WATER QUALITY DEMONSTRATION STUDY

OMUSSEE CREEK WASTEWATER TREATMENT FACILITY

DOTHAN, ALABAMA

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Special Studies Section
Field Operations Division
Alabama Department of Environmental Management

INTRODUCTION

The Omussee Creek Wastewater Treatment Plant (WWTP) operates under the National Pollution Discharge Elimination System (NPDES) Permit AL0022764. This permit establishes limitations, monitoring requirements, and reporting requirements for pollutant discharges into Omussee Creek, the receiving stream for the WWTP, from outfall Discharge Serial Number (DSN) 001. The updated hydraulic design capacity of the plant is 5.0 million gallons per day (MGD), with an average daily flow of approximately 4.0 MGD. The plant was upgraded in 1987 to a tertiary treatment facility by the addition of sand filters designed to remove suspended particles from the waste water. After chlorination and dechlorination, the effluent is discharged into Omussee Creek via a 24-inch outfall.

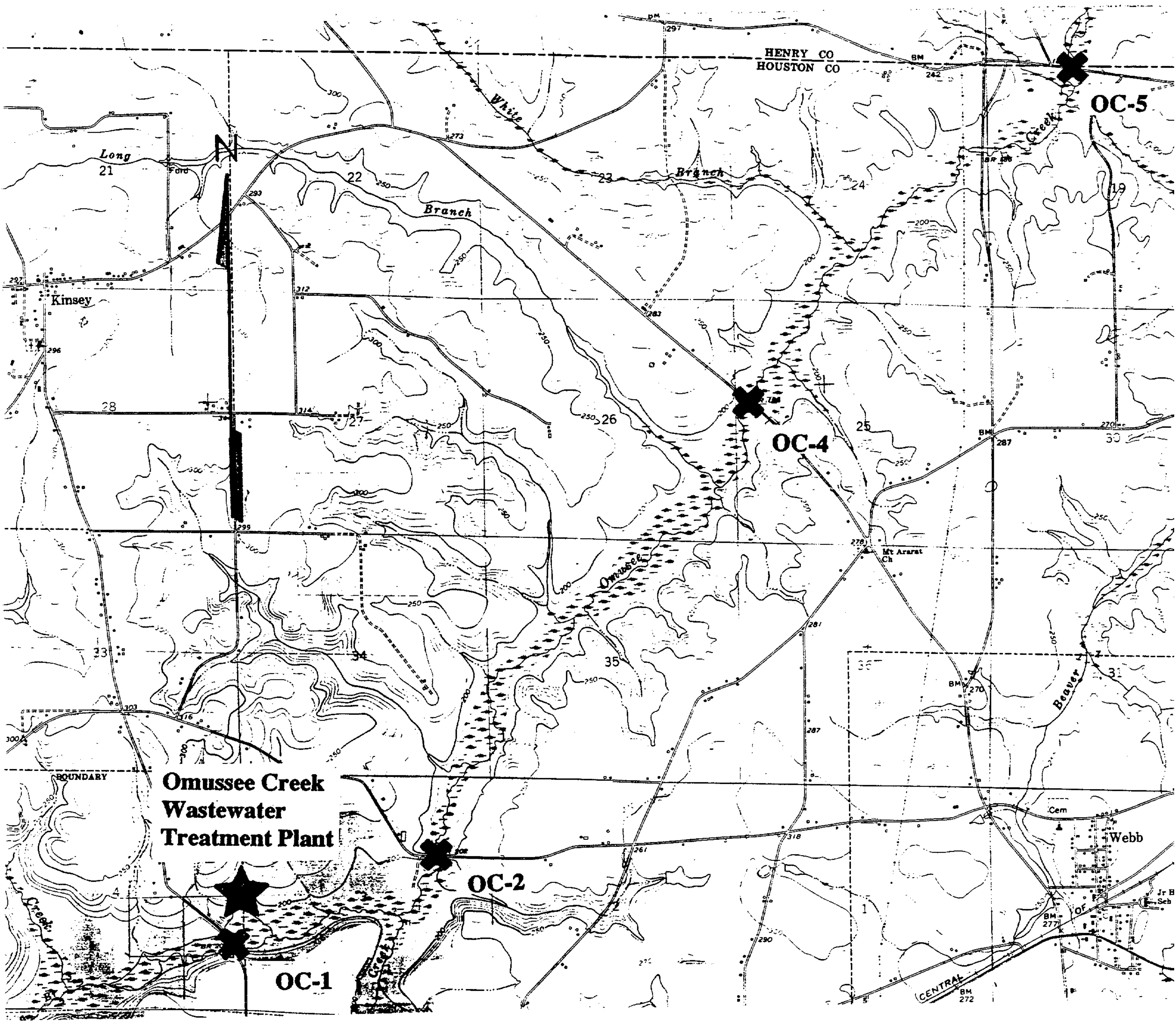
The WWTP receives significant industrial waste from a variety of sources, in addition to receiving domestic waste water. Recent permit-required self-monitoring toxicity tests indicate that the facility effluent is chronically toxic.

Section 101(a)(3) of the Clean Water Act (CWA) states that no toxic pollutants shall be discharged in toxic amounts. The control of possible toxic discharges is a main objective of the National Pollutant Discharge Elimination System (NPDES) and water quality programs. In the Technical Support Document for Water Quality-based Toxics Control (EPA, 1991), EPA recommends an integrated approach towards this end. The integrated approach incorporates chemical testing, toxicity testing, and biological criteria/bioassessments to provide a more complete assessment of water quality. "Since each method has unique as well as overlapping attributes, sensitivities, and program applications, no single approach for detecting impact should be considered uniformly superior to any other approach. For example, the inability to detect receiving water impacts using a biosurvey alone is insufficient evidence to waive or relax a permit limit established using either of the other methods. The most protective results from each assessment conducted should be used in the effluent characterization process. The results of one assessment technique should not be used to contradict or overrule the results of the other(s)."(EPA, 1991) This approach is utilized by the Field Operations Division when appropriate.

Water quality demonstration (WQD) studies are conducted on receiving streams for wastewater treatment plants that are being renovated or upgraded utilizing funds from the State Revolving Fund (SRF) Loan Program. A study of this nature includes monitoring upstream and downstream of the WWTP before construction has started, and again after the work is completed. At the request of the Alabama Department of Environmental Management's (ADEM) Water Division, the Special Studies Section of the Field Operations Division conducted a water quality demonstration study on Omussee Creek, including water chemistry analysis, biological assessment, and toxicity testing , to demonstrate any improvements in water quality of the stream following the upgrade in the treatment facility. Although stream sampling was originally scheduled to coincide with low flow conditions, the 7Q10 of 6.16 cubic feet per second (cfs) was never reached. However, the average stream flow of this sampling year does compare favorably with the stream flow of the study conducted prior to the upgrade to the WWTP.

