from fish collections in Wheeler Reservoir during 1993–2023 to develop a list of RIS. The species occurrence data was first organized in an Excel spreadsheet to determine the rank order of fish species collected, excluding young-of-year age classes. Gizzard and Threadfin shad so overwhelmed the numbers that the percent abundance by species was calculated with and without shad to better determine the relative abundance of the other non-shad species. The RIS was further restricted to include species that had thermal data in the FTMS thermal tolerance database. Species that were represented by at least 100 fish and considered a resident of the reservoir proper were included (Table A2). Species that are transient in the reservoir and resident to the tributaries were excluded from the FTMS thermal tolerance analysis. Temperature-tolerance data for the most abundant and regularly occurring species were obtained from multiple studies published in the biological literature and tabulated. The fish species most sensitive to high temperatures had a limited abundance among samples (<1%), while those that were most abundantly represented are thermally tolerant.

Table A2. *Representative Important Species (RIS) based on numbers collected (greater than 100 individuals), whether they are resident species in Wheeler Reservoir, and for which thermal tolerance data were available in the FTMS database.*

RIS	Species	Number	Percentage	Percentage Excluding Shad	Resident	Transient
	Threadfin shad	366,843	48.24%		X	
X	Gizzard shad	286,846	37.72%		X	
X	Bluegill	27,973	3.68%	26.20%	X	
	Mississippi silverside	18,656	2.45%	17.47%	X	
X	Emerald shiner	9,583	1.26%	8.98%	X	
X	Largemouth bass	7,358	0.97%	6.89%	X	
X	Longear sunfish	4,262	0.56%	3.99%	X	
X	Skipjack herring	3,672	0.48%	3.44%	X	
	Yellow bass	3,603	0.47%	3.37%	X	
X	Channel catfish	3,471	0.46%	3.25%	X	
X	Spotfin shiner	2,616	0.34%	2.45%	X	
	Spotted sucker	2,411	0.32%	2.26%	X	
X	Freshwater drum	2,352	0.31%	2.20%	X	
X	Redear sunfish	2,328	0.31%	2.18%	X	
X	Spotted bass	2,277	0.30%	2.13%	X	
X	Smallmouth bass	2,064	0.27%	1.93%	X	
	Logperch	1,992	0.26%	1.87%	X	
X	White bass	1,816	0.24%	1.70%	X	
X	Smallmouth buffalo	1,764	0.23%	1.65%	X	
X	Green sunfish	1,632	0.21%	1.53%	X	
	Spotted gar	739	0.10%	0.69%	X	
X	Blue catfish	727	0.10%	0.68%	X	
X	Flathead catfish	678	0.09%	0.64%	X	
X	Golden shiner	532	0.07%	0.50%	X	
	Black redhorse	511	0.07%	0.48%		X
X	Sauger	478	0.06%	0.45%	X	
	Golden redhorse	471	0.06%	0.44%		X
X	Common carp	367	0.05%	0.34%	X	
X	Warmouth	354	0.05%	0.33%	X	
X	Longnose gar	271	0.04%	0.25%	X	
X	White crappie	269	0.04%	0.25%	X	
	Redbreast sunfish	222	0.03%	0.21%	X	
X	Striped bass	135	0.02%	0.13%	X	
X	Bullhead minnow	121	0.02%	0.11%	X	
X	Bigmouth buffalo	119	0.02%	0.11%	X	
X	Black buffalo	118	0.02%	0.11%	X	
X	Striped X White bass	110	0.01%	0.10%	X	
	Northern hogsucker	66	0.01%	0.06%		X
	Silver redhorse	60	0.01%	0.06%		X
	Yellow perch	57	0.01%	0.05%	X	
	Blackspotted topminnow	52	0.01%	0.05%	X	
	Threadfin X Gizzard Shad	49	0.01%	0.05%	X	

Table A2. *(Con't)*

RIS	Species	Number	Percentage	Percentage Excluding Shad	Resident	Transient
	Largescale Stoneroller	48	0.01%	0.05%		X
	River Redhorse	38	0.01%	0.04%		X
	Bowfin	37	0.01%	0.04%	X	
	Bluntnose minnow	36	0.01%	0.03%	X	
	Hybrid sunfish	36	0.01%	0.03%	X	
	Quillback	30	0.00%	0.03%		X
	Chestnut lamprey	25	0.00%	0.02%	X	
	Channel shiner	24	0.00%	0.02%	X	
	Walleye	20	0.00%	0.02%	X	
	Striped shiner	19	0.00%	0.02%		X
	Mimic shiner	18	0.00%	0.02%	X	
	River carpsucker	15	0.00%	0.01%	X	
	Stripetail darter	15	0.00%	0.01%		
	Yellow bullhead	14	0.00%	0.01%	X	
	Smallmouth redhorse	9	0.00%	0.01%		X
	Blackstripe topminnow	6	0.00%	0.01%	X	
	Blackside Snubnose Darter	5	0.00%	0.01%		
	Hybrid Bass	5	0.00%	0.01%		
	Steelcolor shiner	4	0.00%	0.00%		X
	Silver chub	4	0.00%	0.00%	X	
	River darter	4	0.00%	0.00%	X	
	Mooneye	4	0.00%	0.00%	X	
	Snubnose Darter	3	0.00%	0.00%		
	Shortnose darter	3	0.00%	0.00%		
	Lake sturgeon	2	0.00%	0.00%	X	
	Rock bass	2	0.00%	0.00%		X
	Bigeye chub	1	0.00%	0.00%		X
	Black bullhead	1	0.00%	0.00%	X	
	Blue sucker	1	0.00%	0.00%		
	Central stoneroller	1	0.00%	0.00%		X
	Total All Species	760,455	100.00%			
	Total Shad	653,689				
	Total All Less Shad	106,766		100.00%		

The Wheeler RIS input variables for the FTMS were selected from the FTMS which lists them in phylogenetic order and then sorted by the Upper Incipient Lethal Temperature (UILT) with the most sensitive of the RIS listed first. White crappie was the most sensitive of the RIS followed by Sauger and Redear sunfish (Table A3). The principal FTMS output are short-term and long-term survival thresholds. The long-term survival output serves as the summer period average temperature limitation and the short-term survival output serves as the daily maximum limitation.

Table A3. RIS species sorted by temperature sensitivity.

