ADEM
Alabama Department of Environmental Management

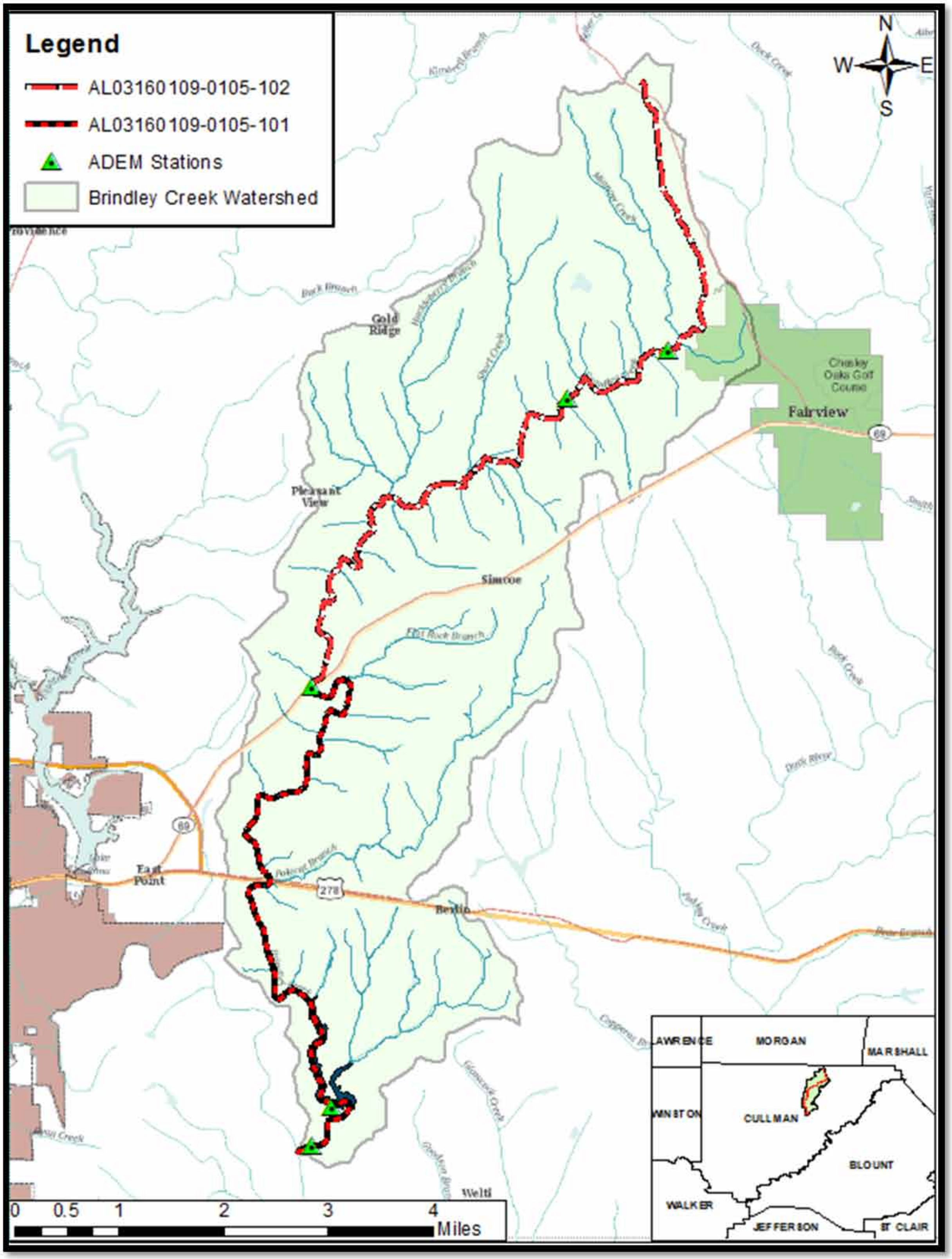
Final
Total Maximum Daily Load
for
Brindley Creek

Assessment Unit ID# AL03160109-0105-101
Assessment Unit ID# AL03160109-0105-102

Nutrients

Alabama Department of Environmental Management
Water Quality Branch
Water Division
February 2012

Figure I Brindley Creek Watershed



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1.0 Executive Summary

The Alabama Department of Environmental Management (ADEM) has identified Brindley Creek of the Black Warrior River Basin as being impaired for nutrients. Brindley Creek, a tributary of the Broglen River, was originally added by the EPA to Alabama's *§303(d)* list in 1998 for impairment by ammonia, pathogens, OE/DO, and nutrients. The listing was based on data obtained from ADEM's 1997 NPS Screening Assessment of the Black Warrior River Basin. There was one Brindley Creek station during that study, station BRIC-72a. Data from that station is provided in Appendix B.

At the time of the original addition to the 1998 *§303(d)* list, Brindley Creek was considered as one single segment, from the confluence with the Broglen River upstream to it's source. In 2004, Brindley Creek was re-segmented from one segment, representing the entire waterbody, into two individual segments. The first segment, AL03160109-0105-101, represents from the confluence with the Broglen River extending upstream to State Highway 69. The second segment, AL03160109-0105-102, represents from State Highway 69 upstream to the source. ADEM deemed it necessary to re-segment Brindley Creek in order to aid in tracking purposes when assessing whether a Total Maximum Daily Load (TMDL) or Delisting Decision (DD) document was applicable.

In 2003, the Alabama Department of Environmental Management (ADEM) addressed the pathogen impairment for Brindley Creek with a Total Maximum Daily Load (TMDL) document for the upper portion of Brindley Creek, and a Delisting Decision (DD) document for the lower portion of Brindley Creek. ADEM also addressed the OE/DO impairment on Brindley Creek with a Delisting Decision (DD) document in 2003 as well. Following EPA approval, both the lower portion of Brindley Creek impaired by pathogens and the upper portion of Brindley Creek impaired for OE/DO were removed from the 2002 *§303(d)* list. Furthermore, after EPA approval of the pathogen TMDL for the upper portion of Brindley Creek, it was subsequently removed from the 2004 *§303(d)* list and placed in Category 4a. Finally, the ammonia pollutant on both portions of Brindley Creek was addressed by ADEM with a Delisting Decision (DD) document in 2006, and, following EPA approval, was removed from the 2004 *§303(d)* list.

In 2009, §303(d) sampling studies were performed by ADEM on Brindley Creek to further evaluate the water quality of the impaired stream. For purposes of this TMDL, the 2009 data will be used to assess the water quality of Brindley Creek because it was collected less than six years ago and provides the best picture of the current water quality conditions of the stream. The January 2010 edition of *Alabama's Water Quality Assessment and Listing Methodology* section 4.8.2, prepared by ADEM, provides the rationale for the Department to use the most recent data to prepare a TMDL for an impaired waterbody when that data indicates a change in water quality has occurred.

Brindley Creek remains on the 2010 *§303(d)* list for nutrient impairment. Nutrients are of concern due to their ability to promote algal growth, which in turn affects the dissolved oxygen balance through photosynthesis, respiration, and the regeneration of organic materials. For Brindley Creek, only total phosphorus (TP) is addressed in this TMDL. The existing total nitrogen (TN) concentrations in Brindley Creek are similar to the Level IV Ecoregional reference conditions; therefore, it is believed that TN does not cause or contribute to the existing nutrient impairment in Brindley Creek. In addition, downstream uses are not expected to be impacted by the existing TN concentrations.

The Brindley Creek TP target was calculated using a reference condition approach which utilizes data collected from unimpaired streams that are within the same Level IV Ecoregion. The entire Brindley Creek watershed is within the Level IV Ecoregion 68d, the Southern Table Plateaus. Both the eco-reference station information and the water quality data has been provided in Appendix B. The 90th percentile of the data distributions from this ecoregion will be utilized in establishing the TP target. The TP target concentration for Brindley Creek is 0.05 mg/L.

The small impoundment, Forest Ingram Lake, located near the mouth of Brindley Creek presents complications in that the water quality impacts, as a result of nutrient over-enrichment, are being observed within the lake itself, and not the wadeable portions of the stream. Observed water quality data collected within the impounded portions of Brindley Creek (Forest Ingram Lake) yield a high presence of algal growth, which in turn affects the dissolved oxygen balance through photosynthesis, respiration, and the regeneration of organic materials. According to the *Nutrient Criteria Technical Guidance Manual for Rivers and Streams* (USEPA, 2000b), Chlorophyll-a, a photosynthetic pigment and sensitive indicator of algal biomass, is considered the most important biological response variable for nutrient-related impairment problems. This relationship between stressor variables and response variables is very complex and highly site specific. Therefore, in conjunction with the "reference condition" approach, the BATHTUB eutrophication model will be utilized to predict the chlorophyll-a concentration within the reservoir as a result of reducing the inflow total phosphorus concentration down to the eco-reference target TP concentration of 0.05 mg/L

A summary of the Brindley Creek Nutrient TMDL is provided below.

TMDL[a]	Margin of Safety (MOS)	Waste Load Allocation (WLA)[b]		Load Allocation (LA)	
		WWTPs[c]	MS4s[d]		
Total Phosphorus (mg/L)	Total Phosphorus (mg/L)	Total Phosphorus (mg/L)	(% reduction)	Total Phosphorus (mg/L)	(% reduction)
0.050	Implicit	N/A	N/A	0.050	66%

a. TMDL is to be applied as a growing season (Apr-Oct) median TP concentration as measured at Station BINC-192.
b. There are no CAFOs in the Brindley Creek watershed. Future CAFOs will be assigned a waste load allocation (WLA) of zero.
c. N/A = not applicable, no WWTPs are currently located within the watershed.
d. N/A = not applicable, no regulated MS4 areas are currently located within the watershed. Future MS4 areas would be required to demonstrate consistency with the assumptions and requirements of this TMDL.
e. Considering a TP load reduction of 66% as noted above, it is therefore reasonable to assume the necessary BMPs implemented to achieve this TP load reduction will also inherently reduce the TN load by approximately 20% as well.
f. A flow rate of 18.3 cfs, representing the statistical average of the measured flows at the time of the total phosphorus concentrations sampling events, was assumed for the inflow into the reservoir. Following the TMDL concentration reductions (66% TP and an inherent 20% TN), the average daily loads expected to enter Forest Ingram lake are 4.93 lbs/day for TP and 234.85 lbs/day for TN.

2.0 Basis for §303(d) Listing

2.1 Introduction

Section 303(d) of the Clean Water Act (CWA), as amended by the Water Quality Act of 1987, and EPA's Water Quality Planning and Management Regulations [(Title 40 of the Code of Federal Regulations (CFR), Part 130)] require states to identify water bodies which are not meeting water quality standards applicable to their designated uses and to determine the total maximum daily load (TMDL) for pollutants causing use impairment. The TMDL process establishes the allowable loading of pollutants for a water body based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water-quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources (USEPA, 1991).

The Alabama Department of Environmental Management (ADEM) has identified Brindley Creek of the Black Warrior River Basin as being impaired for nutrients. Brindley Creek, a tributary of the Broglen River, was originally added by EPA to Alabama's *§303(d)* list of impaired waters in 1998 for ammonia, pathogens, OE/DO and nutrients. This listing was based on data acquired from ADEM's 1997 NPS Screening Assessment of the Black Warrior River Basin. There was one Brindley Creek station that was sampled during that study, station BRIC-72a. Data from that station is provided in Appendix B.

At the time of the original addition to the 1998 *§303(d)* list, Brindley Creek was considered as one single segment, from the confluence with the Broglen River upstream to its source. In 2004, Brindley Creek was re-segmented from one segment, representing the entire waterbody, into two individual segments. The first segment, AL03160109-0105-101, represents from the confluence with the Broglen River extending upstream to State Highway 69. The second segment, AL03160109-0105-102, represents from State Highway 69 upstream to the source. ADEM deemed it necessary to re-segment Brindley Creek in order to aid in tracking purposes when assessing whether a Total Maximum Daily Load (TMDL) or Delisting Decision (DD) document was applicable.

In 2004, the Alabama Department of Environmental Management (ADEM) addressed the pathogen impairment for Brindley Creek with a Total Maximum Daily Load (TMDL) document for the upper portion of Brindley Creek, and a Delisting Decision (DD) document for the lower portion of Brindley Creek. ADEM also addressed the OE/DO impairment on Brindley Creek with a Delisting Decision (DD) document in 2004 as well. Following EPA approval, both the lower portion of Brindley Creek impaired by pathogens and the upper portion of Brindley Creek impaired for OE/DO were removed in 2004 from the *§303(d)* list. Furthermore, after EPA approval of the pathogen TMDL for the upper portion of Brindley Creek, it was subsequently removed from the 2004 *§303(d)* list and placed in Category 4a. Finally, the ammonia pollutant on both portions of Brindley Creek was addressed by ADEM with a Delisting Decision (DD) document in 2006, and, following EPA approval, was removed from the 2004 *§303(d)* list

2.2 Problem Definition

Waterbody Impaired:	Brindley Creek, from the Broglen River to its source
Waterbody length:	17.1 miles
Waterbody drainage area:	24.83 square miles
Water Quality Standard Violation:	Narrative criteria (nutrients)
Pollutants of Concern:	Total Phosphorus
Water Use Classification:	Public Water Supply (PWS)

Usage of waters in the Public Water Supply category is described as follows in ADEM Admin. Code R. 335-6-10-.09(5) (a), (b), (c), and (d):

(a) Best usage of waters: source of water supply for drinking or food-processing purposes.