Map 1

Sampling Locations
Omussee Creek



SAMPLING LOCATIONS

The study consisted of four (4) sampling sites on Omussee Creek and the WWTP effluent stream. The station names and locations are as follows:

STATION	DESCRIPTION
OC-1	Omussee Creek upstream of the WWTP at county road 51 crossing. T3N, R27E, S4, NE1/4 of SE1/4. Latitude 31 15' 31", Longitude 85 19' 56"
OC-WWTP	T3N, R27E, S3, NW/4 of SW1/4 Latitude 31 15' 33", Longitude 85 19' 54"
OC-2	Omussee Creek approximately 1 mile downstream of the WWTP at the first county road crossing. T3N, R27E, S3, SE1/4 of NE1/4 Latitude 31 15' 50", Longitude 85 19' 04"
OC-4	Omussee Creek at the second county road crossing downstream of the WWTP. T4w, R27E, S25, SW1/4 of NW1/4. Latitude 31 17' 26", Longitude 85 17' 47"
OC-5	Omussee Creek at the third county road crossing downstream of the WWTP. T4N, R28E, S19, SE1/4 of NE1/4. Latitude 31 18' 20", Longitude 85 16' 54"

METHODOLOGY

Omussee Creek was sampled at all stations in the months of June, August and September for field parameters and water chemistry. Flow was measured at OC-1, OC-WWTP, OC-2, and OC-5 during each sampling event. Toxicity samples were collected at stations OC-1, OC-WWTP, and OC-2 at each sampling event. Biological samples were collected utilizing the multihabitat bioassessment protocol (RBP-multihabitat) at stations OC-1, OC-2, OC-4, and the closest ecoregional reference site (a least impacted site) on Bear Creek-Houston County (BRH-1) during the August sampling event. The RBP-multihabitat method, as outline in the ADEM Field Operations Division Standard Operating Procedures and Quality Control Assurance Manual, Volume II, corroborates the physical and chemical data, and provides an aspect that reflects response to pollutants over time.

All field parameters, chemical and biological sampling, physical data, and sample handling techniques used are described in the ADEM Field Operations Division Standard Operating Procedures and Quality Control Assurance Manual , Volumes I, II, and IV. Chain-of-custody was maintained at all times. All water samples taken for laboratory analysis were transported to the ADEM Central Laboratory. Analysis methodology were as specified in the Federal Register, 40 CFR Part 136, October 1984, as amended. Results of these analyses are summarized in Tables 1 and 2.

Single station and comparison biometrics were calculated to analyze the macroinvertebrate samples collected at each station. Tables 3A and 3B provide simplified interpretations of single station and comparison metrics, respectively. The Biological Condition Scoring Criteria (BCSC), developed by the EPA (Plafkin et al. 1989), was used to assess the biotic integrity of each study station in relation to the ecoregional reference site (Table 4A). A listing of the metrics and scoring procedure used to calculate the BCSC for each study station is provided in Table 4B.

DISCUSSION AND RESULTS

A. PHYSICAL

Omussee Creek is a third order stream at OC-1 , a fourth order stream from OC-2 through OC-5, and lies within the Chattahoochee River drainage basin. The canopy cover for the creek varies over the length of the sampling reach from mostly open to mostly shaded and the dominant streamside vegetation is trees. The creek drains forest, field/pasture, agricultural, and residential lands and falls within the Dougherty and Marianna Plains sub-ecoregion. Bottom structure at OC-1 and OC-2 is dominated by sand, while at OC-4 and OC-5 the dominant substrate is mud/muck; all stations have a silty deposit on the creek bottom. Omussee Creek shows slight erosion at OC-1 and heavy erosion within the watershed at the downstream stations. There are obvious sources of non-point runoff pollution at OC-2, with pasture land both upstream and downstream of the bridge and the farm animals having free access to the stream. Bank stability varies widely from moderately stable to unstable , and all stations show signs of some natural channel alteration due to the large amounts of sand present in the area. Habitat assessments rated the creek as FAIR to GOOD at all locations. Although habitats available for colonization by aquatic macroinvertebrates differed somewhat between stations, comparisons were based upon macroinvertebrate communities from habitats available at all stations.

Flow data collected on Omussee Creek before and after the upgrade appear similar (Tables 1&2, Figure 1). However, the lowest flow measured at OC-1 was 15 cfs, 2.5 times greater than the 7Q10 low flow of 6.16 cfs for this station. Discharge from the WWTP contributed 5-23% of total stream flow at OC-2, the station most impacted by the WWTP, during the 1993 study period. These percentages are much lower than the permitted instream waste concentration (IWC) of 56%, suggesting that the chemical impact from the WWTP observed during this study may have been buffered by elevated stream flows.

B. CHEMICAL

Omussee Creek has a Water Use Classificaton of Fish and Wildlife (F&W) over the length of the study reach. This Water Use Classification specifies the waters to be suitable for "fishing, propagation of fish, aquatic life and wildlife, and any other usage except for swimming and water contact sports or as a source of water supply for drinking or food processing purposes" (ADEM, 1982).

Data collected prior to the upgrade of the WWTP indicated that the discharge was not meeting the dissolved oxygen standard of 5.0 mg/l required for the F&W Water Use Classification (Table 1 and Figure 2). Biochemical Oxygen Demand (BOD5) measurements, and concentrations of ammonia-Nitrogen (NH3), Total Kjeldahl Nitrogen (TKN), and Total Organic Nitrogen (TON) were higher at stations OC-2 and OC-4 than at the upstream control (OC-1) (Table 1). Measurements of these parameters were comparable at OC-1 and OC-5, however, suggesting that the impact on water quality decreased downstream.

Chemical data collected after the upgrade indicate an improvement in the chemical water quality of the Omussee Creek downstream of the WWTP. Dissolved oxygen concentrations increased to equal to or above the 5.0 mg/l DO standard for the F&W Classification (Table 2 and Figure 2). In addition, BOD5 (Figure 3), NH3 (Figure 4a) , TKN (Figure 4b), and TON (Figure 4c) concentrations decreased at the WWTP as well as the downstream stations (Table 2). The WWTP's current contribution to the creek's Total Suspended Solids (TSS) and turbidity (Table 2) is negligible. The higher values of these two parameters downstream of the WWTP may be attributable to runoff from highly erosional areas and other non-point sources.