Common Name	Optimum °C	MWAT Growth °C	Upper Avoidance °C	UILT °C	Latin Name
White Crappie	28.6	29.9	30.8	32.5	*Pomoxis annularis*
Sauger	23.9	26.9	30.3	32.9	*Stizostedion canadense*
Warmouth Sunfish	25.1	27.7	28.8	32.9	*Lepomis gulosus*
Freshwater Drum	29.1	30.5	31.2	33.4	*Aplodinotus grunniens*
Golden Shiner	27.8	29.9	30.7	34.0	*Notemigonus crysoleucas*
Skipjack Herring	27.3	29.6	30.7	34.3	*Alosa chrysochloris*
Redear Sunfish	21.9	26.1	30.3	34.4	*Lepomis microlophus*
Largemouth Bass	29.1	30.9	31.6	34.5	*Micropterus salmoides*
Emerald Shiner	27.0	29.5	31.1	34.5	*Notropis atherinoides*
Smallmouth Bass	30.0	31.6	32.0	34.7	*Micropterus dolomieui*
Green Sunfish	27.8	30.3	30.9	35.3	*Lepomis cyanellus*
Gizzard Shad	30.0	31.9	34.0	35.8	*Dorosoma cepedianum*
Longear Sunfish	24.1	28.0	31.8	35.9	*Lepomis megalotis*
Spotted Bass	30.6	32.4	33.3	36.0	*Micropterus punctulatus*
Spotfin Shiner	29.8	31.9	33.7	36.0	*Cyprinella spiloptera*
Striped Bass	28.5	31.1	31.1	36.3	*Morone saxatalis*
Bluegill Sunfish	30.4	32.4	33.8	36.4	*Lepomis macrochirus*
Str. Bass X Wh. Bass	28.7	31.3	32.4	36.5	HYBRID
Bigmouth Buffalo	29.9	32.1	33.3	36.6	*Ictiobus cyprinellus*
Blue Catfish	30.9	33.0	33.9	37.2	*Ictalurus furcatus*
Bullhead Minnow	31.7	33.6	35.0	37.3	*Pimephales vigilax*
Common Carp	31.5	33.4	34.9	37.3	*Cyprinus carpio*
Smallmouth Buffalo	28.5	31.5	34.1	37.4	*Ictiobus bubalus*
Longnose Gar	32.5	34.3	34.5	37.8	*Lepisosteus osseus*
Flathead Catfish	31.1	33.4	34.7	38.0	*Pylodictis olivaris*
Channel Catfish	31.1	33.5	34.8	38.3	*Ictalurus punctatus*
Spotted Sucker	24.8	26.9	27.0	31.0	*Minytrema melanops*
Logperch	22.0	23.3	22.7	31.5	*Percina caprodes*

Applying the FTMS results for the long and short-term survival include the following, based on temperature stress: recovery concept described by Bevelhimer and Bennett (2000) and Bevelhimer and Coutant (2007):

1. The short-term survival of the most sensitive of the RIS is applied as a not-to-exceed maximum daily value during the selected summer period of June 15–September 15;

2. Exceedances of the daily maximum are allowed provided they occur over a cumulative period not exceeding 3% of the hours and never exceeding the maximum by more than 3°F;
3. The long-term survival of the most sensitive of the RIS is applied as a period average over the selected summer period of June 15–September 15. This average is applied as a summer period average for long term survival (most sensitive fish can survive this temperature through the summer) and, in the future, could replace the ΔT which has been determined to have no biological relevance;
4. A ratio of one hour of exceedance of the daily maximum to 10 hours below the period average is also required to assure that heat stress periods are adequately offset by heat stress recovery periods (i.e., stress:recovery ratio of 1:10; Figure A1). An example of prior use of this concept in a 316(a) Demonstration is provided in Figure A2.

The point of compliance is at the edge of the permit defined mixing zone, which is notably small for the volume of thermal effluent from BFN, and relative to the overall size and complexity of the discharge region of Wheeler Reservoir. The 2005–2023 compilation of temperature duration values were assessed and summarized in Table A4. The data shows that the ratio of stress:recovery was less than 1:10 in only a single year, 2010, when the ratio was 1:5. The other BFN data years exceeded these ratios, suggesting adequate recovery periods for all other years of data. A future 316(a) demonstration may evaluate the value of a more size appropriate mixing zone that would likely increase the recovery component of the marginal ratios.

Table A4. *Summarized data from the 2005-2023 data from the TVA NPDES monitoring program for BFN. The data are from the reported data collected at the downstream edge of the BFN mixing zone. Definitions of the parameters are found in Table A1 (above).*

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Summer Average Temp (°F)	85.0	86.3	86.6	85.3	84.0	87.0	84.8	85.1	82.2	84.4
Hours ≤ 86.9°F	1609	1216	1228	1658	1972	961	1636	1679	2226	2060
Hours > 86.9°F	623	1016	1004	574	260	1271	596	553	6	172
Hours ≥ 90.5°F but ≤ 93.5°F	6	24	37	24	2	182	21	15	0	5
Hours > 93.5°F	0	0	0	2	0	5	0	0	0	0
Ratio of Recovery/Stress Hours	268	51	33	64	986	5	78	112	*	412

Table A4. *(Con't)*

	2015	2016	2017	2018	2019	2020	2021	2022	2023
Summer Average Temp (°F)	84.9	86.1	82.7	84.7	84.5	84.9	83.4	85.4	84.0
Hours ≤ 86.9°F	1645	1571	1988	2049	1883	1733	2070	1565	1984
Hours > 86.9°F	587	661	244	183	349	499	162	667	248
Hours ≥ 90.5°F but ≤ 93.5°F	6	44	11	2	5	30	5	24	0
Hours > 93.5°F	0	0	0	0	0	0	0	0	0
Ratio of Recovery/Stress Hours	274	36	181	1025	377	58	414	65	*

The presence of populations of temperature sensitive species like Sauger during extreme hot and dry years (e.g., 2010) suggests that they have access to cooler refuges when summer temperatures in Wheeler Reservoir exceed known tolerance limits. A future demonstration may document these thermal refuge regions for the aquatic biota.

The following figures (Figure A1 and A2) provide a graphic depiction of the stress:recovery concept (Figure A1) as well as an applied FTMS approach used in the successful thermal limit modification for the Marathon Petroleum Company project in Illinois.

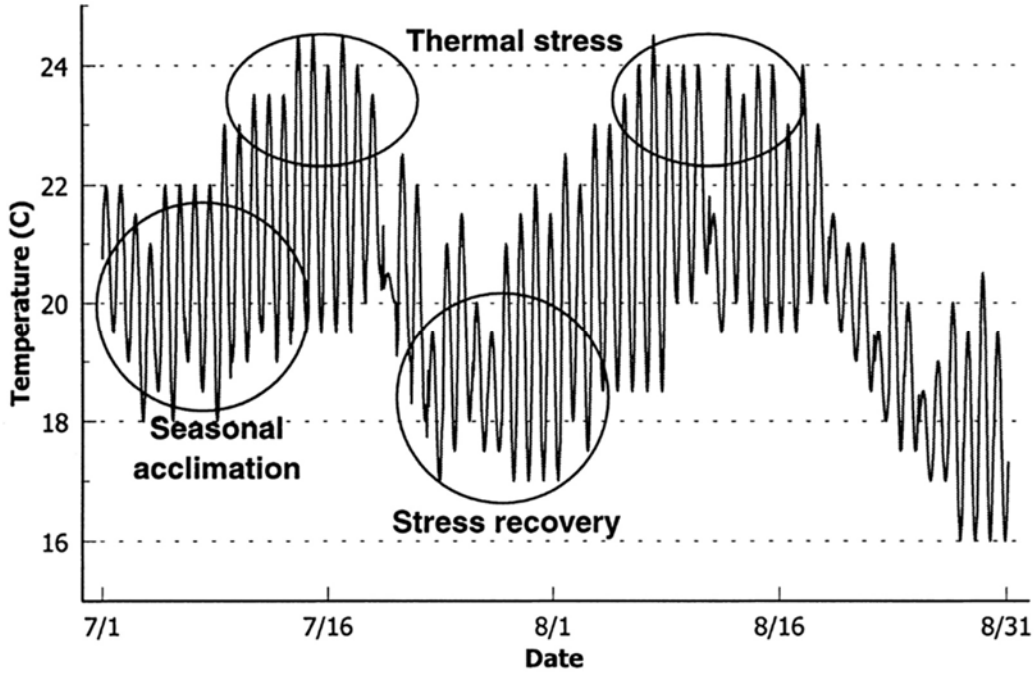


Figure A1. *Factors that affect thermal stress accumulation in fish in environments with fluctuating temperatures (after Bevelhimer and Bennet 2000).*