(b) Conditions related to best usage: the waters, if subjected to treatment approved by the Department equal to coagulation, sedimentation, filtration and disinfection, with additional treatment if necessary to remove naturally present impurities, and which meet the requirements of the Department, will be considered safe for drinking or food-processing purposes.

(c) Other usage of waters: it is recognized that the waters may be used for incidental water contact and recreation during June through September, except that water contact is strongly discouraged in the vicinity of discharges or other conditions beyond the control of the Department or the Alabama Department of Public Health.

(d) Conditions related to other usage: the waters, under proper sanitary supervision by the controlling health authorities, will meet accepted standards of water quality for outdoor swimming places and will be considered satisfactory for swimming and other whole body water-contact sports.

2.3 Water Quality Criteria

ADEM's decision to list Brindley Creek as being impaired for nutrients was authorized under ADEM's Water Quality Standards Program, which employs both numeric and narrative criteria to ensure adequate protection of designated uses for surface waters of the State. Numeric criteria typically have quantifiable endpoints for given parameters such as pH, dissolved oxygen, or a toxic pollutant, whereas narrative criteria are qualitative statements that establish a set of desired conditions for all State waters. These narrative criteria are more commonly referred to as "free

from" criteria that enable States a regulatory avenue to address pollutants or problems that may be causing or contributing to a use impairment that otherwise cannot be evaluated against any numeric criteria. Typical pollutants that fall under this category are nutrients and siltation. Historically, in the absence of established numeric nutrient criteria, ADEM and/or EPA would use available data and information coupled with best professional judgment to determine overall use support for a given waterbody. Narrative criteria continue to serve as a basis for determining use attainability and subsequently listing/delisting of waters from Alabama's §303(d) List. ADEM's Narrative Criteria are shown in ADEM's Administrative Code 335-6-10-.06 as follows:
335-6-10-.06 **Minimum Conditions Applicable to All State Waters**. *The following minimum conditions are applicable to all State waters, at all places and at all times, regardless of their uses:*

(a) State waters shall be free from substances attributable to sewage, industrial wastes or other wastes that will settle to form bottom deposits which are unsightly, putrescent or interfere directly or indirectly with any classified water use.

(b) State waters shall be free from floating debris, oil, scum, and other floating materials attributable to sewage, industrial wastes or other wastes in amounts sufficient to be unsightly or interfere directly or indirectly with any classified water use.

(c) State waters shall be free from substances attributable to sewage, industrial wastes or other wastes in concentrations or combinations, which are toxic or harmful to human, animal or aquatic life to the extent commensurate with the designated usage of such waters.

3.0 Technical Basis for TMDL Development

3.1 Water Quality Target Identification

ADEM continues its efforts to develop comprehensive numeric nutrient criteria for all surface waters throughout Alabama, including rivers/streams, lakes/reservoirs, wetlands, and coastal/estuarine waters. However, until numeric nutrient criteria or some form of quantitative interpretation of ADEM's narrative criteria are developed, the Department will continue to use all available data and information coupled with best professional judgment to make informed decisions regarding overall use support and establishing targets for TMDLs.

Typically, the development of a water quality criterion for a given pollutant involves extensive research using information from many areas of aquatic toxicology. For example, development of numeric criteria for toxic pollutants, such as mercury, involves numerous toxicological studies such as dose/response relationships, bioaccumulation studies, fate and transport studies, and an understanding of both the acute and chronic effects to aquatic life. As part of the toxicological evaluations, EPA performs uncertainty analysis to help guide selection of the recommended water quality criterion for a given pollutant. For toxic pollutants, the more uncertainty revealed during the evaluation, the more conservative (i.e. the lower the value) the recommended criterion becomes.

Nutrients such as phosphorus and nitrogen are essential elements to aquatic life, but can be undesirable when present at sufficient concentrations to stimulate excessive plant growth. Even though these pollutants are generally considered non-toxic (the exception being un-ionized ammonia toxicity to aquatic life), they can impact aquatic life due to their indirect effects on water quality, either when in overabundance or when availability is limited.

For rivers and streams, ADEM's water quality criteria with respect to nutrients are narrative; therefore, a numerical translator is needed to define the TMDL target. Based on the historical data collected on Brindley Creek, there is evidence that designated uses are impaired by nutrient over-enrichment. However, some uncertainty remains in the exact quantification of the nutrient target due to the complexity of the cause and effect relationship and the state of the science. This is a very common dilemma in nutrient water quality management, and often warrants an alternate approach. EPA recommends, in the absence of sufficient "effects-based" information, a reference condition approach for determining protective nutrient criteria. With this approach, a numerical value can be empirically developed that can be assumed to inherently protect uses supported in the reference waters. This approach can provide an initial target while continuing studies will allow further evaluation of the cause and effect relationships that might result in refinement of the initial target.

In developing a nutrient target for the Brindley Creek Nutrient TMDL, ADEM has chosen to use the "reference condition" approach for determining the appropriate levels of nutrients necessary to support designated uses. This approach is based on using ambient water quality data from candidate reference streams that are located in characteristically similar regions of Alabama known as ecoregions. An ecoregion is defined as a relatively homogeneous area defined by similar climate, landform, soil, potential natural vegetation, hydrology and other ecologically relevant variables (USEPA, 2000b). "Reference streams" are defined as waterbodies that have been relatively undisturbed or minimally-impacted that can serve as examples of the natural biological integrity of a particular ecoregion. These "reference streams" can be monitored over time to establish a baseline to which other waters can be compared. Reference streams are not necessarily pristine or undisturbed by humans, however they do represent waters within Alabama that are healthy and fully support their designated uses, to include protection of aquatic life. The reference streams selected for a particular analysis depends primarily on the available number of reference streams and associated data within a particular ecoregion. Therefore, the total number of reference sites selected and the aerial scale (i.e. Ecoregion Level III, Level IV) used to represent a reference condition will often vary on a case-by-case basis. ADEM believes that the "reference condition" approach used to determine appropriate nutrient targets for the Brindley Creek TMDL, is reasonable, scientifically defensible, protective of designated uses, and consistent with USEPA guidance.

Target pollutants for nutrient impaired waterbodies are chosen on a case by case basis. For Brindley Creek, only total phosphorus (TP) is included in this TMDL. The existing total nitrogen (TN) concentrations in Brindley Creek are similar to the Level IV Ecoregional reference conditions; therefore, it is believed that TN does not cause or contribute to the existing nutrient impairment in Brindley Creek. In addition, downstream uses are not expected to be impacted by the existing TN concentrations.

In developing and establishing reference conditions from best available data, frequency distributions are recommended by the *Nutrient Criteria Technical Guidance Manual for Rivers and Streams* (USEPA, 2000b) as the preferred method for setting nutrient criteria. ADEM selected to use the 90th percentile of the data distributions from the selected eco-region reference sites to be used in establishing the TP target. The 90th percentile of the data distribution was considered an appropriate target, since it falls within an acceptable range of "least-impacted" conditions (i.e. upper quartile).

If the TP concentrations of the subject impaired stream are relatively the same or below reference condition levels, then the stream is considered not to be impaired for nutrients. If TP concentrations within the impaired stream are shown to be above reference conditions, then other water quality data and information are used in the evaluation. The additional data and information that can be used includes, but is certainly not limited to, diurnal dissolved oxygen readings, algal biomass measurements (periphyton or suspended algae), habitat assessments, and macroinvertebrate and fish community indices.

The Brindley Creek TP target was calculated using a reference condition approach which utilizes data collected from streams that are within the same Level IV Ecoregion. The entire Brindley Creek watershed is within the Level IV Ecoregion 68d, the Southern Table Plateaus. Both the eco-reference station information and the water quality data has been provided in Appendix B. The 90th percentile of the data distributions from this eco-region will be utilized in establishing the TP target. The TP target concentration for Brindley Creek is 0.05 mg/L.

The small impoundment, Forest Ingram Lake, located near the mouth of Brindley Creek presents complications in that the water quality impacts, as a result of nutrient over-enrichment, are being observed within the lake itself, and not the wadeable portions of the stream. Observed water quality data collected within the impounded portions of Brindley Creek (Forest Ingram Lake) yield a high presence of algal growth, which in turn affects the dissolved oxygen balance through photosynthesis, respiration, and the regeneration of organic materials. According to the *Nutrient Criteria Technical Guidance Manual for Rivers and Streams* (USEPA, 2000b), chlorophyll-a, a photosynthetic pigment and sensitive indicator of algal biomass, is considered the most important biological response variable for nutrient-related impairment problems. This relationship between stressor variables and response variables is very complex and highly site specific. Therefore, in conjunction with the "reference condition" approach, the BATHTUB eutrophication model will be utilized to predict the chlorophyll-a concentration within the reservoir as a result of reducing the inflow total phosphorus concentration down to the eco-reference target TP concentration.

3.2 Source Assessment

A point source can be defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Point source contributions can typically be attributed to municipal wastewater facilities, illicit discharges, and leaking sewers in urban areas. Municipal wastewater treatment facilities are permitted through the National Pollutant Discharge Elimination System (NPDES) process administered by ADEM. In urban settings sewer lines can typically run parallel to streams in the floodplain. If there is a leaking sewer line, high concentrations of phosphorus can typically flow into the stream or leach into the groundwater. Illicit discharges are found at facilities that are discharging pollutants when they are not permitted, or they are violating their defined permit limit by exceeding their NPDES permit limits.

3.2.1 Point Sources in the Brindley Creek Watershed

Continuous Point Sources

There are no NPDES regulated continuous point sources in the Brindley Creek watershed. Therefore, the WLA portion of this TMDL is not applicable.

Any future NPDES regulated discharges that are considered by the Department to be a nutrient source will be required to meet an instream TP concentration equal to background conditions. Background conditions are defined as the 90th percentile of values observed in reference streams located within the same Level IV Ecoregion.

Non-Continuous Point Sources

Currently there are no Municipal Separate Stormwater Sewer System (MS4) areas located within the Brindley Creek watershed. Future NPDES regulated stormwater discharges will be required to demonstrate consistency with the assumptions and requirements of this TMDL.

Sanitary sewer overflows (SSOs) have the potential to severely impact water quality and can often result in the violation of water quality standards. It is the responsibility of the NPDES wastewater discharger or collection system operator for non-permitted “collection only” systems to ensure that releases do not occur. Unfortunately, releases to surface waters from SSOs are not always preventable or reported. From review of ADEM DMR files, there were no SSOs found within the Brindley Creek watershed. Furthermore, after reviewing the most recent ADEM files, there are no permitted CAFOs or AFOs within the watershed.

3.2.2 Nonpoint Sources in the Brindley Creek Watershed

Nonpoint sources of phosphorus do not have a defined discharge point, but rather, occur over the entire length of a stream or waterbody. On the land surface phosphorus can accumulate over time and be washed into streams or waterbodies during rain events. Therefore, there is some net loading of phosphorus into streams as dictated by the watershed hydrology.

Due to the absence of point sources in the Brindley Creek watershed, nonpoint sources are believed to be the primary source of phosphorus loading. Land in this watershed is primarily used for agricultural purposes. Based on the 2006 National Land Cover Data (NLCD), the approximate land use proportions are 59% agricultural, 26% forested, and 7% developed. The agricultural component represents both pastures/hayfields and cultivated crops.

Agricultural land can be a major source of nutrients. Runoff from pastures, animal feeding areas, improper land application of animal wastes, and animals with direct access to streams are all mechanisms that can contribute to phosphorus loading to waterbodies.

Phosphorus loading from urban areas is potentially attributable to multiple sources including storm water runoff, unpermitted discharges of wastewater, runoff from improper disposal of waste materials, failing septic tanks, and domestic animals. On-site septic systems are common in unincorporated portions of the watershed and may be direct or indirect sources of nutrient loading via ground and surface waters due to system failures and malfunctions.