C. BIOLOGICAL

1. In-Stream Bioassessment

A listing of the macroinvertebrate taxa collected during the 1993 sampling period is included in the appendix. Single station and comparison metrics calculated from the macroinvertebrate data collected at the control, reference and study stations and discussed in this report are located in Tables 3a and 3b, respectively. A simplified interpretation of these metrics is included in each of these Tables. All comparisons were based upon macroinvertebrate communities within habitat types present at all stations: rock/log, sand, and coarse particulate organic material (CPOM) habitats.

a. Single Station Metrics

Taxa richness was 33 and 39 at the control (OC-1) and reference stations (BRH1), respectively. Taxa richness decreased slightly at OC-2 (24), downstream of the WWTP, indicating a decrease in water quality. This may be expected below a discharge; however, the decrease may be attributable in part to non-point source runoff at this station. An increase in taxa richness at OC-4 suggests that the stream has recovered to above the quality of OC-1 for this metric. (Table 3a)

The Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness was 7 and 8 at the control (OC-1) and reference stations (BRH-1), respectively. The EPT taxa richness was 3 at OC-2, indicating impacted water quality, but recovered at OC-4 to levels found at the control and reference sites (Table 3a).

The Biotic Index values of the downstream stations (OC-2 and OC-4) did not differ greatly from either the control station or the reference station. The reference station had a Biotic Index (Table 3a) of 5.03, while the control station had a value of 6.15. Stations OC-2 and OC-4 had values of 5.40 and 5.28, respectively.

The percent contribution of dominant taxon (Figure 5) ranged from 15% at the reference station to 29% at OC-4 and indicates a balanced trophic structure within each station. The percent contribution of the of collector-gatherers dominated the macroinvertebrate community at all stations. The macroinvertebrate community of the upstream control station was characterized by a higher proportion of shredders and lower proportion of collectors than the downstream stations (Figure 6). This shift in functional feeding group assemblages is expected, however, as a result of changes in available resources that occur along the stream continuum (Vannote et al. 1980).

b. Station Comparison Metrics

The results of the overall station comparison metrics, summarized in Table 3b, suggest that OC-2 was the least similar to the control (OC-1) and reference (BRH-1) stations, and the most impacted. The Community Loss Index indicates the largest loss of taxa at OC-2 when compared to either the control (OC-1) or reference stations (BRH-1). Values for the Quantitative Similarity Index for Taxa (QSI-Taxa) indicate that the macroinvertebrate assemblages of the control (OC-1) and reference sites (BRH-1) to be the two most similar stations.

Results of the QSI-Taxa also suggests that the macroinvertebrate communities of OC-1 and OC-4 are more similar than OC-1 and OC-2. The results of the Sorenson's Community Similarity Index (SCSI) support the QSI-Taxa results and suggest that the macroinvertebrate community may be recovering by the time the stream reaches OC-4. The SCSI results also suggest greater similarity between BRH-1 and OC-2 than between BRH-1 and the upstream control (OC-1) or BRH-1 and the most downstream station (OC-4), however. (Table 3b)

Comparisons between OC-4, the most downstream site, and the control and reference stations indicate a recovery of the aquatic macroinvertebrate community at the downstream station location. These results are further supported by the BCSC bioassessment results which score the macroinvertebrate samples of the study stations in relation to the ecoregional reference site (Table 5A). The macroinvertebrate community was "slightly impaired" at OC-2, but was found to be "non-impaired" at OC-4. The control site at OC-1 was also found to be slightly impaired by the BCSC bioassessment.

2. Whole Effluent Toxicity Testing

Short-term, static renewal, chronic toxicity tests were performed on samples collected from the Omussee Creek-Dothan WWTP effluent, OC-1, and OC-2 during the June and August sampling events; tests were performed only on the WWTP and OC-2 during September. Test species utilized were the fathead minnow *Pimephales promelas* and the daphnid *Ceriodaphnia dubia*. The WWTP effluent samples were diluted to the permitted instream waste concentration (IWC) of 56% and subsequently analyzed. The upstream and downstream samples were analyzed as collected (100% stream water). The measured endpoints for the fathead minnow tests were survival and growth, while the measured endpoints for the daphnid tests were survival and reproduction. Toxicity was indicated if there were significant differences between survival and growth (fathead minnow) or survival and reproduction (daphnid) between the controls and effluent or receiving water test solutions. Tests were considered invalid if there was greater than 20% mortality in the controls, or control mean growth (weight, fathead minnow) was <0.25 mg per replicate or control mean reproduction was < 15 per female.

Initial water chemistry data for each sampling site/event were determined either on site or upon receipt at the laboratory. A summary of toxicity test conditions is included in Table 6. Water chemistry and adverse toxicant effects were recorded at test initiation, solution renewal, and at test termination. To insure sensitivity to toxicants, organism condition, and test validity, reference toxicant tests are performed on a monthly basis.

A summary of toxicity test results may be found in Table 7. The results of the toxicity tests indicate that the upstream station (OC-1) is not chronically toxic, while the WWTP effluent is sometimes chronically toxic. The downstream station (OC-2) also exhibits some degree of chronic toxicity. However due to the presence of an unmonitored stream located between the outfall and OC-2, it remains uncertain whether this toxicity may be attributable to the WWTP effluent.

CONCLUSIONS

Physical, chemical , and biological data collected after the upgrade of the WWTP indicate Omussee Creek is currently meeting the requirements for the Water Use Classification of Fish and Wildlife. The creek shows a slight deterioration in water quality at OC-2, approximately 1 mile downstream of the discharge, compared to the station upstream of the WWTP (OC-1), but recovery of the creek is apparent at OC-4. The deterioration of water quality at OC-2 cannot be fully attributed to the WWTP discharge due to the presence of non-point source runoff at this site. Comparison of chemical data collected before and after the upgrade to the WWTP indicates a slight improvement in water quality. Although the flows taken "before" and "after" the WWTP upgrade were comparable to each other, they averaged 3 to 4 times the 7Q10 flow. Additional monitoring during stream flow conditions nearer the 7Q10 would provide important information with regard to any potential adverse impacts to Omussee Creek from the WWTP discharge.