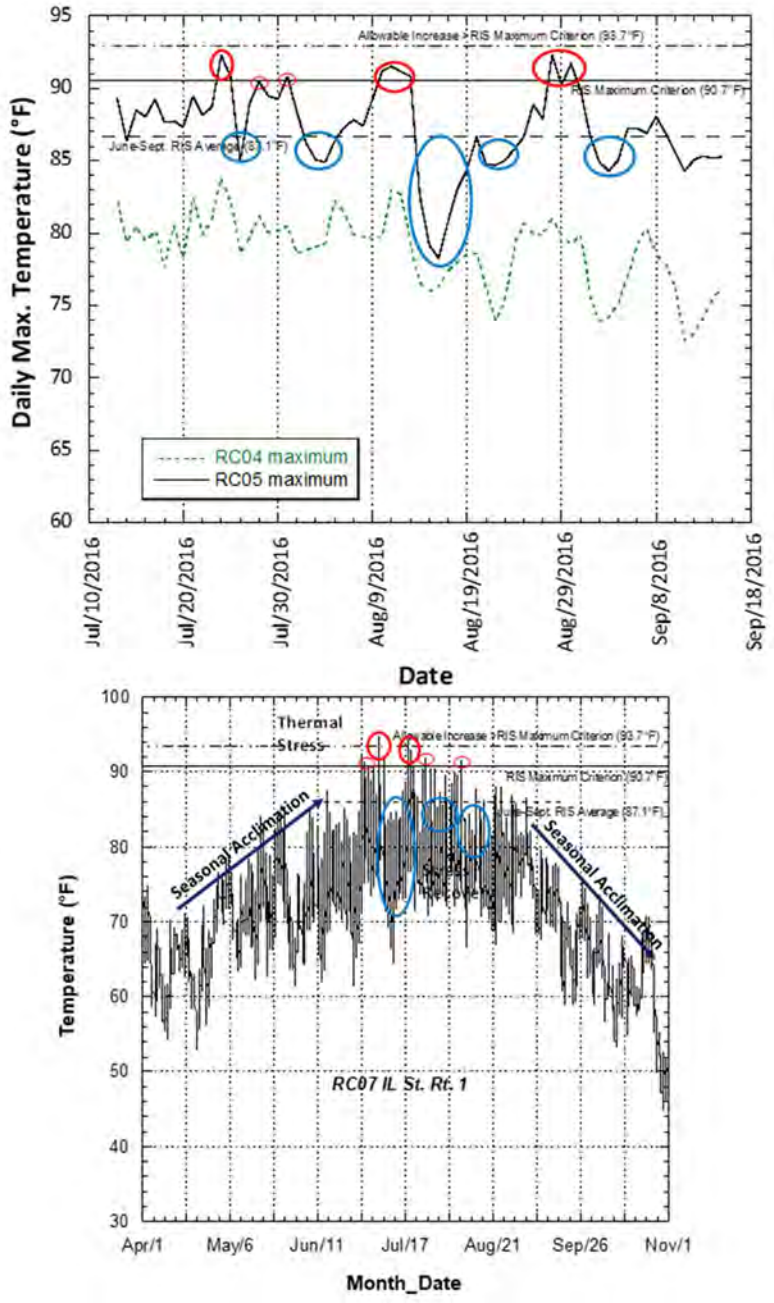


Figure A2. *Daily temperature profile of Robinson Creek immediately downstream from the Marathon Petroleum Company discharge (upper) and 2012 modeled temperature at IL Rt. 1. The FTMS maximum temperature threshold of 90.7°F is shown along with the 87.1°F FTMS summer season average threshold and the Illinois 3°F not-to-exceed the 90.7°F maximum. Red ellipses indicate periods of thermal stress and blue circles indicate subsequent periods of stress recovery (after Bevelhimer and Bennet 2000).*

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Yoder, C. O., and E. B. Emery. 2003. Updating a temperature criteria methodology for the Ohio River mainstem. ORSANCO (Ohio River Valley Water Sanitation Commission) temperature criteria reevaluation. November 27, 2003.

APPENDIX B
24-HOUR AND 7-DAY ROLLING AVERAGE TEMPERATURES (2005-2023)