3.3 Land Use

The land use map of the watershed is presented in Figure 3.3.1. Shown below in Table 3.3.1 and Figure 3.3.2 is a summary of the land usage in the Brindley Creek watershed. The predominate land uses within the watershed are agriculture and forest cover (National Land Cover Dataset (NLCD), 2006). Each landuse has the potential to contribute to the nutrient loading in the watershed due to nutrients on the land surface that potentially can be washed off into the receiving waters of the watershed. Possible non-point source contributions of impairment could include failing septic systems, and agricultural runoff.

Figure 3.3.1 Brindley Creek Landuse, NLCD 2006.

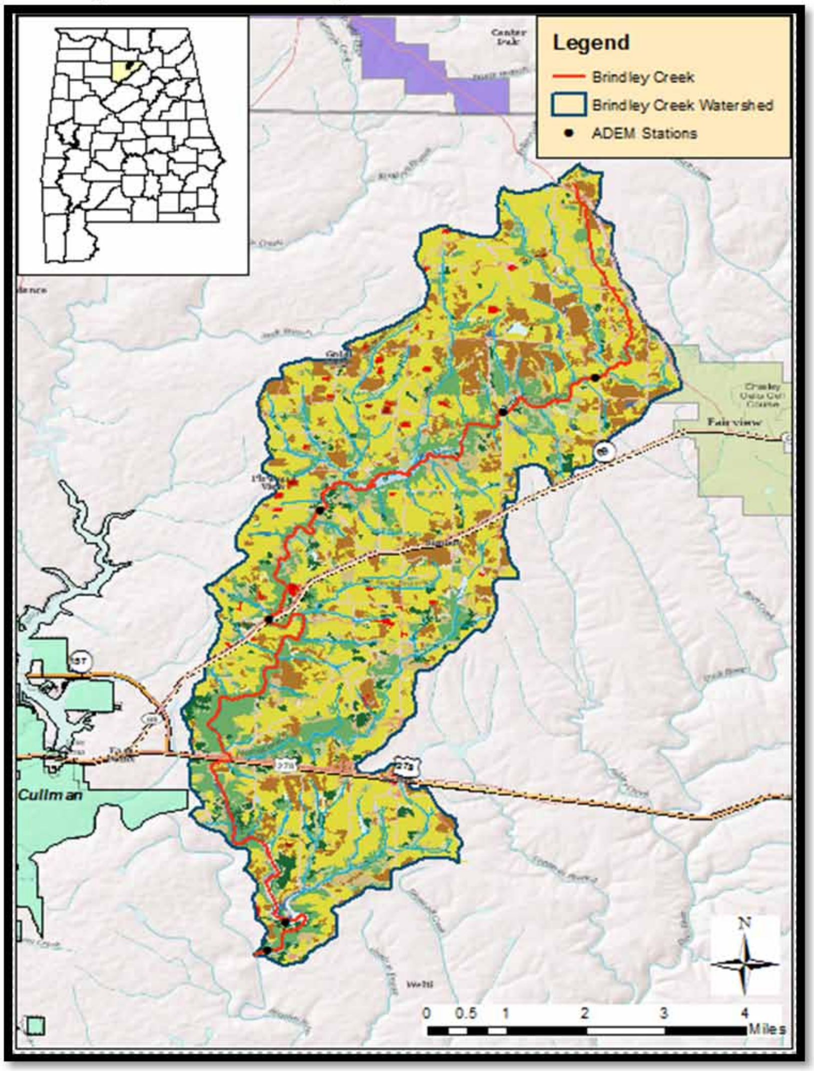
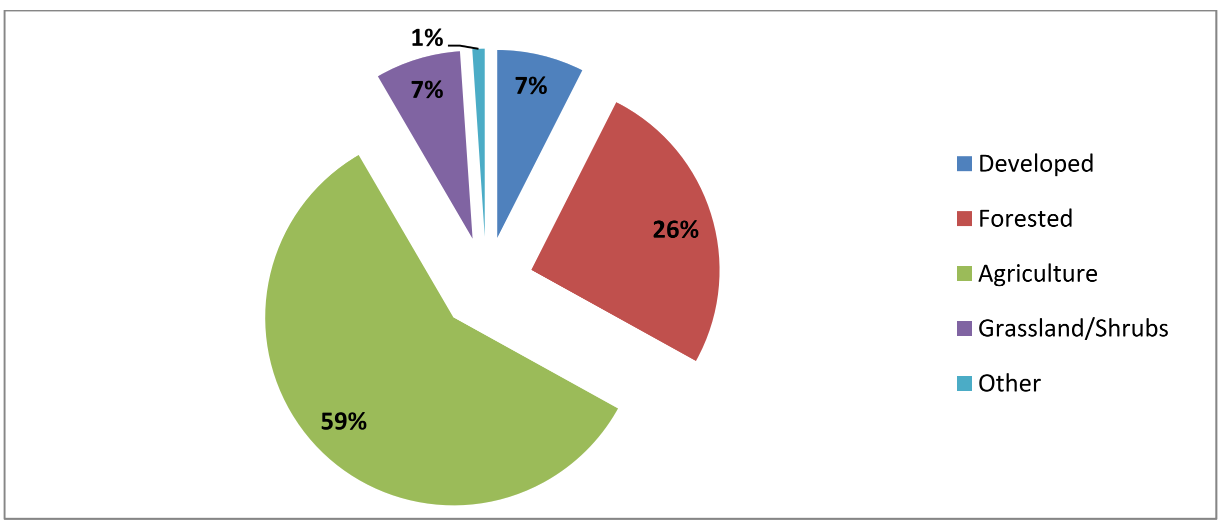


Table 3.3.1 Brindley Creek Watershed, Land Uses

Land Use Description	Acres	Square Miles	Percent (%)
Open Water	136.11	0.21	0.86
Developed, Open Space	747.47	1.17	4.70
Developed, Low Intensity	328.03	0.51	2.06
Developed, Medium Intensity	96.74	0.15	0.61
Developed, High Intensity	12.90	0.02	0.08
Barren Land (Rock/Sand/Clay)	32.91	0.05	0.21
Deciduous Forest	2446.34	3.82	15.40
Evergreen Forest	629.60	0.98	3.96
Mixed Forest	867.12	1.35	5.46
Shrub/Scrub	974.76	1.52	6.13
Grassland/Herbaceous	191.04	0.30	1.20
Pasture/Hay	7411.75	11.58	46.64
Cultivated Crops	1892.14	2.96	11.91
Woody Wetlands	121.21	0.19	0.76
Emergent Herbaceous Wetlands	2.22	0.00	0.01
Total	**15890.33**	**24.83**	**100**
Cumulative Land Use	**Acres**	**Square Miles**	**Percent (%)**
Developed	1185.14	1.85	7.46
Forested	4066.49	6.35	25.59
Grassland/Shrubs	1165.79	1.82	7.34
Agriculture	9303.89	14.54	58.55
Other	169.02	0.26	1.06
Total	**15890.33**	**24.83**	**100**

Figure 3.3.2 Cumulative Land Uses



3.4 Data Availability and Analysis

There have been numerous studies that can be employed as data sources for the Brindley Creek watershed. The first study is ADEM's 1997 NPS Screening Assessment of the Black Warrior River Basin. There was one station from that study, identified as BRIC-72a. The data collected at station BRIC-72a placed the creek on the 1998 §303(d) list. This data consisted of chemical parameters, biological parameters, and a habitat assessment.

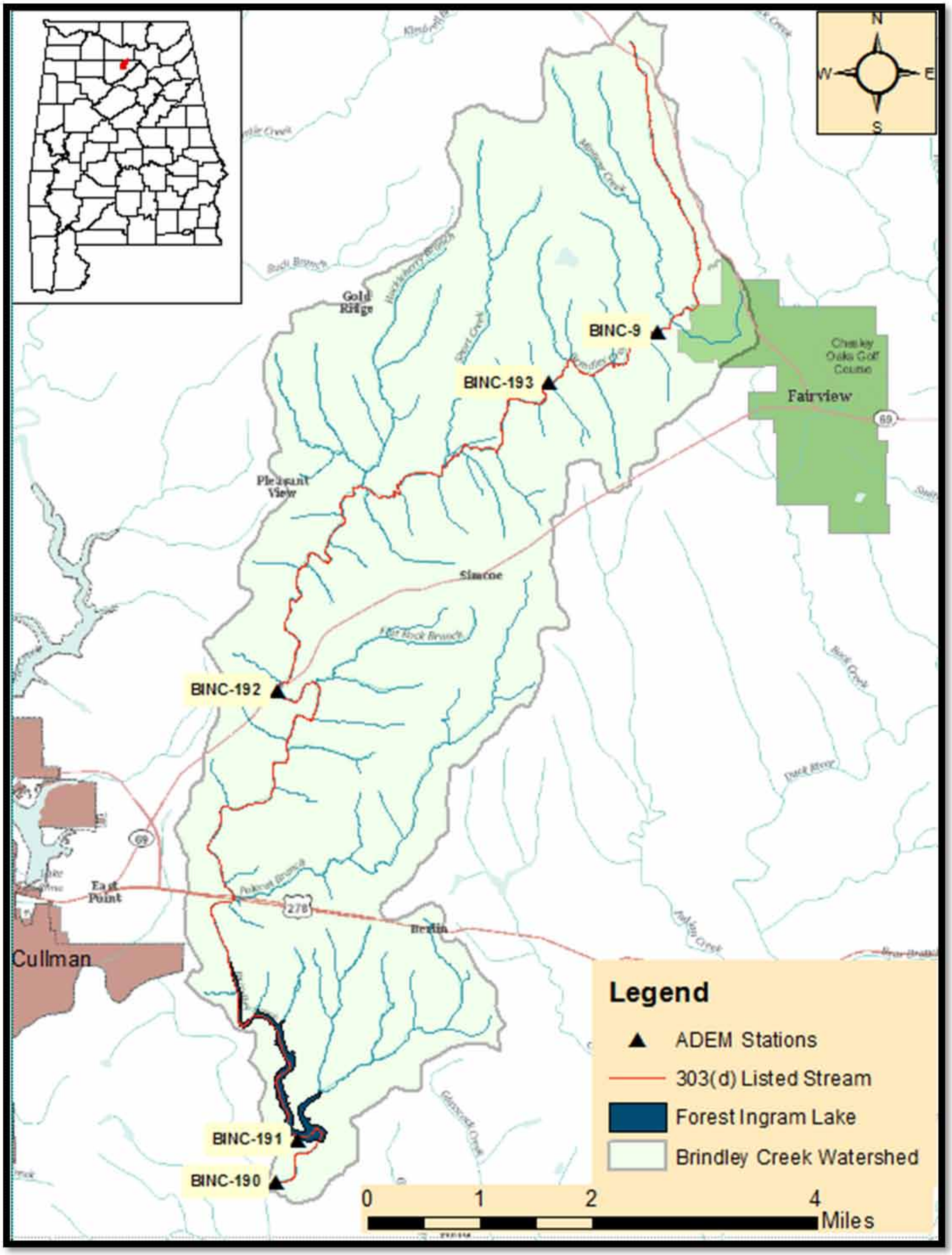
The second study was derived from a cooperative agreement between ADEM, Alabama Department of Conservation and Natural Resources (ADCNR), U.S. Fish and Wildlife (FWS), and the Geological Survey of Alabama (GSA). The purpose of the agreement was to perform bio-monitoring in the Black Warrior Basin from 1999 through 2001. The study was performed by GSA. There was one station in the Brindley Creek watershed, identified as GSA station 40. Data collected included field parameters, fish IBI scores, and habitat scores.
During ADEM's 2001-2003 303(d) sampling program, data was again collected on Brindley Creek. The results from this data were utilized in both TMDL development for pathogen impairment in 2005 and delisting document for OE/DO and Ammonia in 2004 and 2006, respectively.

The source of data that was utilized in the evaluation of Brindley Creek's nutrient impairment is from ADEM's most recent 303(d) sampling program in 2009, in which physical, chemical and biological data were collected at five sampling stations: BINC-190, BINC-191, BINC-192, BINC-193, and BINC-9. The January 2010 edition of ***Alabama's Water Quality Assessment and Listing Methodology*** section 4.8.2 prepared by ADEM provides the rationale for the Department to use the most recent data to prepare a TMDL for an impaired waterbody when that data indicates a change in water quality has occurred. Refer to Table 3.4.1 for location descriptions of all recent sampling stations and to Figure 3.4.1 on page 11 for a map depicting the locations of all recent sampling stations.