REFERENCES

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TABLE 1
OMUSSEE CREEK WATER QUALITY DEMONSTRATION STUDY
BEFORE WWTP UPGRADE

Station	Date/Time	BOD5, mg/l	Hardness mg/l	TSS mg/l	NH3 mg/l	NO2NO3 mg/l	PO4 mg/l	TKN mg/l	TON mg/l	Temp air,C	Temp water, C	pH s.u.	DO mg/l	Flow cfs
OC-1	7/28/87 1005									31.0	24.0		5.9	18
	7/29/87 0710	1.0			<.2	0.51	0.20	1.6	>1.4	23.3	23.3	6.9	6.3	17
	7/29/87 1600	0.4		5.0	<.2	0.65	0.14	1.1	>.99	33.5	27.0	7.0	6.1	16
	7/30/87 0725	0.6	32.0	8.0	<.2	0.63	0.09	1.2	>1	26.7	25.0	6.9	6.3	15
OCWWTP	7/28/87--	24.0		14.0	0.6	0.47	4.60	16.0	15.4		28.3	7.3	4.6	
	7/29/87 24-hr	23.2		11.0	11.6	0.34	5.60	12.9	1.3		29.4	7.4	5.6	
	composite	38.4		16.0	10.6	0.29	6.00	13.6	3.0		28.9	7.5	5.5	
OC-2	7/28/87 1015									31.0	25.0		4.3	
	7/29/87 0740	3.3			0.7	0.67	0.74	3.6	2.9	25.0	23.9	6.9	4.4	
	7/29/87 1530	1.8		6.0	0.7	0.71	0.56	2.4	1.7	33.5	26.0	7.0	4.3	
	7/30/87 0750	2.4		8.0	0.6	0.59	0.88	1.6	1.0	27.8	25.0	6.8	4.2	
OC-4	7/28/87 1025									29.5	25.0		3.7	
	7/29/87 0755	1.5			<.2	1.22	0.56	2.0	>1.8	25.0	23.9	6.8	4.4	
	7/29/87 1515	1.2		19.0	0.3	1.26	0.63	2.7	2.4	33.5	26.0	7.1	4.1	
	7/30/87	1.2		1.3	<.2	0.96	0.60	1.2	>1	28.3	25.6	6.9	4.4	
OC-5	7/28/87 1100									31.0	25.0			48
	7/29/87 0745	0.9			<.2	1.29	0.53	2.1	>1.9	23.0	23.5	7.3	5.8	41
	7/29/87 1445	1.0		13.0	<.2	1.29	0.41	0.8	>.6	33.0	26.0	7.2	5.5	
	7/30/87 0810	0.8		18.0	<.2	1.22	0.46	1.1	>.9	27.5	25.0	7.0	5.6	39

TABLE 2
OMUSSEE CREEK WATER QUALITY DEMONSTRATION STUDY
AFTER WWTP UPGRADE

Station	Date	Time 2400 hrs	BOD5 mg/l	Hardness mg/l	TSS mg/l	NH3, mg/l	NO2NO3 mg/l	PO4 mg/l	TKN mg/l	TON mg/l	Temp, air,C	Temp, water, C	pH s.u.	Cond umhos at 25 C	Turb NTU	Fecal coliform col/100 ml	DO mg/l	Flow cfs
OC-1	6/15/93	1030	1.0	43.0	15.0	<.015	0.65	0.05	<.15	0.0	30.0	23.0	7.5	73	24.0		6.8	18.9
	6//16/93	0625	1.0	44.0	25.0	<.015	0.70	0.72	0.28	0.3	19.0	21.5	6.5	64	26.0	>116	6.7	
	8/3/93	1045									29.0	23.0	7.1	83	8.0		7.5	21.7
	8/4/93	1215	0.6	55.0	10.0	<.015	0.70	0.03	<.15	0.0	32.0	23.0	7.0	88	8.0		7.3	
*	8/5/93	0700	1.7	60.0	30.0	<.015	0.60	0.12	<.15	0.0	24.0	21.5	6.9	80	51.0	>2000	6.1	36.2
	9/28/93	1045	0.6	46.0	3.0	<.015	0.75	0.03	<.15	<.09	21.0	18.0	7.1	81	5.1		8.6	17.3
	9/29/93	0705	0.6	46.0	7.0	<.015	0.84	0.04	<.15	<.1	11.0	15.5	7.0	65	6.0	est 53	8.0	
OCWWTP	6/15/93	1015	2.0	122.0	1.0	<.015	0.02	7.19	0.95	1.0								4.3
	6/16/93	1000	2.0	125.0	2.0	<.015	0.23	4.28	0.59	0.6	28.0	27.0	6.5	963	0.6	<1	8.1	5.3
	8/3/93	1025									27.0	27.0	7.0	915	0.7		7.1	4.3
	8/4/93	1100	2.0	117.0	<1.0	<.015	13.70	3.22	1.26	1.3	32.0	28.5	7.3	844	1.0		7.3	5.1
*	8/5/93	0725	0.7	117.0	4.0	<.015	14.10	3.32	0.15	0.2	22.0	25.0	6.8	900	1.8	<1	6.5	2.5
	9/28/93	1100	0.8	117.0	<1.0	<.015	10.80	3.05	0.86	0.9	19.5	25.0	7.1	800	0.7		7.9	4.6
	9/29/93	0720	0.4	120.0	<1.0	<.015	13.60	3.56	0.92	0.9	12.0	23.5	7.1	824	0.7	est 1		3.9
OC-2	6/15/93	1300	1.0	64.0	10.0	<.015	3.73	0.53	0.28	0.3	31.5	25.0	7.1	210	17.0		6.6	27.7
	6/16//93	0645	1.0	61.0	18.0	<.015	3.08	0.46	0.33	0.3	20.0	22.0	6.9	186	23.5	>128	6.6	
	8/3/93	1245									34.0	25.0	7.3	210	7.7		7.2	25.8
	8/4/93	1255	0.7	73.0	7.0	<.015	2.08	0.56	0.25	0.3	25.0	23.0	7.2	224	7.3		6.9	
*	8/5/93	0745	1.7	92.0	33.0	<.015	1.25	0.23	0.75	0.8	23.5	22.0	6.8	154	55.0	>2000	6.0	47.8
	9/28/93	1305	0.7	72.0	3.0	<.015	2.60	0.80	0.37	0.4	23.0	20.0	7.2	232	6.6		7.7	20.2
	9/29/93	0750	0.5	67.0	5.0	<.015	2.70	0.59	0.32	0.3	14.0	15.5	7.2	208	6.2	100	7.9	
OC-4	6/15/93	1515	1.0	66.0	33.0	<.015	2.66	0.92	0.84	0.8	28.5	24.0	7.0	184	31.5		6.5	
	6/16/93	0705	1.0	64.0	38.0	<.015	3.02	0.25	0.56	0.6	20.0	22.0	7.0	191	31.5	230	6.5	
	8/3/93	1500									35.0	24.0	7.2	184	19.0		7.0	
	8/4/93	1320	0.6	75.0	15.0	<.015	1.62	0.40	<.15	0.0	25.0	23.0	7.2	192	17.0		6.9	
*	8/5/93	0805	2.2	84.0	71.0	<.015	0.96	0.42	0.95	1.0	23.5	22.0	6.8	138	71.0	>2000	6.0	
	9/28/93	1455	0.8	70.0	50.0	<.015	1.84	0.51	0.39	0.4	25.0	19.5	7.2	196	7.6		7.6	
	9/29/93	0825	0.4	77.0	10.0	<.015	2.14	0.52	0.35	0.4	14.5	16.0	7.2	202	8.2	77	7.9	
OC-5	6/15/93	1600	1.0	59.0	34.0	<.015	2.41	0.36	0.43	0.4	27.5	24.0	7.0	153	37.0		6.7	34.5
	6/16/93	0730	1.0	58.0	35.0	<.015	2.45	0.36	0.26	0.3	23.0	22.0	7.1	164	35.5	>780	6.9	
	8/4/93	0930									27.0	23.0	7.2	182	31.0		7.3	36.7
	8/4/93	1340	0.5	67.0	22.0	<.015	1.46	0.35	<.15	0.0	25.0	23.0	7.2	182	17.0		7.7	
*	8/5/93	0835	1.2	71.0	58.0	<.015	1.46	0.40	<.15	0.0	25.0	23.0	7.0	151	55.0	est 200	6.7	
	9/28/93	1515	0.3	68.0	14.0	<.015	1.67	0.33	0.26	0.3	25.0	19.5	7.2	173	7.9		8.1	33.6
	9/29/93	0845	0.7	65.0	53.0	<.015	1.92	0.41	0.34	0.3	16.0	16.0	7.2	182	8.6	80	8.4	
BRH-1	8/4/93	0745	1.0	50.0	5.0	<.015	0.37	0.02	<.15	0.0	23.0	23.0	6.8	73	7.5		5.2	