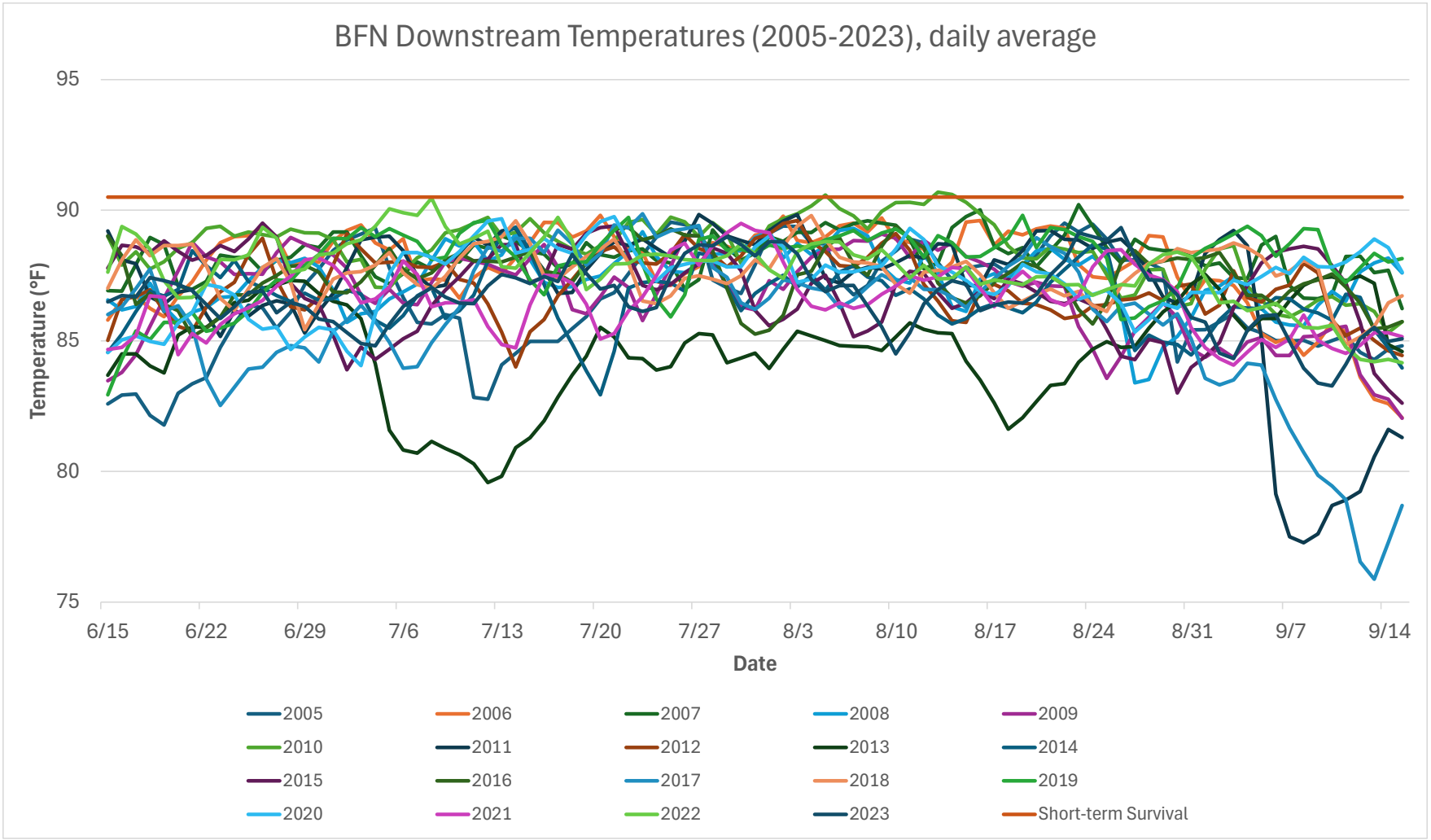


Figure B1. The 24-hour average temperature (℉) at the edge of the BFN discharge plume during the summer (2005-2023). The rust orange horizontal line indicates the average temperature. The rust orange horizontal line indicates the short-term survival exposure maximum for all RIS species (90.5 ℉).

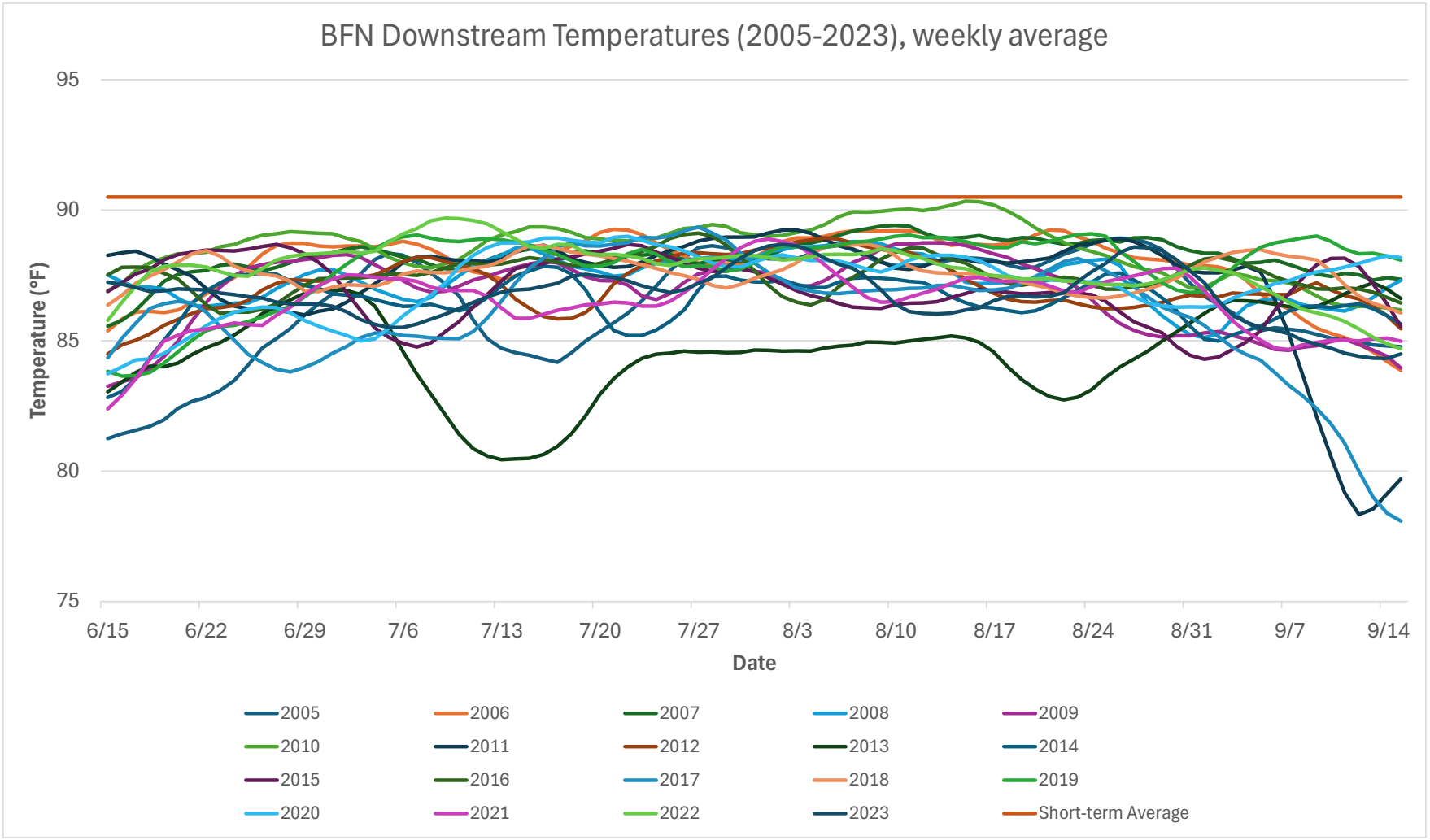


Figure B2. The 7-day rolling average temperature (℉) at the edge of the BFN discharge plume during the summer (2005-2023). The rust orange horizontal line indicates the short-term survival exposure maximum for all RIS species (90.5℉).