Table 3.4.1 ADEM Brindley Creek Stations Description

Station_ID	Latitude	Longitude	Description of Sampling Locations
BINC-9	34.25583	-86.70696	Brindley Cr. at unnamed Cullman Co. Rd.
BINC-193	34.249201	-86.72394	Brindley Creek @ Co. Rd. in the SE 1/4 of Sect 15, R2S, T9S
BINC-192	34.209467	-86.766545	Brindley Creek @ State Hwy 69
BINC-191	34.151205	-86.763452	Brindley Creek @ the dam forebay of Forest Ingram Lake
BINC-190	34.14574	-86.76688	Brindley Creek @ Co. Rd. prior to confluence with Eightmile Creek

Figure 3.4.1 ADEM Sampling Stations on Brindley Creek



4.0 Total Maximum Daily Load Development for Brindley Creek

This section presents the TMDL developed to address nutrient impairment for Brindley Creek. A TMDL is the total amount of a pollution load that can be assimilated by the receiving water while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are comprised of the sum of individual waste load allocations (WLAs) for point sources, load allocations (LAs) for non-point sources, and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the following equation:

$$TMDL = LC = \sum WLAs + \sum LAs + MOS$$

In order to develop the TMDL, the following steps will be defined:

1. Numeric Target for TMDL
2. Existing/Baseline Conditions
3. Critical Conditions
4. Margin of Safety
5. Seasonal Variation
6. TMDL Calculation Method and Results

4.1 TMDL Numeric Target

The TMDL endpoint represents the in-stream water quality target used in quantifying the necessary pollutant reductions that are required to achieve applicable water quality standards. The TMDL endpoint can be a combination of water quality standards, both numeric and narrative, and surrogate parameters that would ensure the standards are being attained.

Target pollutants for nutrient impaired waterbodies are chosen on a case by case basis. For Brindley Creek, only total phosphorus (TP) is addressed in this TMDL. The existing total nitrogen (TN) concentrations in Brindley Creek have been calculated to be similar to the reference condition concentrations; therefore, TN does not appear to causing or contributing to the existing nutrient impairment in Brindley Creek.

Establishing a nutrient target that fully supports the designated uses of Brindley Creek is part of the lengthy and complex process of TMDL development. The nutrient target was developed utilizing a “reference condition” approach by using data collected from Ecoregion 68d and taking the 90th percentile of this data set to determine the target concentration. The TP target concentrations that will be utilized for the Brindley Creek TMDL is 0.050 mg/L

4.2 Existing/Baseline Conditions

The results of using in-stream data provide the existing conditions for Brindley Creek. Existing conditions for non-point source concentrations within Brindley Creek will be based on the most recent data collected during ADEM §303(d) sampling studies in 2009. The figure below helps to illustrate how the existing median total nitrogen (TN) concentrations in Brindley Creek are similar to the Level IV Ecoregional reference conditions. Only one station yielded a media TN value slightly higher than eco-reference TN concentration. Observed median TN concentrations at the other four stations were either near or below background conditions. Therefore, ADEM feels it is safe to assume TN does not cause or contribute to the existing nutrient impairment in Brindley Creek. In addition, since observed TN values both within and downstream of Lake Ingram (BINC 191 and BINC 190, respectively) are well below the reference condition concentration, downstream uses are being protected.

Figure 4.2.1 Existing Median Total Nitrogen (TN) Concentrations

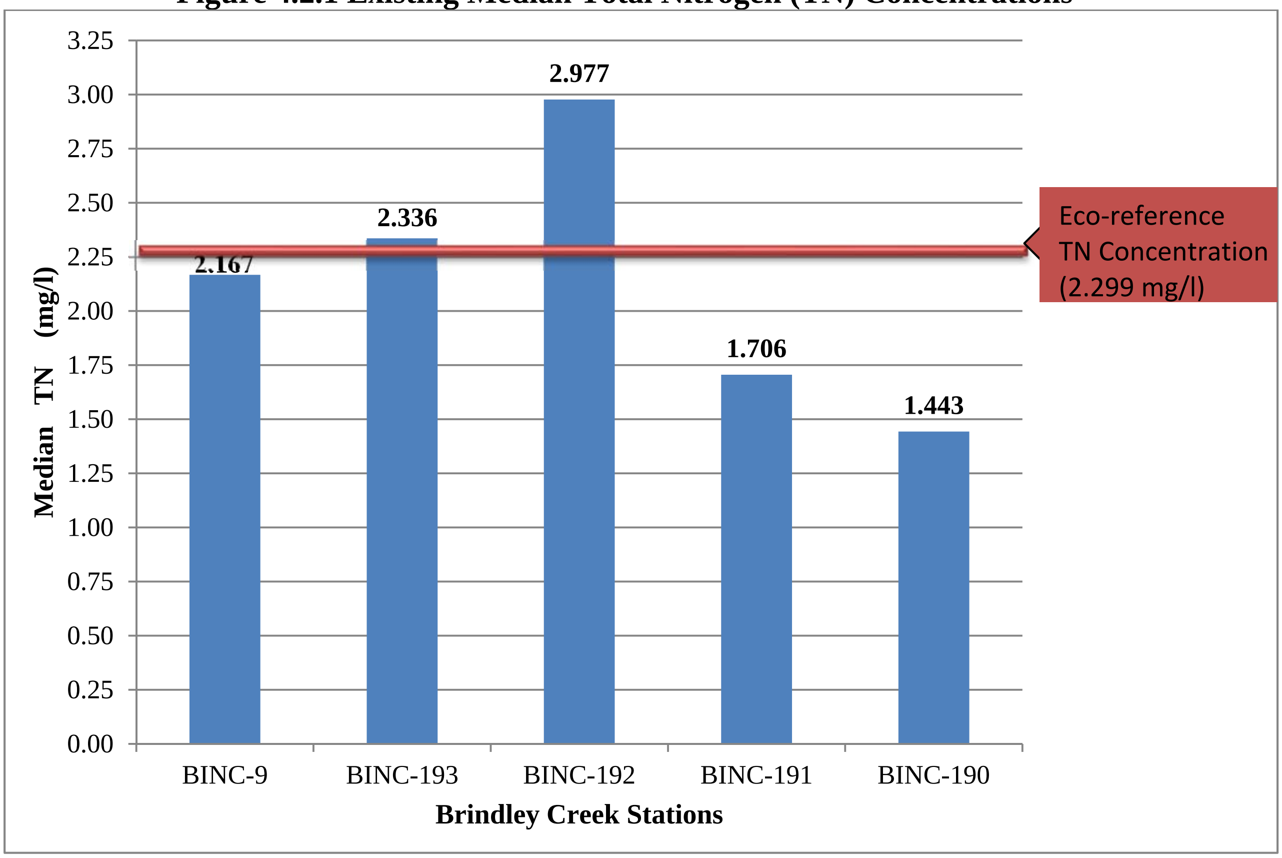
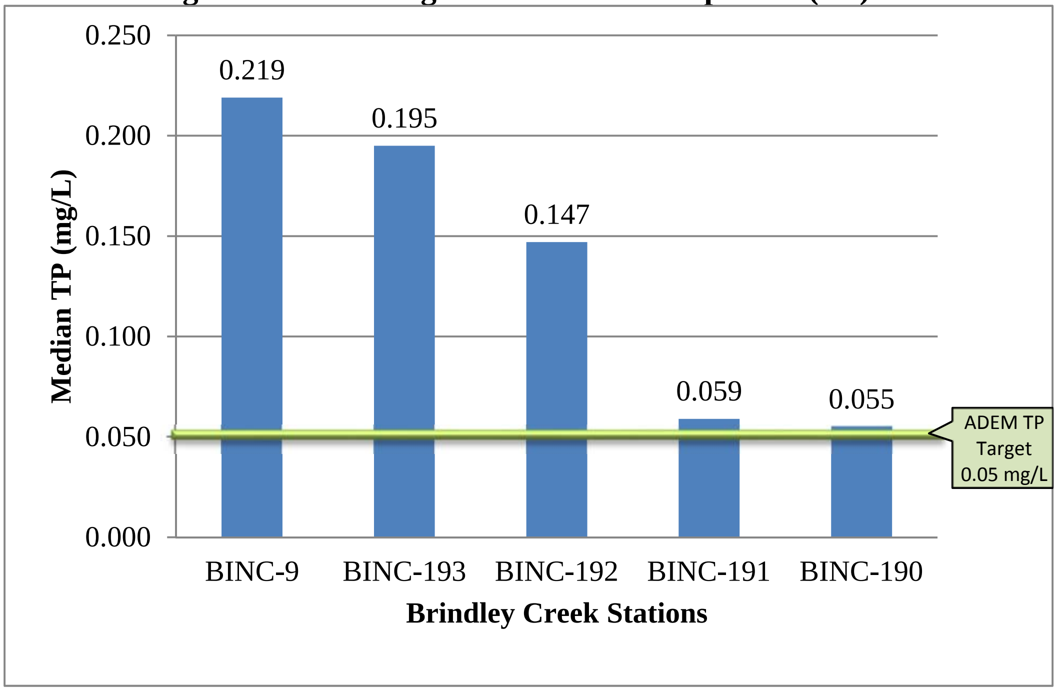


Figure 4.2.2 below demonstrates how the observed TP concentrations within Brindley Creek are significantly above the Level IV Ecoregional reference concentration. Based on the elevated observed TP concentrations, and additional evidence provided in the appendix, ADEM feels that TP is the key nutrient controlling the productivity and causing excess algal biomass in Brindley Creek.

Figure 4.2.2 Existing Median Total Phosphorus (TP) Concentrations



The median TP concentration, derived from water quality data collected at station BINC-192, will be used to represent existing conditions for the Brindley Creek watershed. Station BINC-192 was selected as the most appropriate location for non-point source (NPS) concentration calculations based upon its relative location within the watershed. As mentioned earlier, the water quality impacts, as a result of nutrient over-enrichment, are being observed within the lake itself, and not the wadeable portions of the stream. Station BINC-192 is the most immediate ADEM station located upstream of Forest Ingram Lake, and therefore should provide the most accurate illustration of the existing inflow conditions to the reservoir.

The existing tributary concentrations used in BATHTUB model for the inflow into the reservoir were taken from the ADEM station most immediately upstream of the reservoir at station BINC-192. Furthermore, the existing water quality concentrations for the reservoir were recorded at the ADEM station BINC-191.

4.3 Critical Conditions

It is important when developing a TMDL that it is protective of water quality over a range of possible conditions that might occur within the listed segment. In EPA's Nutrient Criteria Technical Guidance Manual: Rivers and Streams, it states that 'Nutrient and algal problems are frequently seasonal in streams and rivers, so sampling periods can be targeted to the seasonal periods associated with nuisance problems.' ADEM has determined that the seasonal period associated with nutrient enrichment that results in nuisance algal problems for Brindley Creek is the growing season of April through October. Typically, critical conditions specify a flow that will represent an extreme low flow regime or a loading that represents a high possible value. If the growing season median concentration is less than the target concentration, then the loading to the system is said to be protective of water quality. However, if the growing season median concentration is greater than the target, then the loading may not be protective of water quality. This loading, therefore, needs to be reduced until the target concentration is met. Therefore, in order to represent the most critical conditions for this TMDL, only the data collected during the growing season months (April- October) is considered.

4.4 Margin of Safety

Section 303(d) of the Clean Water Act and EPA's regulations state "TMDLs should be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variations and a margin of safety that takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." There are two methods for incorporating a margin of safety (MOS) in the analysis: a) by implicitly incorporating the MOS using conservative model assumptions to develop allocations; b) by explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations.

The MOS in this TMDL is implicit since the total phosphorus target was derived using ecological reference streams, which are considered to representative of the least impacted conditions.

4.5 Seasonal Variation

The TP numeric target is a single value which represents the range of values measured over multiple-year growing seasons at the designated reference sites. Therefore, application and interpretation of the nutrient target for Brindley Creek should consider that ambient TP concentrations may exceed the target at times while still maintaining conditions similar to those in streams that fully support the designated use of aquatic life, as long as the growing season median concentration is maintained. Application of the proposed nutrient target of 0.050 mg/L for TP must consider the methodology of the ecoregion reference stream approach that was used to develop the target. Ecoregion reference stream site data was assessed on a growing-season basis that accounts for natural variability. Therefore, it would be inappropriate to expect Brindley Creek not to exhibit natural variability during the growing season including higher, as well as lower, levels of phosphorus while attaining the growing season median target value. The April-October growing season was determined to be the appropriate time frame for managing TP to control nutrient related issues in Brindley Creek. It was determined that winter reductions (i.e., non-growing season) would not be necessary since high flows, cool temperatures, and low availability of substrate and light, limit algal production. Application of the TP target may be reviewed based on future research as effects-based links become more tangible. It is a valid observation that certain streamflow will combine to result in TP levels higher and lower than the target.

4.6 TMDL Calculation Method and Results

This TMDL is based on an instream total phosphorus (TP) target concentration of 0.050 mg/L established for both the wadeable portions of Brindley Creek and the Forest Ingram Lake, and is applied as a median target during the April through October growing season. Although the 0.050 mg/L target is only applicable during the growing season, it is still considered protective of designated uses throughout the entire year, to include the non-growing season (winter months).