rain overnight

TABLE 3A. BIOLOGICAL METRICS: SINGLE STATION

	Station			
METRIC	BRH-1	OC-1	OC-2	OC-4
Taxa Richness[1a]	39	33	24	42
EPT Taxa Richness[1b]	8	7	3	9
Biotic Index[1c]	5.0	6.2	5.4	5.3

1a. Taxa Richness: Number of taxa present at each station. Generally increases with increasing water quality.

1b. EPT Taxa Richness: Number of pollution "intolerant" taxa present at each station. Generally increases with increasing water quality.

1c. Biotic Index: Scale ranges from 0-10. Values increase with decreasing water quality. A difference of 1.0 or more between control and study sites is generally deemed to reflect a true difference.

TABLE 3B. BIOLOGICAL COMPARISON METRICS

	Station Comparisons				
METRIC	OC-1/OC-2	OC-1/OC-4	BRH-1/OC-1	BRH-1/OC-2	BRH-1/OC-4
Sorenson's Similarity Index[2a]	0.35	0.59	0.39	0.54	0.44
Community Loss Index[2b]	0.95	0.26	0.75	0.91	0.50
QSI-Taxa[2c]	27.68	34.95	30.01	19.06	20.83

2a. Sorenson's Similarity Index: Scale ranges from 0-1. Similarity of study site to control and reference sites generally increases as value approaches 1.

2b. Community Loss Index: Values range from 0 to "infinity". Dissimilarity of study site to control and reference site generally increases with increasing values.

2c. QSI-Taxa: Quantitative Similarity Index-Taxa. Values range from 0-100. Increasing values reflect increasing similarity between reference and study stations.

TABLE 4A.

Results of the Biological Condition Scoring Criteria

Metric	Study Station OC-1	Reference Station BRH-1	S. S. Value	S. S. Score	R. S. Value	R. S. Score
Taxa Richness	48	39	123.08	6	100	6
Biotic Index	5.65	5.03	89.03	6	100	6
Scr/(Scr+F/C)	0.37	0.29	127.59	6	100	6
EPT/(EPT+Chiro.)	0.13	0.33	39.39	2	100	6
% Contr. Dom. Taxa	27	15	27.00	4	15	6
EPT Index	7	8	87.50	4	100	6
Community Loss Index	0.75		0.75	4	100	6
Shredders/Total	0.25	0.2	125.00	6	100	6
				38		48
				S.S./R.S x100 =		**79.17**
		OC-1	**Slightly impaired**			

Metric	Study Station OC-2	Reference Station BRH-1	S. S. Value	S. S. Score	R. S. Value	R. S. Score
Taxa Richness	24	39	61.54	4	100	6
Biotic Index	5.4	5.03	93.15	6	100	6
Scr/(Scr+F/C)	0.12	0.29	41.38	4	100	6
EPT/(EPT+Chiro.)	0.51	0.33	154.55	6	100	6
% Contr. Dom. Taxa	22	15	22.00	4	15	6
EPT Index	3	8	37.50	1	100	6
Community Loss Index	0.91		0.91	4	100	6
Shredders/Total	0.07	0.2	35.00	4	100	6
				33		48
				S.S./R.S x100 =		**68.75**
		OC-2	**Slightly impaired**			

Metric	Study Station OC-4	Reference Station BRH-1	S. S. Value	S. S. Score	R. S. Value	R. S. Score
Taxa Richness	42	39	107.69	6	100	6
Biotic Index	5.28	5.03	95.27	6	100	6
Scr/(Scr+F/C)	0.39	0.29	134.48	6	100	6
EPT/(EPT+Chiro.)	0.65	0.33	196.97	6	100	6
% Contr. Dom. Taxa	29	15	29.00	4	15	6
EPT Index	9	8	112.50	6	100	6
Community Loss Index	0.5		0.50	4	100	6
Shredders/Total	0.03	0.2	15.00	1	100	6
				39		48
				S.S./R.S x100 =		**81.25**
		OC-4	**Nonimpaired**			

TABLE 4B

EXPLANATION OF BIOLOGICAL CONDITION SCORING CRITERIA*

Results are based upon community comparisons between reference and study sites.