FIGURES

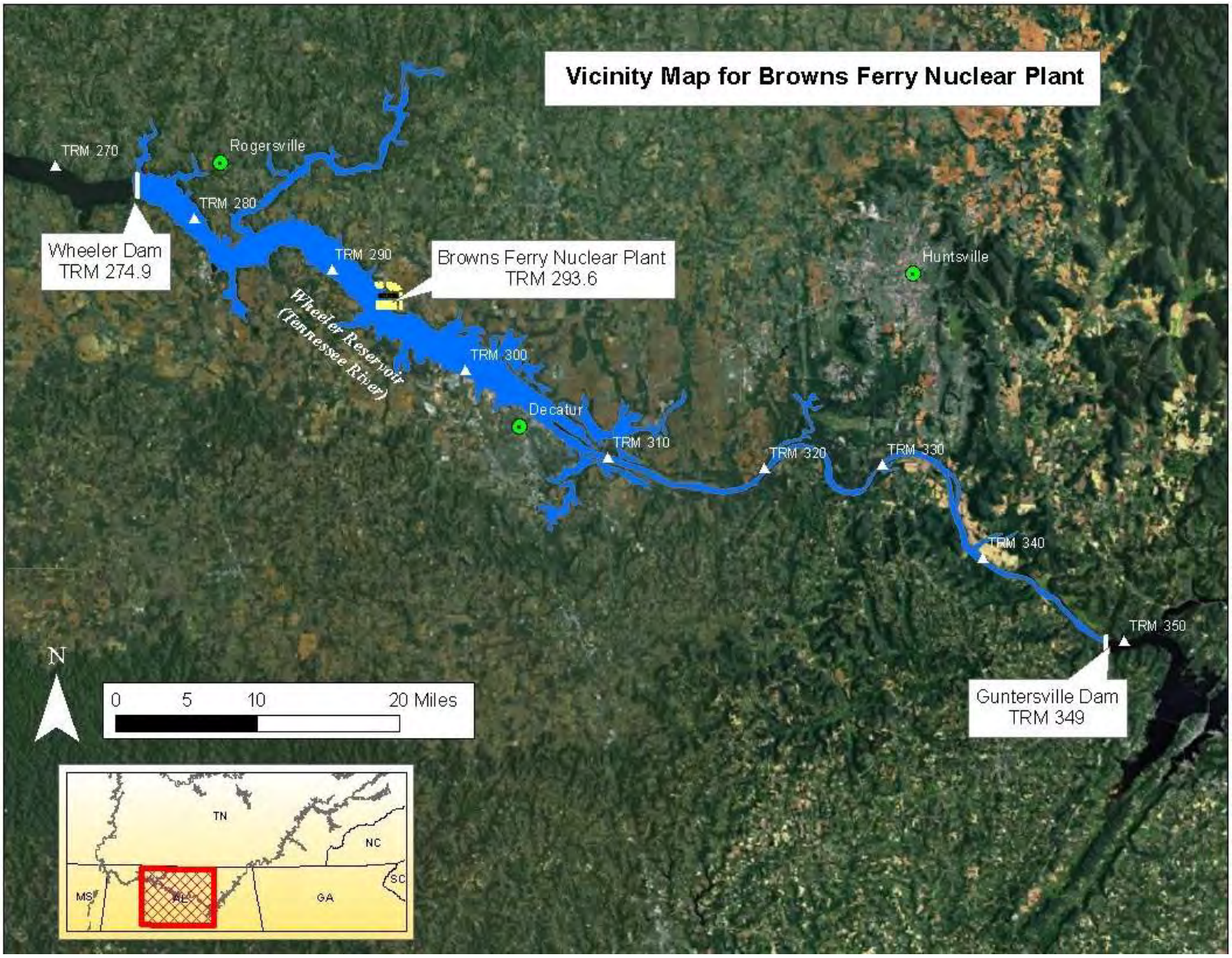


Figure 1. Vicinity map for Browns Ferry Nuclear plant depicting the locations of Wheeler and Guntersville Dams.



Figure 2. Site map for Browns Ferry Nuclear plant showing condenser cooling water intake structure, skimmer boom, and NPDES-permitted discharge Outfall DSN001.

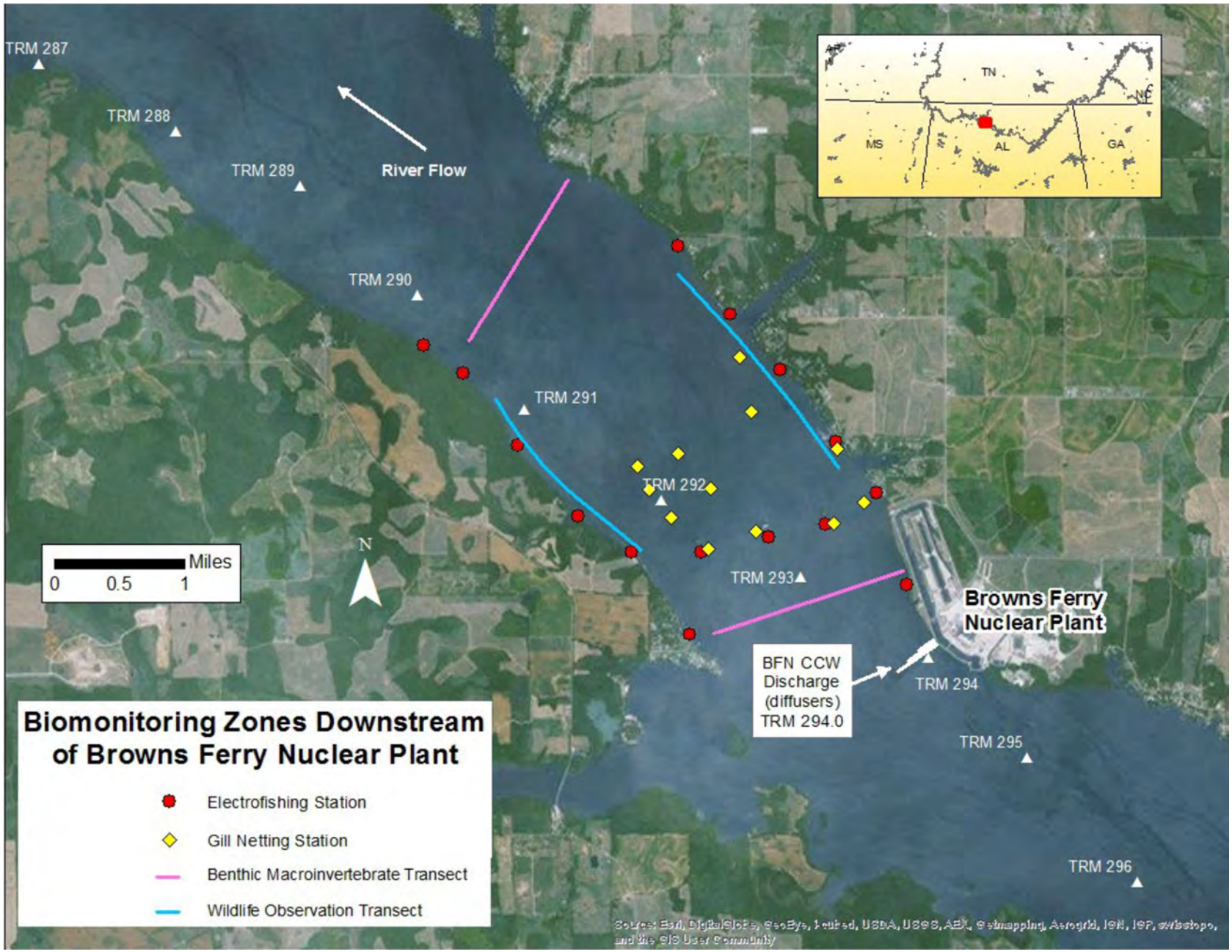


Figure 3. Biological monitoring zone downstream of Browns Ferry Nuclear plant.