Examples of Best Management Practices used in the watershed to minimize the adverse water quality impacts related to nutrient enrichment, for instance performing annual soil tests, adhering to recommended fertilizer application rates, appropriately timing nitrogen application to prevent leaching, and maintaining soil cover to control erosion will simultaneously address both TN and TP. Considering a TP load reduction of 66% as noted below, it is therefore reasonable to assume the necessary BMPs implemented to achieve this TP load reduction will also inherently reduce the TN load by approximately 20% as well.

4.6.1 Waste Load Allocation (WLA)

There are no permitted point sources in the Brindley creek watershed which could be considered a considerable source of nutrients to Brindley Creek. Therefore, the WLA portion of this TMDL is not applicable.

4.6.2 Load Allocation (LA)

The LA for the Brindley Creek watershed was calculated based upon water quality data collected at station BINC-192. The median TP concentration is considered to be the existing TP load allocation (LA) for Brindley Creek. The percent reduction was calculated from the existing concentration to the allowable concentration. Station BINC-192 was selected as the most appropriate location for non-point source (NPS) concentration calculations based upon its relative location within the watershed. As mentioned earlier, the water quality impacts, as a result of nutrient over-enrichment, are being observed within the lake itself, and not the wadeable portions of the stream. Station BINC-192 is the most immediate ADEM station located upstream of Forest Ingram Lake, and therefore should provide the most accurate illustration of the existing inflow conditions to the reservoir.

Table 4.6.1 Brindley Creek Load Allocation

Station ID	Visit Date	Total P (mg/L)
BINC-192	4/15/2009	0.153
BINC-192	5/14/2009	0.286
BINC-192	6/10/2009	0.002
BINC-192	7/15/2009	0.122
BINC-192	8/12/2009	0.147
BINC-192	9/9/2009	0.047
BINC-192	10/14/2009	0.361

Median Growing Season Concentration (mg/L)	0.147

TMDL Target Concentration (mg/L)	0.050

Percent Reduction	**66%**

Table 4.6.2 Brindley Creek TMDL

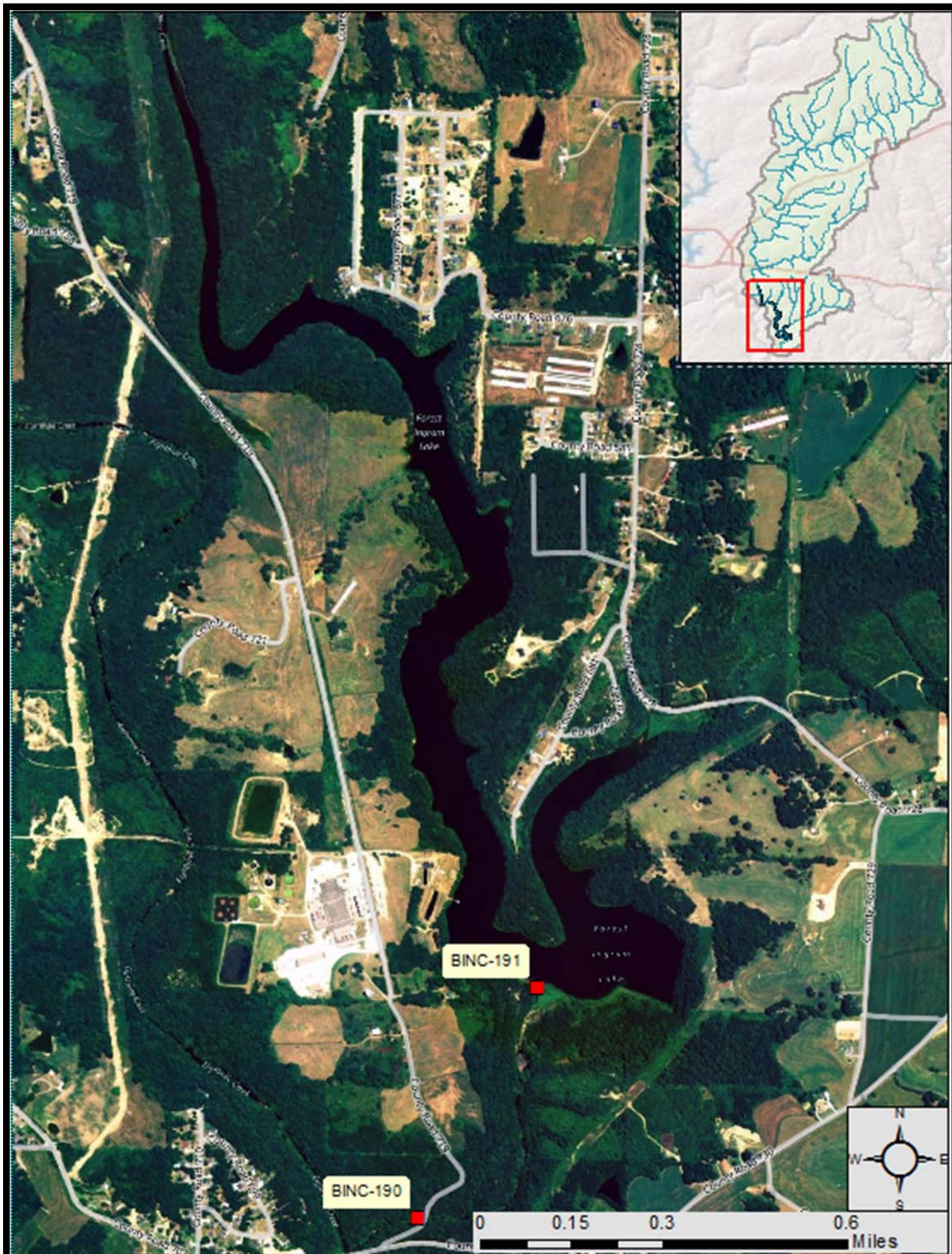
TMDL[a]	Margin of Safety (MOS)	Waste Load Allocation (WLA)[b]		Load Allocation (LA)	
		WWTPs[c]	MS4s[d]		
Total Phosphorus (mg/L)	Total Phosphorus (mg/L)	Total Phosphorus (mg/L)	(% reduction)	Total Phosphorus (mg/L)	(% reduction)
0.050	Implicit	N/A	N/A	0.050	66%

a. TMDL is to be applied as a growing season (Apr-Oct) median TP concentration as measured at Station BINC-192.
b. There are no CAFOs in the Brindley Creek watershed. Future CAFOs will be assigned a waste load allocation (WLA) of zero.
c. N/A = not applicable, no WWTPs are currently located within the watershed.
d. N/A = not applicable, no regulated MS4 areas are currently located within the watershed. Future MS4 areas would be required to demonstrate consistency with the assumptions and requirements of this TMDL.
e. Considering a TP load reduction of 66% as noted above, it is therefore reasonable to assume the necessary BMPs implemented to achieve this TP load reduction will also inherently reduce the TN load by approximately 20% as well.
f. A flow rate of 18.3 cfs, representing the statistical average of the measured flows at the time of the total phosphorus concentrations sampling events, was assumed for the inflow into the reservoir. Following the TMDL concentration reductions (66% TP and an inherent 20% TN), the average daily loads expected to enter Forest Ingram lake are 4.93 lbs/day for TP and 234.85 lbs/day for TN.

5.0 BATHTUB Eutrophication Model

The BATHTUB eutrophication model was utilized in evaluating the water quality impacts as a result of nutrient load reduction in the Brindley Creek reservoir, Forest Ingram Lake. The BATHTUB model is one of several steady state models developed by the U. S. Army Corps of Engineers (USACE) Waterways Experimental Station. By using empirical relationships developed and tested for reservoir applications, eutrophication-related water quality conditions are predicted.

Figure 5.0.1 Forest Ingram Lake



5.1 Model Inputs and Calibration

Due to both lack of bathymetry data and the relatively small volume of the reservoir, Forest Ingram Lake will be modeled as a single spatially averaged reservoir. The required data inputs for the BATHTUB model include the following:

1. Global Variables (including the period of average, annual precipitation and evaporation, and increase in reservoir storage)
2. Atmospheric deposition to the reservoir
3. Segment morphometry and internal load data
4. Tributary Data, including water quality concentrations of the inflows.

Table 5.1.1 Average Annual Precipitation, Birmingham AL

Year	*Precipitation (in)*
2000	48.70
2001	61.33
2002	61.30
2003	60.19
2004	64.67
2005	48.38
2006	50.54
2007	32.01
2008	55.62
2009	70.83
2010	48.98
Annual Average (inches) =	**54.78**

Table 5.1.2 Forest Ingram Lake Morphometry

Reservoir Input Parameter	Input	Source
Surface Area (km^2)	0.39	Determined from GIS shapefile
Mean Depth (m)	8.4	One half of the maximum depth
Estimate Mixed Depth (m)	8.03	Regression model function of mean depth

5.2 Model Application

The BATHTUB model offers multiple options for estimating the influence of sedimentation on the in-lake TP concentrations. For both of the following scenarios, the Canfield and Bachman (1981) analysis for artificial lakes (option 09) was chosen as model of choice. This model for the prediction of phosphorus concentrations was developed and tested on data from over 700 natural and artificial lakes across the United States. Furthermore, since Forest Ingram Lake is an artificial reservoir, this model is especially applicable to the current conditions.

BATHTUB also provides multiple choices for modeling the response of chlorophyll-a in the reservoir. For this application, the default Model Option 2 was selected. Model 2 calculates algal communities as a function of both phosphorus and light intensity. Since the observed chlorophyll-a concentrations in Forest Ingram Lake are exceedingly high, it is reasonably safe to assume the lake has issues related to self shading. Therefore, Model 2 should provide an accurate prediction of chlorophyll-a response.

BATHTUB offers five options to classify how the tributary source encounters the reservoir. In this scenario, Brindley Creek is represented as a “gauged tributary”, meaning the inflow volumes and concentrations are directly measured or estimated. The observed water quality TP concentrations and flowrates used for this input were taken from the most immediate station upstream of the Forest Ingram Lake, station BINC-192. Station BINC-192 was selected as the most appropriate location for non-point source (NPS) concentration calculations based upon its relative location within the watershed. Station BINC-192 is the most immediate ADEM station upstream of Forest Ingram Lake. Furthermore, based upon its geographical location in the center of the watershed, ADEM feels the water quality data observed at station BINC-192 yields the most accurate representation of the existing conditions.

The tables below illustrate the observed water quality conditions for station BINC-192 and BINC-191, respectively.

Table 5.2.1 ADEM Station BINC-192 Water Quality

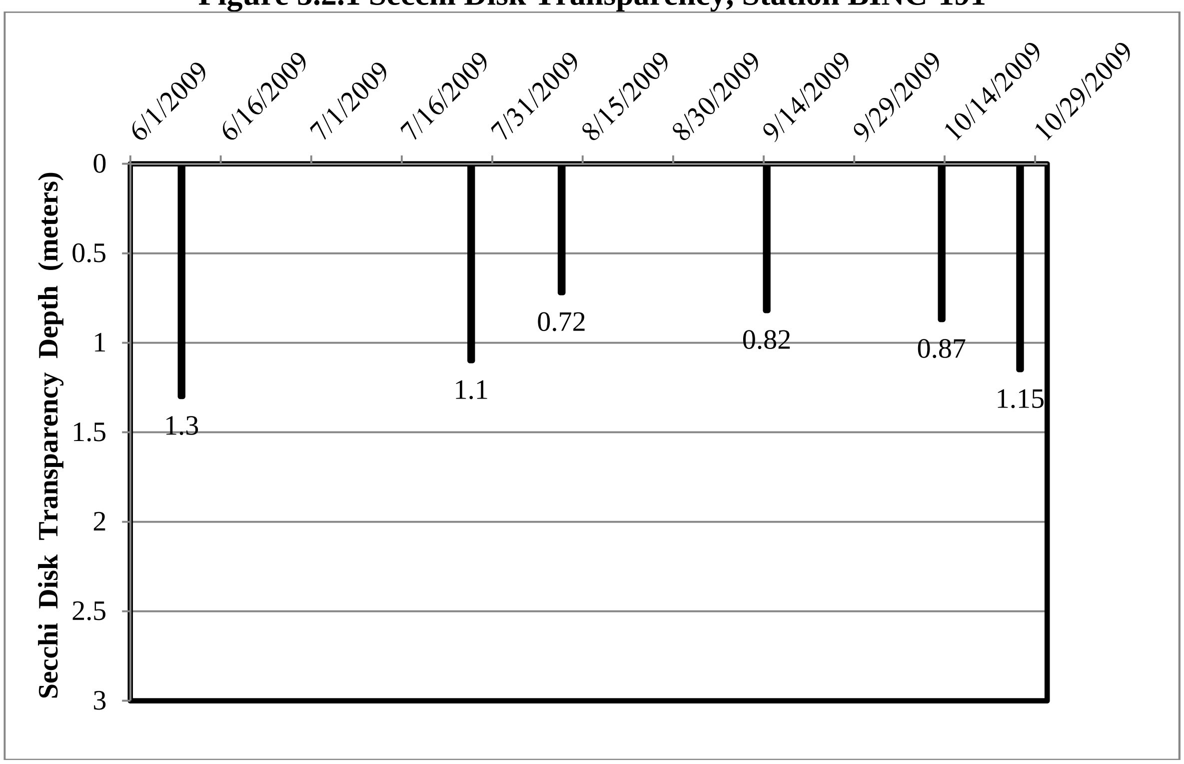
Station ID	Visit Date	Total N mg/L	Total P mg/L
BINC-192	4/15/2009	2.340	0.153
BINC-192	5/14/2009	2.977	0.286
BINC-192	6/10/2009	5.635	0.002
BINC-192	7/15/2009	3.910	0.122
BINC-192	8/12/2009	1.467	0.147
BINC-192	9/9/2009	0.618	0.047
BINC-192	10/14/2009	3.666	0.361