	Metric		Score 6	4	2	1
1	Taxa Richness	(a)	>80%	60-80%	40-60%	<40%
2	Biotic Index	(b)	>85%	70-85%	50-70%	<50%
3	Scr/(Scr+F/C)	(a,c)	>50%	35-50%	20-35%	<20%
4	EPT/(EPT+Chiro.)	(a)	>75%	50-75%	25-50%	<25%
5	% Contr. Dom. Taxa	(d)	<20%	20-30%	30-40%	>40%
6	EPT Index	(a)	>90%	80-90%	70-80%	<70%
7	Community Loss Index	(e)	<0.5	0.5-1.5	1.5-4.0	>4.0
8	Shredders/Total	(a,c)	>50%	35-50%	20-35%	<20%

*From Plafkin (1989)
(a) Score is ratio of study site to reference site X 100
(b) Score is a ratio of reference site to study site X 100
(c) Determination of F. G. is independent of taxonomic grouping
(d) Scoring criteria evaluate actual % contribution, not % comparability to the reference station.
(e) Range of values obtained. A comparison to the reference station is incorporated in these indices

BIOASSESSMENT

% Comp. to Ref. Score	Biolog. Cond. Category	Attributes
>81%	**Nonimpaired**	Comparable to best situation w/i ecoregion. Balanced trophic structure Optimum community structure for stream size and habitat
52-81%	**Slightly impaired**	Community structure less than expected Composition lower than expected due to loss of intolerant spp % contribution of tolerant forms increases
19-52%	**Moderately impaired**	Fewer species due to loss of most intolerant forms Reduction in EPT index
<19%	**Severely impaired**	Few species present

TABLE 5

SUMMARY OF TOXICITY TEST RESULTS

			RESULTS		
STATION	DATE	ORGANISM	MORTALITY	REPRODUCTION	GROWTH
OC-1	6/16-23/93	*C. dubia**	pass	pass	—
	6/15-22/93	*P. promelas*	pass	—	pass
OC WWTP	6/16-23/93	*C. dubia**	fail	fail	—
	6/15-22/93	*P. promelas*	pass	—	fail
OC-2	6/16-23/93	*C. dubia**	pass	pass	—
	6/15-22/93	*P. promelas*	pass	—	pass
OC-1	8/4-11/93	*C. dubia*	pass	pass	—
	8/4-11/93	*P. promelas*	pass	—	pass
OC WWTP	8/4-11/93	*C. dubia*	pass	pass	—
	8/4-11/93	*P. promelas*	pass	—	pass
OC-2	8/4-11/93	*C. dubia*	pass	pass	—
	8/4-11/93	*P. promelas*	fail	—	fail
OC WWTP	9/28-10/5/93	*C. dubia*	pass	pass	—
	9/28-10/5/93	*P. promelas*	pass	—	pass
OC-2	9/28-10/5/93	*C. dubia*	pass	pass	—
	9/28-10/5/93	*P. promelas*	pass	—	fail

*Although results of Ceriodaphnia dubia controls were acceptable (survival and reproduction) daphnids were from a brood board not meeting EPA recommended parameters for initiating toxicity tests

TABLE 6

TOXICITY TEST PARAMETERS

TEST TYPE: CHRONIC SCREENING STATIC RENEWAL

DILUTIONS: OC-1 (UPSTREAM) AND OC-2 (DOWNSTREAM) WERE TESTED AT 100%. OMUSSEE CREEK WWTP WAS DILUTED TO THE IWC OF 56%.

AGE OF TEST ORGANISM: <24 HOURS OLD

TEST CHAMBER SIZE/REPLICATE:
MINNOW =600 ml
DAPHNID = 30ml

TEST SOLUTION VOLUME/REPLICATE:
MINNOW = 250 ml
DAPHNID = 15 ml

INITIAL NO. OF REPLICATES PER CONCENTRATION:
MINNOW = 4
DAPHNID = 10

INITIAL NO. OF TEST ORGANISMS PER REPLICATE:
MINNOW = 15
DAPHNID = 10

TOTAL TEST ORGANISMS PER CONCENTRATION:
MINNOW = 60
DAPHNID = 10

FEEDING REGIME:
MINNOW = NEWLY HATCHED BRINE SHRIMP (*Artemia* sp.) PRIOR TO AND AFTER SOLUTION RENEWALS

DAPHNIDS = YCT AND *Selenastrum* WERE ADDED TO TEST CUPS AT EACH SOLUTION RENEWAL

AERATION: ONLY IF DISSOLVED OXYGEN CONCENTRATION FELL BELOW 40% SATURATION, OR WAS OVER 100% SATURATION AT THE START OF THE TEST

PHOTOPERIOD: 16 HOURS LIGHT; 8 HOUR DARKNESS

LIGHT INTENSITY: 50-100 ft-c

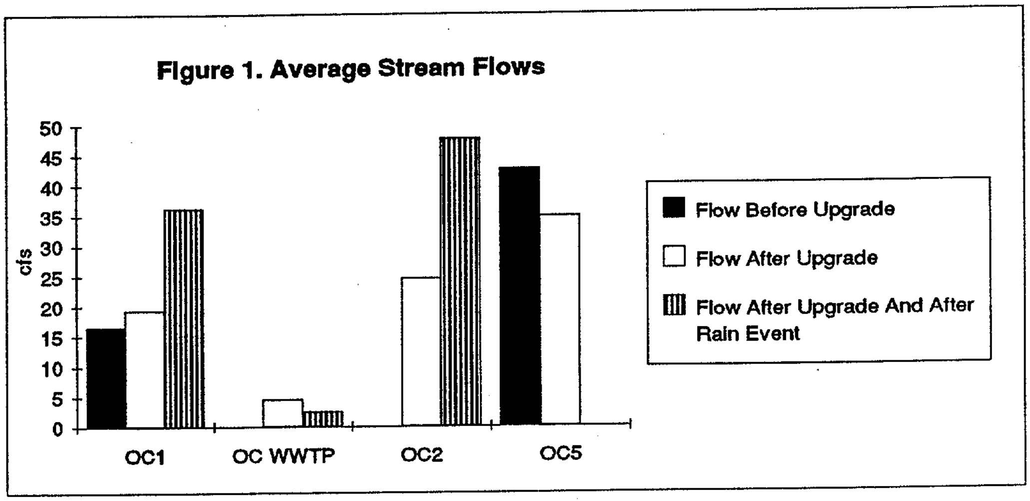


Figure 1. Average Stream Flows
50
45
40
35
30
25
20
15
10
5
0
cfs
OC1
OC WWTP
OC2
OC5
Flow Before Upgrade
Flow After Upgrade
Flow After Upgrade And After Rain Event