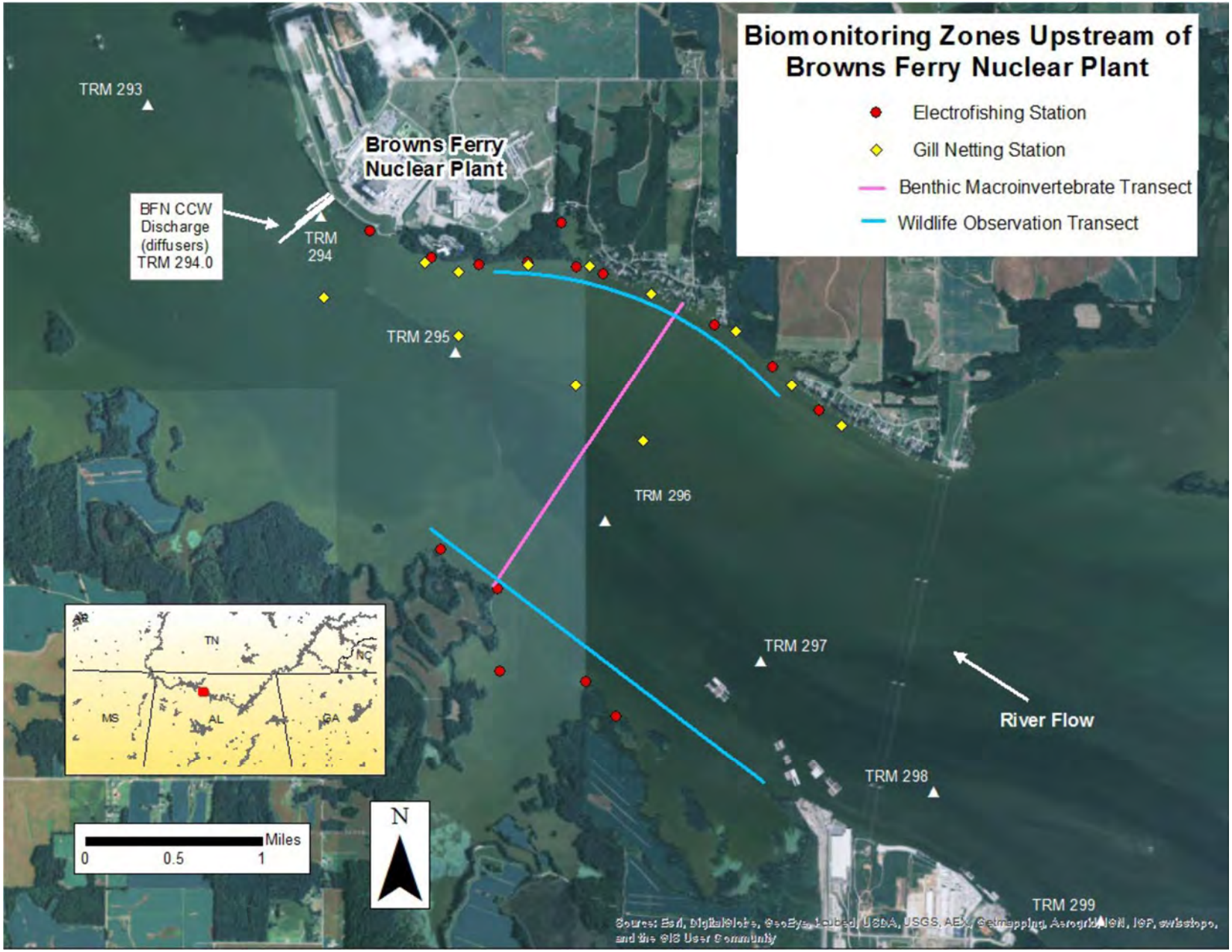


Figure 4. Biological monitoring zone upstream of Browns Ferry Nuclear plant thermal discharge.

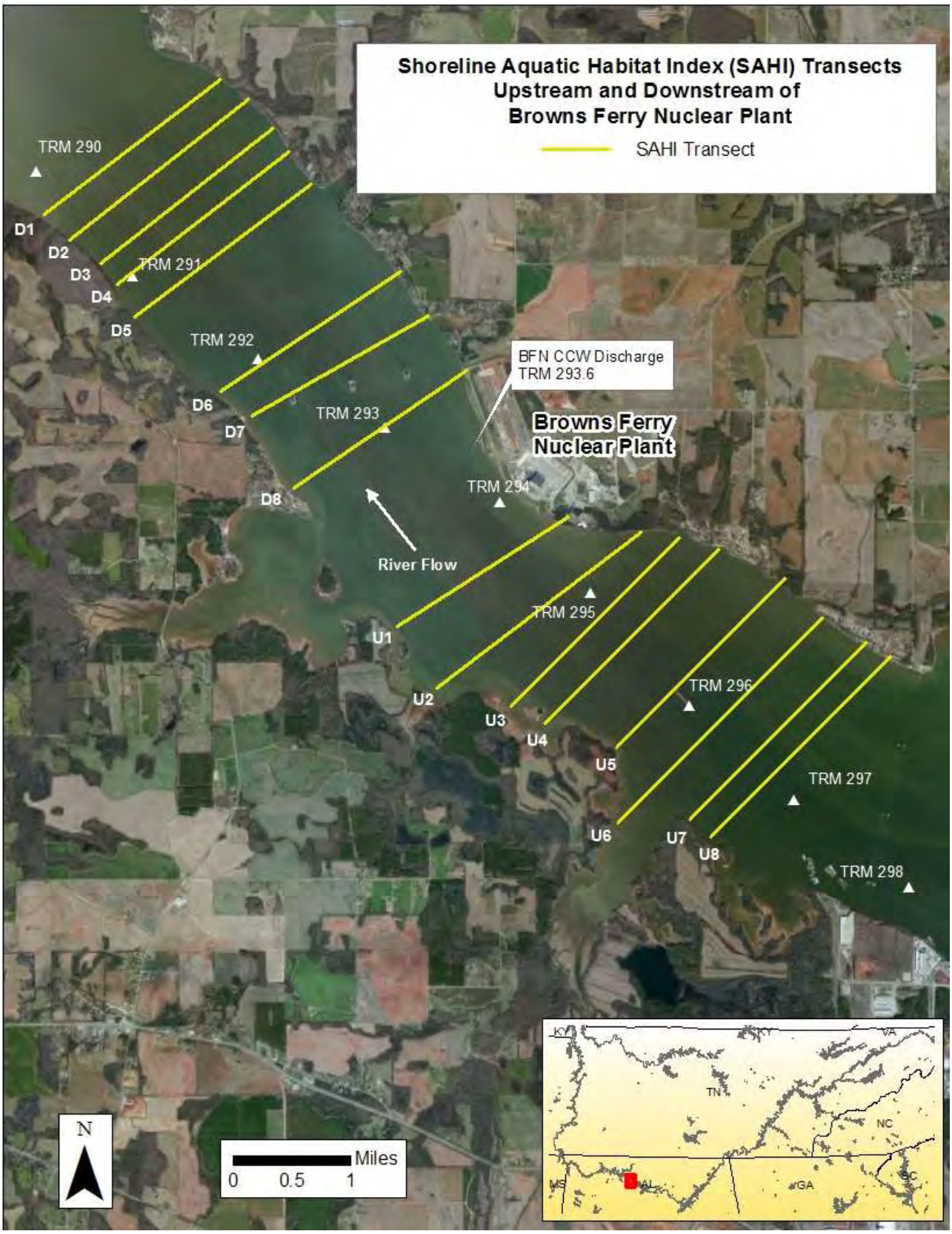


Figure 5. Anticipated transects to be established for conducting the integrative multi-metric shoreline aquatic habitat index (SAHI) assessment.