		Total N mg/L	Total P mg/L
BINC-192 Average:		2.945	0.160
BINC-192 Median:		2.977	0.147
BINC-192 Covariance:		0.57	0.79

Table 5.2.2 ADEM Station BINC-191 Water Quality

Station ID	Visit Date	Chlorophyll-a ug/L	Total P mg/L
BINC-191	4/15/2009	33.10	0.057
BINC-191	5/14/2009	11.20	0.363
BINC-191	6/9/2009	39.00	0.074
BINC-191	7/27/2009	26.20	0.061
BINC-191	8/11/2009	40.60	0.037
BINC-191	9/14/2009	1.00	0.040
BINC-191	10/13/2009	8.54	0.097
BINC-191	10/26/2009	9.79	0.021
		Chlorophyll-a ugl	**Total P mgl**
BINC-191 Average:		21.18	0.094
BINC-191 Median:		18.70	0.059
BINC-191 Covariance:		1.38	0.84

Figure 5.2.1 Secchi Disk Transparency, Station BINC-191



Once the model is calibrated to reflect the observed water quality conditions of the reservoir, the next step is to evaluate how a uniform reduction of the nutrient loading within the Brindley Creek watershed, through the implementation of Best Management Practices (BMPs) for example, impacts the water quality of Forest Ingram Lake. This reduction was simulated within the model by reducing the total phosphorus concentrations of the Brindley Creek tributary down to the TP eco-reference target of 0.05 mg/L. The median TP concentration at station BINC-192, upstream of the reservoir, was considered the existing condition for the tributary inflow into the lake. As noted earlier considering a TP load reduction of 66%, it is reasonable to assume the necessary BMPs implemented to achieve this TP load reduction will also inherently reduce the TN load by approximately 20% as well. Therefore, in accordance with this assumption, the median TN concentration observed at station BINC-192 was reduced by 20 percent prior to running the model. A flow rate of 18.3 cfs, representing the statistical average of the measured flows at the time of the observed total phosphorus concentrations, was assumed for the inflow into the reservoir. This in-flow rate was held constant during all the reduction scenarios. The results from the phosphorus concentration reductions of 25, 50, and 75 percent are given below in the table below.

Table 5.2.3 Observed and Predicted Concentration Values

		Percent Reduction			
Water Quality Variable	**Observed**	**25%**	**50%**	**66%**	**75%**
Brindley Creek Tributary TP (ug/L)	147	110.24	73.5	**50.0**	36.7
Brindley Creek Tributary TN (ug/L)	2977	-	-	**2382**[a]	-
Forest Ingram Lake TP (ug/L)	93.8	71.2	52.2	**38.5**	29.9
Chlorophyll a (ug/L)	21.2	19.5	17.3	**14.7**	12.5
Secci Depth (m)	1.0	1.1	1.1	**1.2**	1.3

a. The tributary TN concentration illustrates the assumed inherent 20% reduction to the TN, as a result of the necessary BMP's implemented to address the 66% reduction to TP

The established chlorophyll-a criteria for reservoirs in the Black Warrior River basin for comparable eco-regions, specifically the Level III Southwestern Appalachians, ranges from 5 ppb in Smith Lake up to 16 ppb in the Bankhead reservoir. Following a 69 % reduction in TP, the BATHTUB predicted chlorophyll-a concentration of 14.7 ppb is within desired range.

For further information, including the predicted water quality conditions within Forest Ingram Lake following the TMDL reduction, the tributary inflow nutrient load estimates, and the Forest Ingram outflow nutrient load estimates, please refer to the BATHTUB output provided in appendix D.

6.0 Follow Up Monitoring

ADEM has adopted a basin approach to water quality management; an approach that divides Alabama's fourteen major river basins into five groups. Each year, ADEM's water quality resources are concentrated in one of the five river basin groups. One goal is to continue to monitor §303(d) listed waters. Monitoring will help further characterize water quality conditions resulting from the implementation of best management practices in the watershed. This monitoring will occur in each basin according the schedule shown in the table below.

Table 6.0.1 §303(d) Follow Up Monitoring Schedule

River Basin Group	Year to be Monitored
Alabama / Coosa / Tallapoosa	2010
Escatawpa / Mobile / Lower Tombigbee / Upper Tombigbee	2011
Black Warrior / Cahaba	2012
Chattahoochee / Chipola / Choctawhatchee / Perdido-Escambia	2013
Tennessee	2014

7.0 Public Participation

As part of the public participation process, this TMDL was placed on public notice and made available for review and comment. The public notice was prepared and published in the four major daily newspapers in Montgomery, Huntsville, Birmingham, and Mobile, as well as submitted to persons who have requested to be on ADEM's postal and electronic mailing distributions. In addition, the public notice and subject TMDL was made available on ADEM's Website: www.adem.state.al.us. The public can also request paper or electronic copies of the TMDL by contacting Mr. Chris Johnson at 334-271-7827 or cljohnson@adem.state.al.us. The public was given an opportunity to review the TMDL and submit comments to the Department in writing. At the end of the public review period, all written comments received during the public notice period became part of the administrative record. ADEM considered all comments received by the public prior to finalization of this TMDL and subsequent submission to EPA Region 4 for final review and approval.

Appendix A.

References

ADEM Administrative Code, 2010. Water Division - Water Quality Program, Chapter 335-6-10, Water Quality Criteria.

ADEM Administrative Code, 2010. Water Division - Water Quality Program, Chapter 335-6-11, Use Classifications for Interstate and Intrastate Waters.

Alabama Department of Environmental Management (ADEM), Alabama's Water Quality Assessment and Listing Methodology, January 2010.

United States Environmental Protection Agency. 1991. Guidance for Water Quality-Based Decisions: The TMDL Process, Office of Water, EPA 440/4-91-001.

USEPA 2000a. Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria. Rivers and Streams in Ecoregion XI. United States Environmental Protection Agency, Office of Water. EPA 822-B-00-020.

USEPA 2000b. Nutrient Criteria Technical Guidance Manual: River and Streams. United States Environmental Protection Agency, Office of Water. EPA 822-B-00-002.

Walker, W. W. 1999. Simplified procedures for eutrophication assessment and prediction: User manual. Instruction Report W-96-2. U.S. Army Corps of Engineers. Washington, DC.

Appendix B.
Eco-reference Data

B-1 Level 4 Ecoregion Station: 68d "Southern Table Plateaus"

Eco-reference Station	Waterbody	LATITUDE	LONGITUDE
BLVC-1	Blevens Creek	34.267361	-87.077611
BYTJ-1	Bryant Creek	34.646583	-85.843028
BERD-9	Bear Creek	34.38094	-85.69789

B-2 Eco-reference Data

Ecoregion	Station ID	Visit Date	Flow cfs	T H2O C	DO mgl	TN mgl	Total P mgl	Chl A µg/L
68D	BLVC-1	26-Jun-02		26.3	7.8	2.418	0.051	1.07
68D	BLVC-1	15-Jul-02	32.8	23	8.1	1.693	0.033	1.07
68D	BERD-9	18-Sep-00	0.2	19	8.7	0.077	0.02	
68D	BLVC-1	16-May-02	5.4	15	9.5	31.32	0.006	0.8
68D	BLVC-1	11-Apr-02	13.4	18.1	12.5	1.015	0.031	0.53
68D	BLVC-1	09-Dec-02	10.9	9	12.1	1.492	0.034	0.1
68D	BLVC-1	13-Nov-02	30.5	25	9.9	1.589	0.048	0.5
68D	BLVC-1	01-Jul-02		24		0.296	0.049	0.53
68D	BLVC-1	27-May-99	3.5	17.3	8.38	0.539	0.004	
68D	BYTJ-1	03-Aug-99		22	5.98	0.802	0.004	
68D	BYTJ-1	11-May-99	150.9	17.8	8.84	1.746	0.004	
68D	BYTJ-1	19-May-98	19.7	19	9.4	0.845	0.005	
68D	BLVC-1	13-Jul-99	18.4	24.4	8.03	0.821	0.021	
68D	BYTJ-1	07-Jul-99	47.1	23.1	5.1	1.557	0.022	
68D	BYTJ-1	08-Jul-99	20.1	22.5	7.56	1.557	0.022	
68D	BYTJ-1	08-Sep-99		25	5.07	1.233	0.025	
68D	BLVC-1	10-Jun-99	0.79	21.1	6.67	0.507	0.029	
68D	BYTJ-1	16-Jun-99	8.8	21	6.6	1.037	0.036	
68D	BLVC-1	17-Aug-99		22.9	5.45	0.734	0.042	
68D	BYTJ-1	06-Jul-98	2.1	25	7.3	1.54	0.05	
68D	BERD-9	14-Jun-00	0.1	23	6.7			
68D	BERD-9	15-Jun-00		23	6.1			
68D	BLVC-1	23-Jun-99						
68D	BLVC-1	10-Jun-02	0.5	22.5	7.7			1.34
68D	BLVC-1	18-Jun-02	1	19	8.2			
68D	BYTJ-1	23-Sep-98						
68D	BLVC-1	13-Mar-02	31.5	12	10	2.269	0.05	1.6
		Number	19	25	24	21	21	9
		Min	0.1	9	5.07	0.077	0.004	0.1
		Max	150.9	26.3	12.5	31.32	0.051	1.6
		Median	10.9	22.5	7.915	1.233	0.029	0.8
		90th Percentile	**35.66**	**25**	**9.97**	**2.269**	**0.050**	**1.392**