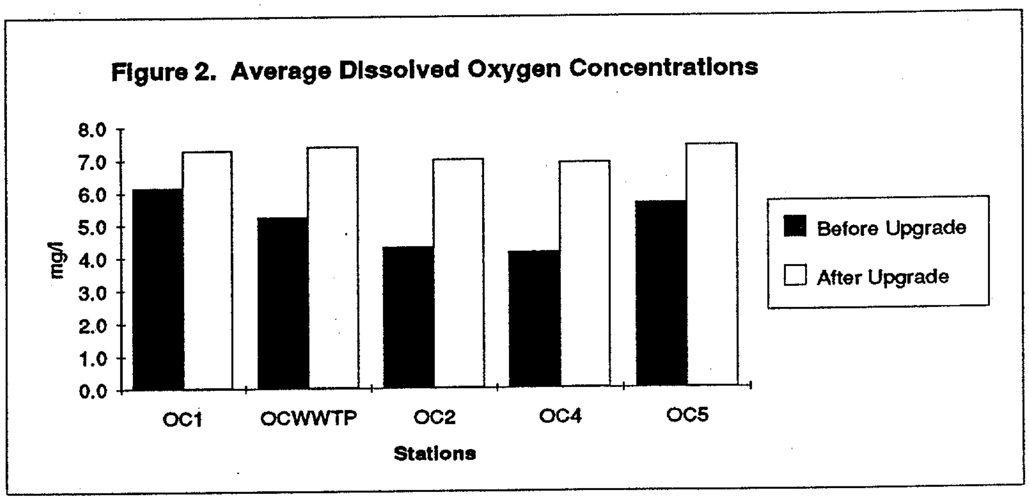


Figure 2. Average Dissolved Oxygen Concentrations
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
mg/l
OC1
OCWWTP
OC2
OC4
OC5
Stations
Before Upgrade
After Upgrade

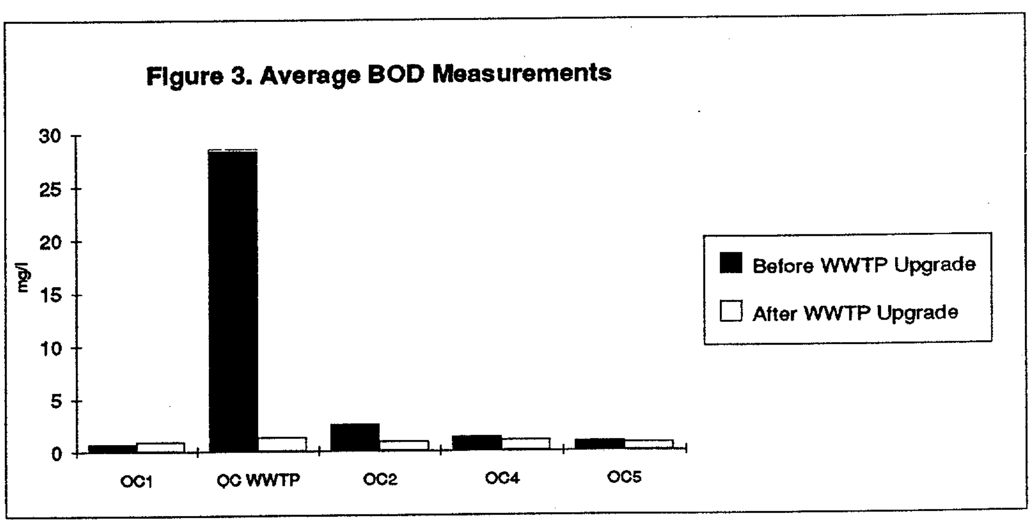


Figure 3. Average BOD Measurements
30
25
20
15
10
5
0
mg/l
OC1
OC WWTP
OC2
OC4
OC5
Before WWTP Upgrade
After WWTP Upgrade

Figure 5. % Contribution of Functional Groups*

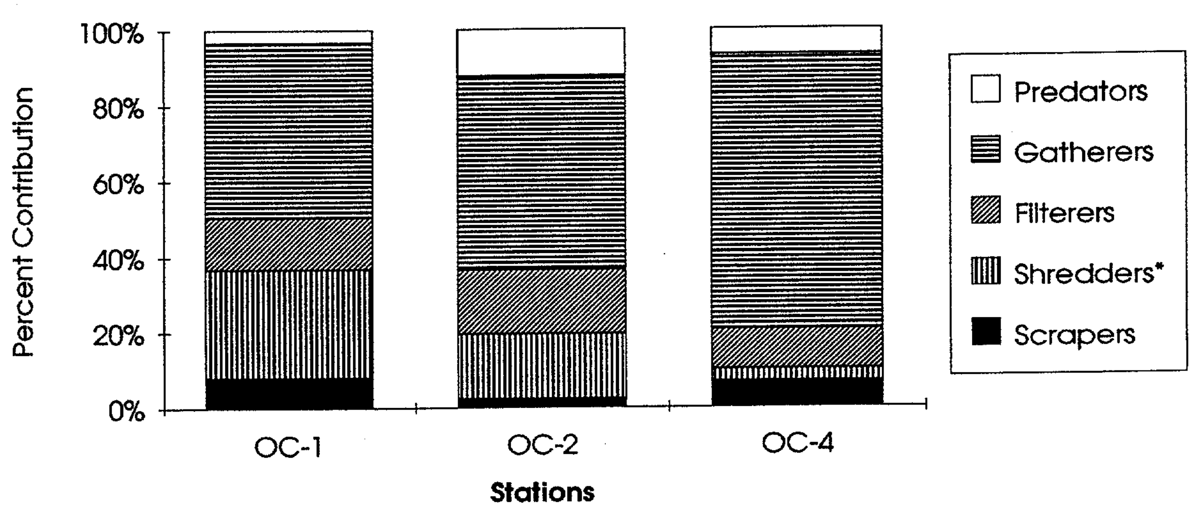
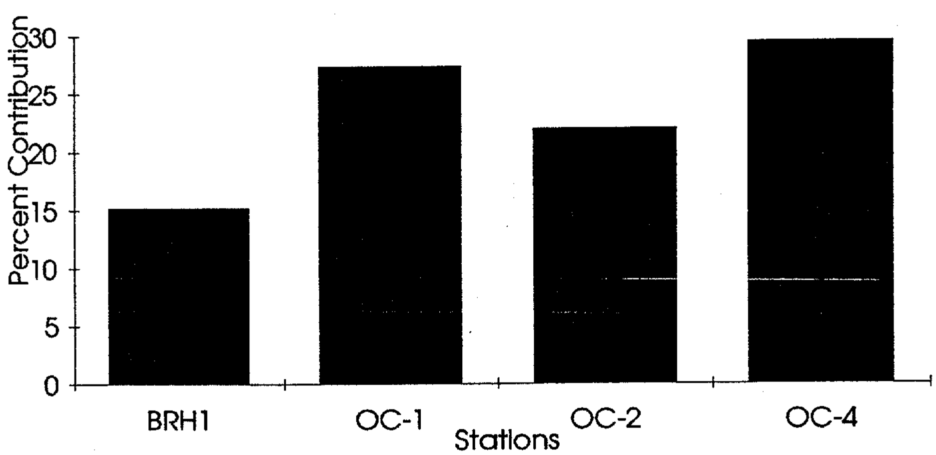


Figure 6. % Dominant Taxon*



* % Contributions of Functional Groups (Figure 5) and Dominant Taxon (Figure 6) should be similar to the control and reference stations.