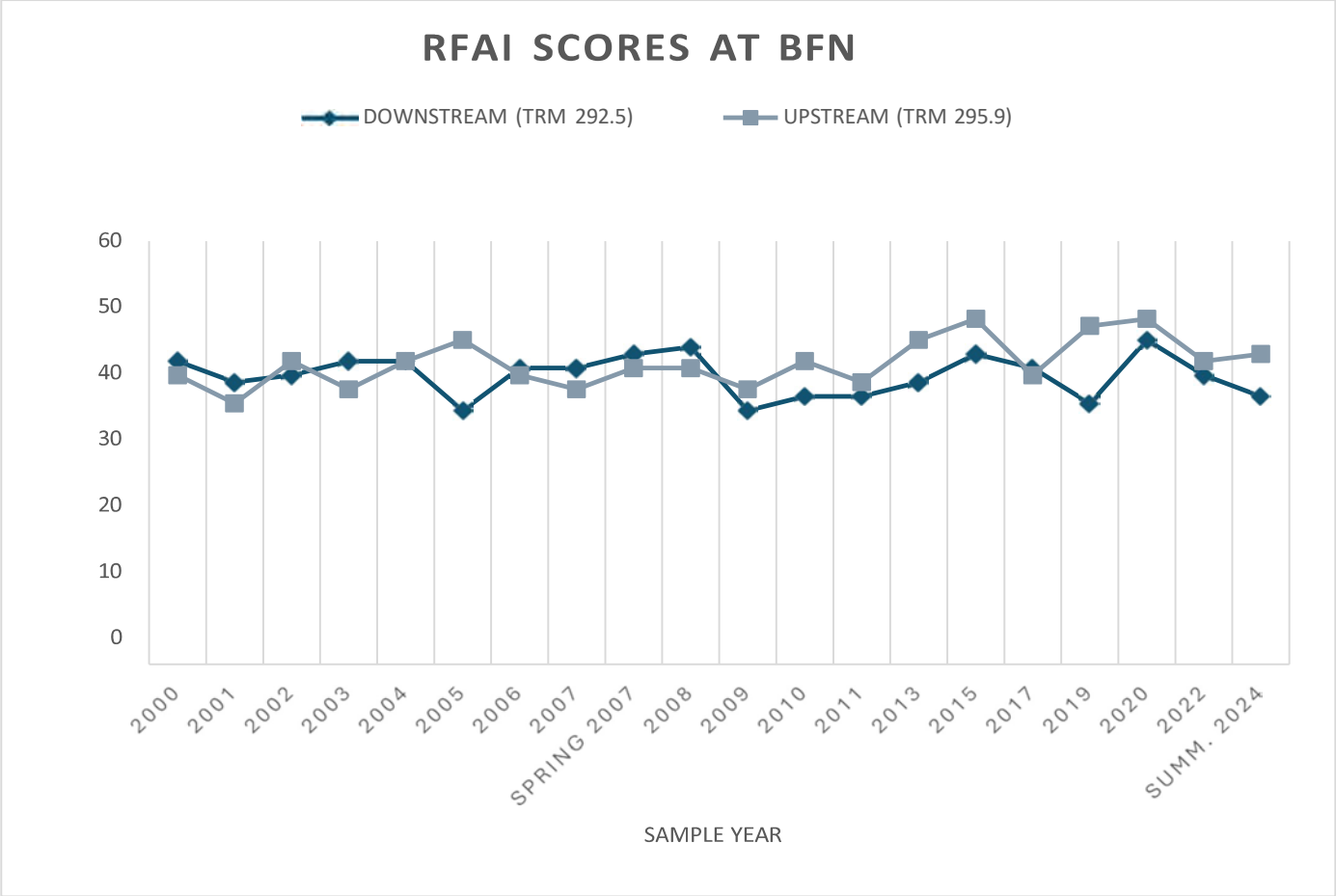


Figure 6. Reservoir Fish Assemblage Index (RFAI) scores and ratings from sites located directly upstream and downstream of Browns Ferry Nuclear plant (BFN; TRM 294) conducted during spring 2007 and autumn 2000-2011, 2013, 2015, 2017, 2019, 2020, 2022, and summer 2024 as part of the Reservoir Ecological Health Monitoring Program in Wheeler Reservoir.

TABLES

Table 1. **Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)**

Wheeler - - 2024

Browns Ferry -- Summer

Metric		Transition TRM 292.5 Obs	Transition TRM 292.5 Score	Transition TRM 295.9 Obs	Transition TRM 295.9 Score
A. Species richness and composition					
1. Number of species		**28**	**3**	**31**	**5**
2. Number of centrarchid species		**5**	**5**	**4**	**5**
3. Number of benthic invertivores		**4**	**3**	**4**	**3**
4. Number of intolerant species		**4**	**3**	**5**	**5**
5. Percent tolerant individuals	Electro Fishing	**46.3**	**1.5**	**28.5**	**1.5**
	Gill Netting	**36.7**	**0.5**	**38.6**	**0.5**
6. Percent dominance by one species	Electro Fishing	**28.7**	**2.5**	**25.5**	**2.5**
	Gill Netting	**34.4**	**0.5**	**33.7**	**1.5**
7. Percent non-native species	Electro Fishing	**28.9**	**0.5**	**25.7**	**0.5**
	Gill Netting	**0.6**	**2.5**	**1.6**	**1.5**
8. Number of top carnivore species		**10**	**5**	**10**	**5**
B. Trophic composition					
9. Percent top carnivores	Electro Fishing	**3.3**	**0.5**	**5.7**	**1.5**
	Gill Netting	**12.8**	**0.5**	**27.7**	**1.5**
10. Percent omnivores	Electro Fishing	**21.8**	**2.5**	**16.7**	**2.5**
	Gill Netting	**76.1**	**0.5**	**66.8**	**0.5**
C. Fish abundance and health					
11. Average number per run	Electro Fishing	**90.8**	**0.5**	**78.7**	**0.5**
	Gill Netting	**18**	**1.5**	**18.4**	**1.5**
12. Percent anomalies	Electro Fishing	**0.3**	**2.5**	**0.4**	**2.5**
	Gill Netting	**0**	**2.5**	**0.5**	**2.5**
RFAI			**38**		**44**
			Fair		**Good**

Table 2. Seasonal Reservoir Fish Assemblage Index (RFAI) scores from fish community monitoring at sites located directly upstream and downstream of Browns Ferry Nuclear Plant (TRM 294) on Wheeler Reservoir during autumn 2000-2011, 2013, 2015, 2017, 2019, 2020, 2022, and summer 2024.

Year	RFAI Scores		Difference
	Downstream (TRM 292.5)	Upstream (TRM 295.9)	
2000	43	41	2
2001	40	37	3
2002	41	43	2
2003	43	39	4
2004	43	43	0
2005	36	46	10
2006	42	41	1
2007	44	42	2
Spring 2007	42	39	3
2008	45	42	3
2009	36	39	3
2010	38	43	5
2011	38	40	2
2013	40	46	6
2015	44	49	5
2017	42	41	1
2019	37	48	11
2020	46	49	3
2022	41	43	2
Summer 2024	38	44	6
Autumn 2000-2019 AVG	**41**	**42.8**	**3.7**

***12-21 “Very Poor”; 22-31 “Poor”; 32-40 “Fair”; 41-50 “Good”; 51-60 “Excellent”**

Table 3. Depth profiles of water temperature (°F) collected to determine the extent of the thermal plume* discharged from TVA's Browns Ferry Nuclear Plant during the Summer 2024 sample on August 22, 2024.