Appendix C.
Water Quality Data

C-1 ADEM 2009 303(d) Data

Station ID	Visit Date	Ecoregion	DO mgL	NH3 mgL	NO3 NO2 N mgL	TKN mgL	TN mgL	Total P mgL	Chl A µg/L
BINC-9	3/17/2009	68D	11.03	0.01	11.8	0.952	12.752	0.098	1.48
BINC-9	4/15/2009	68D	10.33	0.01	0.071	1.615	1.686	0.219	2.49
BINC-9	5/14/2009	68D	8.77	0.01	0.321	1.347	1.668	0.241	1.6
BINC-9	6/10/2009	68D	8.11	0.01	46.8	0.753	47.553	0.02	1
BINC-9	7/15/2009	68D	7.71	0.01	7.66	0.798	8.458	0.332	2.14
BINC-9	8/12/2009	68D	7.95	0.043	1.771	0.396	2.167	0.148	1.42
BINC-9	9/9/2009	68D	8.35	0.006	0.938	0.089	1.027	0.104	1
BINC-9	10/14/2009	68D	9.27	0.111	2.507	0.964	3.471	0.296	9.61
BINC-193	3/17/2009	68D	11.1	0.01	11.08	0.941	12.021	0.094	2.67
BINC-193	4/15/2009	68D	10.87	0.01	0.214	2.122	2.336	0.097	10.7
BINC-193	5/14/2009	68D	9.26	0.01	0.111	1.976	2.087	0.255	6.94
BINC-193	6/10/2009	68D	8.48	0.01	5.78	0.712	6.492	0.005	1
BINC-193	7/15/2009	68D	7.51	0.01	4.259	0.906	5.165	0.289	1.14
BINC-193	8/12/2009	68D	8.22	0.043	1.383	0.385	1.768	0.135	1
BINC-193	9/9/2009	68D	6.54	0.025	0.444	0.089	0.533	0.097	2.14
BINC-193	10/14/2009	68D	9.47	0.12	2.089	1.167	3.256	0.329	9.34
BINC-192	3/17/2009	68D	11.04	0.01	10.67	1.007	11.677	0.095	1.33
BINC-192	4/15/2009	68D	11.32	0.14	0.044	2.296	2.34	0.153	3.4
BINC-192	5/14/2009	68D	9.27	0.01	0.513	2.464	2.977	0.286	3.74
BINC-192	6/10/2009	68D	8.23	0.01	4.65	0.985	5.635	0.002	1
BINC-192	7/15/2009	68D	7.59	0.01	3.049	0.861	3.91	0.122	3.43
BINC-192	8/12/2009	68D	7.84	0.057	0.8	0.667	1.467	0.147	18.7
BINC-192	9/9/2009	68D	8.15	0.006	0.529	0.089	0.618	0.047	1
BINC-192	10/14/2009	68D	9.17	0.066	2.11	1.556	3.666	0.361	5.34
BINC-191	3/17/2009	68D		0.01	8.44	1.61	10.05	0.079	21.36
BINC-191	4/15/2009	68D		0.01	0.033	2.23	2.263	0.057	33.1
BINC-191	5/14/2009	68D		0.01	0.021	2.472	2.493	0.363	11.2
BINC-191	6/9/2009	68D		0.01		1.059	1.059	0.074	39
BINC-191	7/27/2009	68D		0.01	0.003	1.09	1.093	0.061	26.2
BINC-191	8/11/2009	68D		0.006	0.004	1.058	1.062	0.037	40.6
BINC-191	9/14/2009	68D		0.006	0.006	1.142	1.148	0.04	1
BINC-191	10/13/2009	68D		0.022	1.275	1.03	2.305	0.097	8.54
BINC-191	10/26/2009	68D		0.03	9.248	1.48	10.728	0.021	9.79
BINC-191	11/16/2009	68D		0.006	1.625	0.714	2.339	0.038	22.7
BINC-191	12/1/2009	68D		0.15	0.029	0.798	0.827	0.008	22.4
BINC-190	3/17/2009	68D	10.39	0.01	8.39	1.299	9.689	0.093	11.75
BINC-190	4/15/2009	68D	10.61	0.01	1.543	2.016	3.559	0.065	14
BINC-190	5/14/2009	68D	9.5	0.01	0.036	2.507	2.543	0.345	4.45
BINC-190	6/9/2009	68D	7.54	0.01		0.964	0.964	0.051	6.05
BINC-190	7/14/2009	68D	7.93	0.01	0.653	0.79	1.443	0.055	8.01
BINC-190	8/11/2009	68D	6.87	0.096	0.171	0.755	0.926	0.036	10.7
BINC-190	9/9/2009	68D	7.57	0.67	0.09	1.271	1.361	0.031	13.4
BINC-190	10/14/2009	68D	9.97	0.081	1.198	1.167	2.365	0.179	5.34

C-2 Macroinvertebrate Assessment BINC-192, High Gradient (2009)

	Results	Scores	Rating
Taxa richness measures		**(0-100)**	
# Ephemeroptera (mayfly) genera	4	33	Poor (23-46)
# Plecoptera (stonefly) genera	1	17	Poor (16-31)
# Trichoptera (caddisfly) genera	2	17	Very Poor (<22)
Taxonomic composition measures			
% Non-insect taxa	16	35	Poor (24.7-49.4)
% Non-insect organisms	6	83	Fair (62.8-93.9)
% Plecoptera	6	30	Good (19.8-59.8)
Tolerance measures			
Beck's community tolerance index	3	11	Very Poor (<20.2)
WMB-I Assessment Score	**--**	**32**	**Poor (24-48)**

C-3 Macroinvertebrate Assessment BINC-192, High Gradient (2002)

	Results	Scores	Rating
Taxa richness measures		**(0-100)**	
# Ephemeroptera (mayfly) genera	2	17	Very Poor (<23)
# Plecoptera (stonefly) genera	1	17	Poor (16-31)
# Trichoptera (caddisfly) genera	2	17	Very Poor (<22)
Taxonomic composition measures			
% Non-insect taxa	0	100	Excellent (>87.1)
% Non-insect organisms	0	100	Excellent (>97)
% Plecoptera	21	100	Excellent (>59.8)
Tolerance measures			
Beck's community tolerance index	3	11	Very Poor (<20.2)
WMB-I Assessment Score	**--**	**52**	**Fair (49-72)**

C-3 Macroinvertebrate Assessment BINC-9, High Gradient (2004)

	Results	Scores	Rating
Taxa richness measures			
# EPT genera	6	24	Poor (19-37)
Taxonomic composition measures			
% Non-insect taxa	0	100	Excellent (>96.3)
% Plecoptera	3	13	Good (5.7-52.8)
% Dominant taxa	50	1	Very Poor (<23.5)
Functional composition measures			
% Predators	3	9	Very Poor (<15.1)
Tolerance measures			
Beck's community tolerance index	5	23	Fair (21.3-31.8)
% Nutrient tolerant organisms	0	100	Excellent (>88.1)
WMB-I Assessment Score	**--**	**38**	**Fair (38-56)**

C-4 Macroinvertebrate Assessment BINC-190, High Gradient (2002)

	Results	Scores	Rating
Taxa richness measures		**(0-100)**	
# Ephemeroptera (mayfly) genera	5	42	Poor (23-46)
# Plecoptera (stonefly) genera	0	0	Very Poor (<16)
# Trichoptera (caddisfly) genera	5	42	Poor (22-44)
Taxonomic composition measures			
% Non-insect taxa	13	50	Fair (49.5-74.1)
% Non-insect organisms	14	64	Fair (62.8-93.9)
% Plecoptera	0	0	Very Poor (<6.56)
Tolerance measures			
Beck's community tolerance index	2	7	Very Poor (<20.2)
WMB-I Assessment Score	**--**	**29**	**Poor (24-48)**

C-5 BINC-192 Habitat Assessment, June 2, 2009

Habitat Assessment	%Maximum Score	Rating
Instream Habitat Quality	***74***	*Optimal >70*
Sediment Deposition	***68***	*Sub-optimal (59-70)*
Sinuosity	***80***	*Sub-optimal (65-84)*
Bank and Vegetative Stability	***69***	*Sub-optimal (60-74)*
Riparian Buffer	***83***	*Sub-optimal (70-89)*
Habitat Assessment Score	***177***	
% Maximum Score	***74***	***Optimal >70***

C-6 BINC-192 Habitat Assessment, October 22, 2009

Habitat Assessment	%Maximum Score	Rating
Instream Habitat Quality	***68***	*Sub-optimal (59-70)*
Sediment Deposition	***58***	*Marginal (41-58)*
Sinuosity	***65***	*Sub-optimal (65-84)*
Bank and Vegetative Stability	***45***	*Marginal (35-59)*
Riparian Buffer	***84***	*Sub-optimal (70-89)*
Habitat Assessment Score	***155***	
% Maximum Score	***65***	***Sub-optimal (59-70)***

C-7 1997 ADEM NPS Screening Biological Data

Table 3a. Habitat quality and aquatic macroinvertebrate assessments from the Mulberry Fork cataloging unit. In order to compare levels of habitat degradation between stations, values given for each of three major habitat parameters are presented as percent of maximum score.

	Station										
Parameter	BR-1	MARC-2a	SULC-10a	RICC-11a	SPRW-4a	WOLW-51c	BRIC-72a	MILW-6a	THAC-68a	EMIC-73a	BLAW-70a
Habitat assessment form*	Original	RR	RR	RR	RR	RR	RR	GP	GP	GP	GP
Instream habitat quality	94	87	67	83	80	65	70	68	75	67	55
Sediment deposition	66	63	70	35	65	73	83	47	43	60	37
% Sand	2	5	6	25	25	50	10	45	10	35	62
% Silt	5	13	10	7	2	10	3	10	11	2	10*
Sinuosity	90	90	80	70	95	80	25	40	45	40	45
Bank and vegetative stability	92	93	75	58	60	50	63	65	53	50	40
Riparian zone measurements	85	93	75	58	60	50	63	65	53	50	40
% Canopy Cover	30				50	70	60	70	50	50	30
% Maximum Score	85	76	74	69	66	66	65	61	59	56	45
Habitat Assessment Category	Excellent	Excellent	Excellent	Good	Good	Good	Good	Good	Good	Good	Fair
EPT Taxa Collected	8	10	8	9	10	9	6	11	6	11	9
Aq. Macroinvertebrate Assess.	Sl. Imp.	Sl. Imp.	Sl. Imp.	Sl. Imp.	Sl. Imp.	Sl. Imp.	Mod. Imp	Unimp.	Mod. Imp	Unimp.	Sl. Imp.

	Station		
Parameter	SPLW-71a	DORC-9a	DUCC-69c
Habitat assessment form*	GP	GP	GP
Instream habitat quality	48	43	43
Sediment deposition	33	30	30
% Sand	30	60	74
% Silt	30	15	3
Sinuosity	70	65	30
Bank and vegetative stability	35	48	53
Riparian zone measurements	35	48	53
% Canopy Cover	50		20
% Maximum Score	45	43	42
Habitat Assessment Category	Fair	Fair	Fair
EPT Taxa Collected	7	10	5
Aq. Macroinvertebrate Assess.	Mod. Imp.	Sl. Imp	Mod. Imp

* 'original' from Plafkin et al (1989); RR (Riffle Run) or GP (Glide Pool) assessment from Barbour and Stribling (1994).

C-8 1997 ADEM NPS Screening Chemical Data

Appendix J. Results of physical and chemical measurements from stations sampled as part of the nonpoint source watershed screening of the Black Warrior, 1997

C.U.	Sub-Watershed Number	Station Number	Date (YYMMDD)	Time (24hr)	Water Temp. (C)	Dissolved Oxygen (mg/l)	pH (s.u.)	Conductivity (umhos)	Turbidity (ntu)	Flow (cfs)	Fecal Coliform (col/100ml)	Total Alkalinity (mg/l)	Hardness (mg/l)	BOD-5 (mg/l	TSS (mg/l)	TDS (mg/l)	NH3 (mg/l)	NO2/NO3 (mg/l)
109	010	MULC-1a	971001	1415	18	8.7	7.2	26	4.3	37.6	120	22	26.6	0.6	3	66	LDL	1.82
109	020	DUCC-69c	970516	0730	15	8.7	6.9	102	6.0	15.6	<3							
109	030	BRIC-72a	970521	0700	18	6.6	6.3	90	11.0	3.2	70							
109	030	BRIC-72a	971001	1500	21	6.6	6.8	106	5.0	3.2	202	25	34	1	1	67	LDL	0.91
109	040	EMIC-73a	970521	0950	17	8.3	6.1	80	5.3	2.8	31							
109	080	THAC-68a	970516	1000	16	8.6	7.0	90	5.0	2.7	107							
109	110	SULC-10a	970918	------	------	------	------	------	------	Dry	------							
109	120	BLAW-70a	970515	1220	18	8.0	7.1	113	8.0	11.9	53 Est.							
109	120	SPLW-71a	970515	1405	19	8.1	6.8	43	11.0	27.8	60 Est.							
109	120	SPLW-71a	970924	1710	23	6.5	7.0	53	6.8	7.4	31	21	17.6	0.4	1	25	LDL	0.1
109	130	SPRW-4a	970514	0725	17	8.8	7.0	135	8.0	5.6	53 Est.							
109	170	MILW-6a	970515	1630	18	8.7	7.8	359	47.0	19.6	27 Est.							
109	170	MILW-6a	970924	1625	23	6.8	8.1	849	1.5	3.1	147	179	445.5	0.5	LDL	609	LDL	0.05
109	180	WOLW-51c	970514	1740	20	8.7	6.7	197	11.0	4.8	20 Est.							
109	180	WOLW-51c	970924	1525	23	4.0	7.3	1354	1.9	<Detect.	34	152	714.5	LDL	1	1147	LDL	0.02
110	010	TPSL-1	970715	1300	24	8.2	7.5	89	3.8	6.1	100							
110	020	CANW-13a	970522	1320	16	9.0	6.2	43	6.0	2.5	52							
110	020	CANW-13a	970925	1020	20	8.2	7.2	62	226.0	40.1	GDL	12	22.4	3.2	194	53	LDL	0.38
110	020	SANW-12a	970522	1600	17	8.8	5.8	25	4.8	13.5	27							
110	020	SANW-12a	970925	0920	20	7.9	6.7	37	147	57.6	GDL	10	9.8	3.7	146	31	LDL	0.5
110	030	INMW-1	970715	1720	25	8.0	7.0	31	4.9	1.9	40							
110	050	CLCW-53b	970515	1605	20	8.6	7.1	54	6	15.4	80 Est.							
110	050	CLCW-53b	970925	0815	21	6.7	6.5	53	542	High	>600	14	17.3	2.7	472	41	LDL	0.37
110	050	CLCW-53c	970515	1740	19	8.7	7.1	39	7.0	14.2	53 Est.							
110	050	CLCW-53c	970925	0840	21	6.5	6.3	32	266	High	GDL	9	8.9	3.7	256	48	LDL	0.3
110	080	ROCW-52b	970521	1600	18	8.5	6.0	44	4.0	2.4	100							
110	090	CROC-54a	970521	1355	19	8.6	6.5	77	6.0	6.2	----							
110	100	WHEC-17a	970522	0725	14	9.0	6.0	50	6.5	2.6	34							
110	100	WHOC-16a	970522	1000	15	9.4	6.4	55	4.8	3.0	37							
110	100	WHOC-16a	970925	1142	20	7.6	7.0	72	59.3	10.4	GDL	19	21.2	4.5	39	55	LDL	1
110	130	MILW-18a	970523	0715	17	8.4	7.9	949	1.8	11.0	14 Est.							
110	130	MILW-18a	970918	1010	21	8.0	8.1	1205	0.6	5.7	35	334	725.4	0.4	1	1317	LDL	4.67
111	030	CLEM-76a	970520	0945	18	7.1	6.1	107	3.0	7.9	400							
111	030	CLEM-76a	971001	1209	18	8.3	7.0	102	4.1	27.2	130	21	29.7	0.4	LDL	72	0.22	1.75
111	040	SLAM-22c	970520	0720	18	7.0	6.2	208	8.6	11.2	520							
111	040	SLAM-22c	971001	1250	20	7.3	7	226	7.7	15.3	340	36	66	0.4	1	158	LDL	4.17
111	050	DRYB-75a	970519	1200	21	9.6	8.0	579	4.8	6.2	3675							
111	050	DRYB-75a	970918	1210	29	12.0	8.1	1077	2.2	0.3	30 Est.	123	621	1.3	3	1241	LDL	0.08
111	050	GRAB-77a	970519	1350	19	6.7	6.4	98	5.7	3.8	35							
111	050	GRAB-77a	970918	1240	23	6.5	7.5	179	2.1	0.8	67	80	86.2	0.5	LDL	15	LDL	0.24
111	050	WHIB-74a	970520	1200	20	8.5	6.1	207	5.0	8.7	1800							
111	050	WHIB-74a	971001	1120	19	8.4	7.5	204	4.8	10.6	160	49	84.5	0.7	2	154	LDL	1.03
111	060	LCPB-23a	970519	1620	21	8.4	6.2	62	8.4	3.3	3600							
111	060	LCPB-23a	971001	1019	18	8.1	7.7	281	8.3	22.8	>270	95	151	0.6	LDL	197	LDL	0.37