APPENDIX

TABLE 5
TAXA LIST
Omussee Creek Control Station (OC1-930803)
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	ROCK LOG	CPOM	SAND	TOTAL
NNELIDA				
OLIGOCHAETA	1		7	8
RTHROPODA				
MALACOSTRACA				
DECAPODA		1		1
INSECTA				
COLEOPTERA				
Elmidae				
Ancyronyx	6	4		10
Macronychus	18	7		25
Microcylloepus		3		3
Gyrinidae				
Dineutus		2		2
Helodidae				
Scirtes		1		1
Hydrophilidae				
Hydrochus	1			1
DIPTERA				
Ceratopogonidae				
Bezzia		1	2	3
CHIRONOMIDAE				
Chironominae				
Chironomini				
Chironomus		1		1
Dicrotendipes		1	3	4
Paralauterborniella			32	32
Phaenopsectra			3	3
Polypedilum		2	13	15
Xestochironomus	6			6
Tanytarsini				
Rheotanytarsus		3		3
Tanytarsus	8	8	3	19
Tanytarsini UNID			1	1

TABLE 3
TAXA LIST
Omussee Creek Control Station (OC1-930803)
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	ROCK LOG	CPOM	SAND	TOTAL
Ferrissia		1		1
Planorbidae				
Planorbula	1			1
MESOGASTROPODA				
Hydrobiidae				
Amnicola		1		1

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TAXA LIST
Omussee Creek Downstream of WWTP (OC2-930803)
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	ROCK LOG	CPOM	SAND	TOTAL
Tabanidae				
Tabanus			2	2
DIPTERA UNID dif			1	1
EPHEMEROPTERA				
Ephemeridae				
Hexagenia			15	15
Heptageniidae				
Stenonema	1	1		2
MEGALOPTERA				
Corydalidae				
Corydalus		3		3
ODONATA				
Aeshnidae				
Boyeria		2		2
TRICHOPTERA				
Hydropsychidae				
Hydropsychidae UNID		2		2
Leptoceridae				
Oecetis	1			1
MOLLUSCA				
PELECYPODA				
HETERODONTA				
Corbiculidae				
Corbicula			1	1

TAXA LIST
Omussee Creek Downstream of WWTP (OC4-930803)
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	ROCK LOG	CPOM	SAND	TOTAL
Epoicocladius			1	1
Orthocladius	4			4
Rheocricotopus		9		9
Thienemanniella		2		2
Tanypodinae				
Ablabesmyia			1	1
Clinotanypus			6	6
Tanypus			1	1
Thienemannimyia Grp	1			1
Tanypodinae UNID	1			1
CHIRONOMIDAE UNID			1	1
Tabanidae				
Tabanus			1	1
Tipulidae				
Pilaria			1	1
EPHEMEROPTERA				
Baetidae				
Baetis		2		2
Baetidae UNID	3			3
Caenidae				
Caenis		8		8
Ephemeridae				
Hexagenia	1		29	30
Heptageniidae				
Stenacron	3			3
Stenonema	8	1		9
HEMIPTERA				
Gerridae				
Trepobates		1		1
ODONATA				

TAXA LIST
Omussee Creek Downstream of WWTP (OC4-930803)
MACROINVERTEBRATE DATA

IACROINVERTEBRATE	ROCK LOG	CPOM	SAND	TOTAL
Aeshnidae				
Boyeria		1		1
TRICHOPTERA				
Hydropsychidae				
Cheumatopsyche	2	16		18
Hydropsychidae UNID		6		6
Hydroptilidae				
Neotrichia		6		6
Leptoceridae				
Oecetis	1	4		5
Triaenodes		1		1
MISCELLANEOUS				
Collembola		1		1

TAXA LIST
Omussee Creek Study Reference Site Control (BRH1-930804)
MACROINVERTEBRATE DATA

ACROINVERTEBRATE	ROCK LOG	CPOM	SAND	TOTAL
NNELIDA				
OLIGOCHAETA		1	4	5
RTHROPODA				
MALACOSTRACA				
AMPHIPODA				
Talitridae				
Hyalella	1			1
DECAPODA		1		1
INSECTA				
COLEOPTERA				
Elmidae				
Dubiraphia			2	2
Macronychus		1		1
Hydrophilidae				
Helophorus		2		2
Ptilodactylidae				
Anchytarsus		1		1
Staphylinidae				
Staphylinidae UNID dif		1		1
DIPTERA				
Ceratopogonidae				
Bezzia		3		3
CHIRONOMIDAE				
Chironominae				
Chironomini				
Cryptochironomus			3	3
Polypedilum	2	54		56
Stenochironomus	11	7		18
Tribelos	2	7	2	11
Xestochironomus	7	7		14
Tanytarsini				
Rheotanytarsus	4	34		38
Stempellinella	2		1	3
Tanytarsus	17	34	5	56

TAXA LIST
Omussee Creek Study Reference Site Control (BRH1-930804)
MACROINVERTEBRATE DATA

ACROINVERTEBRATE	ROCK LOG	CPOM	SAND	TOTAL
Orthocladinae				
Parametriocnemus		7		7
Rheocricotopus	6	7		13
Xylotopus	2	7		9
Tanypodinae				
Ablabesmyia			2	2
Clinotanypus			10	10
Paramerina *		7		7
Procladius			2	2
Thienemannimyia Grp		20		20
Simulidae				
Simulium	2	5		7
EPHEMEROPTERA				
Caenidae				
Caenis		2	1	3
Heptageniidae				
Stenonema	13	53		66
Leptophlebiidae	1			1
Leptophlebiidae UNID		2		2
LEPIDOPTERA				
Pyralidae				
Pyralidae UNID dif		1		1
MEGALOPTERA				
Corydalidae				
Corydalus		1		1
ODONATA				
Aeshnidae				
Boyeria		1		1
Gomphidae				
Dromogomphus			2	2
PLECOPTERA				
Leuctridae				

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TAXA LIST
Omussee Creek Study Reference Site Control (BRH1-930804)
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	ROCK LOG	CPOM	SAND	TOTAL
Leuctra	1	1		2
TRICHOPTERA				
Calamoceratidae				
Anisocentropus		8		8
Hydropsychidae				
Cheumatopsyche		48		48
Leptoceridae				
Oecetis		1		1
Philopotamidae				
Dolophilodes		4		4
MOLLUSCA				
PELECYPODA				
HETERODONTA				
Corbiculidae				
Corbicula	1			1