	Transect and Profile Location (% from right descending bank)																								
	Ambient-TRM 297.8					BFN Discharge-TRM 293.9					TRM 293.2					TRM 292.3					TRM 291.2				
Depth (m)	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%
August 2024																									
0.3	80.2	80.7	81.3	83.0	82.4	84.4	84.4	82.3	81.7	81.6	82.9	83.4	82.5	82.5	82.2	83.1	82.9	83.0	82.8	82.6	82.8	83.0	82.9	82.7	82.7
1.5	79.9	80.7	81.2	83.0	82.3	84.5	84.1	81.8	81.6	81.6	82.6	83.4	82.5	82.4	81.9	83.1	82.7	83.1	82.8	82.4	82.4	82.7	81.6	82.5	82.4
3	79.7		80.8	82.5	82.2	84.4	83.9	81.2	80.8	81.2		82.7	81.3	82.0		82.4	82.4	82.5	82.3	81.8	82.3	82.5	81.4	81.9	81.5
4				82.4		84.3	84.0					82.6		81.7			82.4		82.3			82.2		81.7	
5				82.3		84.1	83.5					82.5					82.3		82.1			82.2		81.5	
6				82.2		83.0	83.6					82.4					82.2		82.1			82.1		81.4	
7				82.0		83.3	82.9					82.2					82.0		81.8			81.8			
8						82.6	82.9												81.8						
9						82.4	82.8																		
10																									

Table 4. Reservoir Benthic Index (RBI) results for laboratory-processed samples collected upstream and downstream of the Browns Ferry Nuclear Plant CCW discharge, 2001 through 2024.

Season	Year	Sample Transect		RBI Score and Ecological Health Rating	Average number of taxa		Proportion of samples with long-lived organisms		Average number of EPT taxa		Average proportion comprised by oligochaetes		Average proportion comprised by the two most abundant taxa		Average density excluding chironomids and oligochaetes		Proportion of samples containing no organisms	
					Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc
Autumn	2001	Downstream	TRM 291.7	31 Excellent	7.8	5	1.0	5	1.1	3	7.6	5	71.7	5	315.0	3	0	5
		Upstream	TRM 295.9	29 Good	7.3	5	1.0	5	1.0	3	6.9	5	75.4	5	281.7	1	0	5
	2002	Downstream	TRM 291.7	23 Fair	5.4	3	1.0	5	0.9	3	10.9	5	88.2	1	106.7	1	0	5
		Upstream	TRM 295.9	29 Good	6.8	5	1.0	5	1.1	3	5.0	5	74.1	5	281.7	1	0	5
	2003	Downstream	TRM 291.7	33 Excellent	7.3	5	1.0	5	1.0	3	0.4	5	73.2	5	1270.0	5	0	5
		Upstream	TRM 295.9	27 Good	6.3	3	1.0	5	0.9	3	0.6	5	82.2	3	583.3	3	0	5
	2004	Downstream	TRM 291.7	31 Excellent	7.9	5	1.0	5	1.0	3	1.6	5	73.5	5	551.7	3	0	5
		Upstream	TRM 295.9	29 Good	6.2	3	1.0	5	0.8	3	1.1	5	72.2	5	336.2	3	0	5
	2005	Downstream	TRM 291.7	33 Excellent	7.7	5	1.0	5	1.2	3	1.9	5	71.2	5	640.0	5	0	5
		Upstream	TRM 295.9	27 Good	6	3	0.8	3	1.0	3	3.1	5	87.6	3	935.0	5	0	5
	2006	Downstream	TRM 291.7	31 Excellent	9.4	5	1.0	5	1.6	5	2.3	5	78.1	3	448.2	3	0	5
		Upstream	TRM 295.9	29 Good	9.2	5	0.8	3	1.2	3	5.1	5	78.6	3	1273.3	5	0	5
	2011	Downstream	TRM 290.4	21 Fair	6.1	3	0.6	3	0.7	3	5.0	5	89.2	1	193.3	1	0	5
			TRM 293.2	23 Fair	11.3	5	0.8	3	1.2	3	35.4	1	80.6	3	321.7	3	0	5
		Upstream	TRM 295.9	27 Good	8.4	5	0.7	3	1.0	3	6.3	5	81.1	3	430.0	3	0	5
	2013	Downstream	TRM 290.4	31 Excellent	7.4	5	1.0	5	1.2	3	2.7	5	81.1	3	1161.7	5	0	5
			TRM 293.2	35 Excellent	10.2	5	1.0	5	1.8	5	8.3	5	66.7	5	1228.3	5	0	5
		Upstream	TRM 295.9	35 Excellent	10.8	5	1.0	5	1.7	5	3.6	5	67.3	5	1111.7	5	0	5
	2015	Downstream	TRM 295.9	33 Excellent	9.2	5	1.0	5	1.4	3	8.1	5	66.8	5	991.7	5	0	5
			TRM 290.4	33 Excellent	8.7	5	1.0	5	1.5	5	12.7	3	67.7	5	611.7	5	0	5
		Upstream	TRM 293.2	31 Excellent	10	5	1.0	5	1.3	3	19.1	3	66.4	5	736.7	5	0	5
	2017	Downstream	TRM 290.4	31 Excellent	10.5	5	1.0	5	1.0	3	18.6	3	63.0	5	810.0	5	0	5
			TRM 293.2	29 Good	11	5	1.0	5	1.3	3	29.4	1	64.6	5	1001.7	5	0	5
		Upstream	TRM 295.9	33 Excellent	8.5	5	1.0	5	1.4	3	6.5	5	73.3	5	1330.0	5	0	5
	2020	Downstream	TRM 290.4	33 Excellent	10.4	5	1.0	5	1.2	3	7.7	5	63.2	5	678.3	5	0	5
			TRM 293.2	31 Excellent	9.4	5	0.9	3	1.1	3	10.3	5	66.2	5	635.0	5	0	5
		Upstream	TRM 295.9	31 Excellent	10	5	1.0	5	1.4	3	11.1	3	64.7	5	1040.0	5	0	5
	2022	Downstream	TRM 290.4	33 Excellent	8.5	5	1.0	5	1.5	5	9.5	5	68.5	5	478.3	3	0	5
			TRM 293.2	27 Good	8.1	5	0.9	3	0.9	3	18.7	3	63.4	5	455.0	3	0	5
		Upstream	TRM 295.9	35 Excellent	10.9	5	1.0	5	1.6	5	10.0	5	67.3	5	833.3	5	0	5
Summer	2024	Downstream	TRM 290.4	31 Excellent	10.9	5	0.9	3	1.5	5	12.7	3	71.1	5	648.3	5	0	5
			TRM 293.2	29 Good	9.5	5	1.0	5	0.7	3	42.0	1	76.7	5	661.7	5	0	5
		Upstream	TRM 295.9	31 Excellent	12.5	5	1.0	5	1.4	3	12.0	3	68.9	5	648.3	5	0	5

Obs: Observed CCW: Condenser Cooling Water

Sc: Score TRM: Tennessee River Mile EPT: Ephemeroptera, Plecoptera, and Trichoptera

Ecological Health Ratings: 7-12 ("Very Poor"), 13-18 ("Poor"), 19-23 ("Fair"), 24-29 ("Good"), 30-35 ("Excellent")