Appendix D
Bathtub Output

Predicted concentrations within Forest Ingram Lake after TMDL reduction.

Bathtub Output:
Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 1 single

	Predicted Values--->			Observed Values--->		
Variable	Mean	CV	Rank	Mean	CV	Rank
TOTAL P MG/M3	38.5	0.77	40.4%	93.8	0.84	77.2%
TOTAL N MG/M3	2378.3	0.67	91.2%			
C.NUTRIENT MG/M3	37.7	0.74	52.7%			
CHL-A MG/M3	14.7	1.01	72.0%	21.2	1.38	85.5%
SECCHI M	1.2	0.75	57.2%	1.0		46.0%
ORGANIC N MG/M3	525.2	0.55	58.0%			
TP-ORTHO-P MG/M3	32.5	0.46	53.3%			
ANTILOG PC-1	314.7	0.98	57.6%	540.0	1.30	72.7%
ANTILOG PC-2	9.7	1.14	78.0%	10.6	0.92	83.0%
(N - 150) / P	58.0	1.04	96.4%			
INORGANIC N / P	310.6	3.36	99.1%			
TURBIDITY 1/M	0.4	2.01	35.6%	0.4	2.01	35.6%
ZMIX * TURBIDITY	3.5	2.01	55.9%	3.5	2.01	55.9%
ZMIX / SECCHI	6.5	0.76	70.1%	8.0	0.12	81.5%
CHL-A * SECCHI	18.2	1.57	79.3%	21.2	1.38	84.9%
CHL-A / TOTAL P	0.4	0.95	85.3%	0.2	1.60	58.8%
FREQ(CHL-a>10) %	62.2	0.99	72.0%	81.6	0.70	85.5%
FREQ(CHL-a>20) %	21.0	2.23	72.0%	41.4	2.07	85.5%
FREQ(CHL-a>30) %	7.2	3.08	72.0%	19.2	3.18	85.5%
FREQ(CHL-a>40) %	2.7	3.72	72.0%	9.1	4.06	85.5%
FREQ(CHL-a>50) %	1.1	4.24	72.0%	4.5	4.79	85.5%
FREQ(CHL-a>60) %	0.5	4.66	72.0%	2.3	5.42	85.5%
CARLSON TSI-P	56.8	0.19	40.4%	69.6	0.17	77.2%
CARLSON TSI-CHLA	57.0	0.17	72.0%	60.6	0.22	85.5%
CARLSON TSI-SEC	56.9	0.19	42.8%	60.0		54.0%

Bathtub Output: Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area (km^2)	Flow (hm^3/yr)	Variance ($(hm3/yr)^2$)	CV (-)	Runoff (m/yr)
1	1	1	Brindley Creek		18.2	0.00E+00	0.00	
2	4	1	Forest Ingram Lake Outflow		23.1	0.00E+00	0.00	
PRECIPITATION				0.4	0.5	1.14E-02	0.20	1.37
TRIBUTARY INFLOW					18.2	0.00E+00	0.00	
***TOTAL INFLOW				0.4	18.8	1.14E-02	0.01	48.12
GAUGED OUTFLOW					23.1	0.00E+00	0.00	
ADVECTIVE OUTFLOW				0.4	-4.6	1.82E-02	0.03	
***TOTAL OUTFLOW				0.4	18.5	1.82E-02	0.01	47.42
***EVAPORATION					0.3	6.71E-03	0.30	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations
Component: CONSERVATIVE SUBST.

Trb	Type	Seg	Name	Load (kg/yr)	%Total	Load Variance ($(kg/yr)^2$)	%Total	CV	Conc (mg/m^3)	Export ($kg/km^2/yr$)

Overflow Rate (m/yr)	47.4	Nutrient Resid. Time (yrs)	0.0000
Hydraulic Resid. Time (yrs)	0.1856	Turnover Ratio	0.0
Reservoir Conc (mg/m3)	0	Retention Coef.	0.000

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations
Component: TOTAL P

Trb	Type	Seg	Name	Load (kg/yr)	%Total	Load Variance ($(kg/yr)^2$)	%Total	CV	Conc (mg/m^3)	Export ($kg/km^2/yr$)
1	1	1	Brindley Creek	911.5	98.7%	5.13E+05	100.0%	0.79	50.0	
2	4	1	Forest Ingram Lake Outflow	888.2		4.71E+05		0.77	38.5	
PRECIPITATION				11.7	1.3%	3.42E+01	0.0%	0.50	21.9	30.0
TRIBUTARY INFLOW				911.5	98.7%	5.13E+05	100.0%	0.79	50.0	
***TOTAL INFLOW				923.2	100.0%	5.13E+05	100.0%	0.78	49.2	2367.2
GAUGED OUTFLOW				888.2	96.2%	4.71E+05		0.77	38.5	
ADVECTIVE OUTFLOW				-177.2		1.88E+04		0.77	38.5	
***TOTAL OUTFLOW				711.0	77.0%	3.02E+05		0.77	38.5	1823.2
***RETENTION				212.2	23.0%	1.75E+05		1.97		

Overflow Rate (m/yr)	47.4	Nutrient Resid. Time (yrs)	0.1429
Hydraulic Resid. Time (yrs)	0.1856	Turnover Ratio	7.0
Reservoir Conc (mg/m3)	38	Retention Coef.	0.230

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations
Component: TOTAL N

Trb	Type	Seg	Name	Load (kg/yr)	%Total	Load Variance ($(kg/yr)^2$)	%Total	CV	Conc (mg/m^3)	Export ($kg/km^2/yr$)
1	1	1	Brindley Creek	42949.9	99.1%	5.91E+08	100.0%	0.57	2356.0	
2	4	1	Forest Ingram Lake Outflow	54938.0		1.37E+09		0.67	2378.3	
PRECIPITATION				390.0	0.9%	3.80E+04	0.0%	0.50	729.1	1000.0
TRIBUTARY INFLOW				42949.9	99.1%	5.91E+08	100.0%	0.57	2356.0	
***TOTAL INFLOW				43339.9	100.0%	5.91E+08	100.0%	0.56	2309.6	111127.9
GAUGED OUTFLOW				54938.0	126.8%	1.37E+09		0.67	2378.3	
ADVECTIVE OUTFLOW				-10959.2		5.46E+07		0.67	2378.3	
***TOTAL OUTFLOW				43978.7	101.5%	8.77E+08		0.67	2378.3	112766.0
***RETENTION				-638.8		6.37E+08		10.00		

Overflow Rate (m/yr)	47.4	Nutrient Resid. Time (yrs)	0.1883
Hydraulic Resid. Time (yrs)	0.1856	Turnover Ratio	5.3
Reservoir Conc (mg/m3)	2378	Retention Coef.	-0.015

Appendix E
Photographs of Brindley Creek

Photo E-1 Livestock in the Brindley Creek Watershed

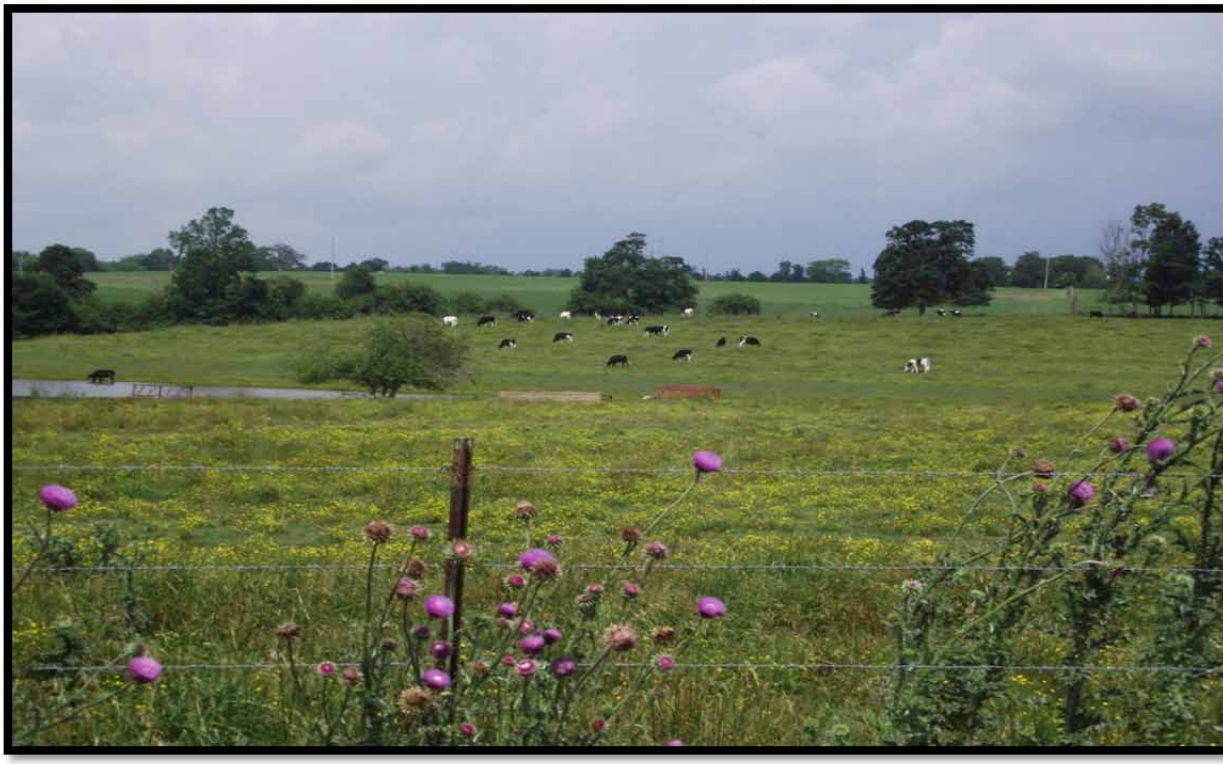


Photo E-2 Livestock in the Brindley Creek Watershed(2)

Photo E-3 Chicken Houses in the Brindley Creek Watershed

Photo E-4 Chicken Houses within the Brindley Creek Watershed

Photo E-5 Forest Ingram Lake

Photo E-6 Station BINC-191 @ Forest Ingram Lake

Photo E-7 ADEM Station BINC-192

Photo E-8 ADEM Station BINC-193

Photo E-9 ADEM Station BINC-9