Water Quality Assessment
Walnut Creek
Troy, Alabama
Pike County

September – October 1997

Environmental Indicators Section
Field Operations Division
Alabama Department of Environmental Management

Introduction

The city of Troy in Pike County has an NPDES permit (AL0032310) to discharge treated wastewater to Walnut Creek downstream of U.S. Highway 231. Walnut Creek is a tributary to Whitewater Creek. Both of these streams are classified as Fish and Wildlife (F&W). Whitewater Creek is a tributary to the Pea River which is, in turn, a part of the Choctawhatchee River basin.

At the request of the Municipal Branch of the Water Division of the Alabama Department of Environmental Management (ADEM), staff members of the Environmental Indicators Section of Field Operations Division conducted a study to document the effects of the wastewater discharge on the instream macroinvertebrate community of Walnut Creek. This effort included aquatic macroinvertebrate sampling, toxicity testing and chemical analyses.

The aquatic macroinvertebrate sampling and habitat assessments along with the chemical sample collection were conducted on September 30, 1997. The bioassay portion of the study was initiated on November 18, 1997.

Sampling Locations and Methodology

The following sampling locations were chosen for Walnut Creek (see Figure 1). In addition, an established ecoregional reference stream with similar stream characteristics and habitat types was sampled to further assess the conditions of the stream.

WC-1 (control)	Sec 11, T9N, R21E, Walnut Creek approximately 1/3 mile downstream of U.S. Highway 231, immediately upstream of the Troy Walnut Creek WWTP effluent mixing zone.
WC-1a	Sec 11, T9N, R21E, Walnut Creek just downstream of the Troy Walnut Creek WWTP effluent mixing zone.
WC-3	Sec. 26, T9N, R21E, Walnut Creek just downstream of the County Road 59 bridge.
BRH-1 (ecoregional reference)	Sec 28, T3N, R25E, Bear Creek just upstream of the bridge at an unnamed road crossing.

Macroinvertebrate samples were collected using the intensive Multihabitat Bioassessment method (MB-I) described in the ADEM Standard Operating Procedures (SOP) and Quality Control Assurance (QCA) Manual, Volume 2 (1996). Habitat quality was assessed using the modified Barbour & Stribling (1996) habitat assessment form. All macroinvertebrate sample assessments were calculated using the Biological Condition Scoring Criteria (BCSC) (EPA 1989). Table 1 provides a simplified interpretation of the biological metrics used to evaluate this stream.

Instream water samples collected for field parameters and chemical analyses were grab collections using the methodology outlined in Volume 1 of the ADEM SOP and QCA Manual (1994).

Samples collected from the WWTP discharge for toxicity testing were 24-hour composite samples taken at the permitted sampling point. The toxicity test was conducted as specified in NPDES permit number AL0032310 and per methodology outlined in ADEM SOP and QCA Manual, Volume 4 (1994).

Sample handling techniques, physical data collection and chain-of-custody procedures utilized during this assessment were as described in the ADEM Standard Operating Procedures and Quality Control Assurance Manual, Volumes 1(1994), 2(1996) & 4(1994). Chain-of-custody was maintained by locking the samples in a departmental vehicle when not in sight of a Field Operations employee.

Discussion and Results

A. Physical

The physical characteristic of Walnut Creek was estimated to have 80%–100% hardwood canopy cover with moderately stable banks. Walnut Creek is a slow moving braided stream comprised mainly of sandy substrate with run depths of approximately 2 feet and pools of 4 feet or greater. Multiple habitats suitable for colonization by aquatic macroinvertebrates are present and habitat assessments at all sampling locations are similar (see Figure 3 (habitat assessment), Table 2).

The ecoregional reference site BRH-1 was similar to the study stations in stream characteristics and habitat types. The habitat quality (Table 2) of the three study locations was within ninety percent of the ecoregional reference chosen.

B. Chemical

The Water Use Classification for Walnut Creek is F&W, which 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 (Rules and Regulations: Water Quality Criteria and Use Classifications, Water Division-Water Quality Program, ADEM, Ch.335-6-10).

The field parameters measured at each station were pH, conductivity, dissolved oxygen, turbidity and water temperature. Results showed little change in the pH, dissolved oxygen or turbidity between stations (Table 3). However, the conductivity did increase below the Walnut Creek WWTP discharge. Walnut Creek at each of the sampling locations does appear to be meeting its Water Use Classification of Fish & Wildlife.

Water samples were also collected for laboratory analyses and results are provided in Table 3. Several parameters showed increases below the effluent discharge as compared to the control station WC-1. Among those were Total Alkalinity, Hardness, Total Dissolved Solids and Chloride. The increase in Chloride concentration is supported by increased conductivity below the effluent discharge (Figure 2). Nutrient levels were also affected by the effluent discharge. Levels of Phosphate, Total Kjeldahl Nitrogen and Total Organic Nitrogen increased at WC-1a. The downstream station (WC-3) showed a higher level of Nitrate, possibly influenced by the field/pasture that runs along that segment of the creek. The concentration of Zinc at WC-1a (0.174 mg/L) was higher than the control WC-1 (0.052 mg/L).

The National Criteria for instream Zinc concentrations as described in Quality Criteria for Water (EPA 440/5-86-001, 1986) indicate that the Zinc concentration at the control station WC-1 (52 μg/L) is below the acute limit of 57.2 μg/L but above the chronic limit of 51.8 μg/L. The Zinc concentration at WC-1a (174μg/L) is above both the acute (86.5 μg/L) and chronic (78.4 μg/L) limits. The downstream most station WC-3 had a Zinc concentration (66 μg/L) below both the acute (81.5 μg/L) and chronic (73.8 μg/L) limits. It should be noted however, that these criteria are based on the one-hour average concentration and four-day average concentration for acute and chronic limits respectively.

A Diazinon concentration of 0.24 μg/L at WC-1a showed an increase from the upstream station, WC-1, which was less than detectable (<0.01 μg/L). Bioassay testing has demonstrated that the aquatic LC50 for Diazinon is in the range of 0.43 to 0.61 μg/L for a 48-hour acute toxicity test. In addition, Diazinon concentrations as low as 0.12 μg/L have been found to be toxic to *Ceriodaphnia dubia*, an organism used in toxicity testing.

C. Aquatic Macroinvertebrate Assessment

Aquatic macroinvertebrate data were analyzed according to the biological condition scoring criteria (BCSC) developed by EPA (Plafkin 1989). WC-1a was evaluated as moderately impaired, due to a decrease in the number of taxa present (taxa richness) and an increase in community tolerance (biotic index) at WC-1a in comparison to the control WC-1 or the ecoregional reference station BRH-1 (Table 2).

WC-3, the downstream most station, was evaluated as nonimpaired (Table 2). WC-3 when compared to the control station WC-1 appeared to have recovered from the impacts of the effluent discharge.

D. Bioassay

Short-term chronic toxicity tests conducted on the Troy-Walnut Creek WWTP effluent indicated that there was a significant difference to *Ceriodaphnia dubia* survival when exposed to a 66% effluent concentration (Appendix A). This effluent concentration is similar to the measured instream waste concentration of approximately 62% at the time of aquatic macroinvertebrate and chemical sample collection.

Effluent samples were also collected for laboratory analyses in conjunction with the toxicity test. Results summarized in Appendix B showed that Dissolved and Total levels of Lead and Zinc were present in the effluent sample collected on November 18, 1997.

Conclusions

The results of this study indicate the water quality of Walnut Creek below the Troy WWTP to be moderately impaired. Degradation to the macroinvertebrate community below the discharge was evidenced by decreased taxa richness and increased community tolerance at WC-1a. Although nutrient concentrations increased below the discharge, there was no associated increase in total number of organisms collected. These results are indicative of an invertebrate community negatively impacted by toxic wastes (Welsh 1992). In addition, the results of the short-term chronic tests toxicity tests indicated a toxic effect present in the effluent. (No change in dissolved oxygen, biological oxygen demand, total suspended solids or turbidity – changes in these parameters would be more indicative of organic enrichment). Associated water samples suggest that increased concentrations of Zinc, Diazinon, conductivity, and/or chloride may be causing the impairment. The data from WC-3, further downstream from the WWTP, suggest that the stream has recovered from the negative impacts of the WWTP.

Walnut Creek
Troy, AL

Figure 1

Station Location Map

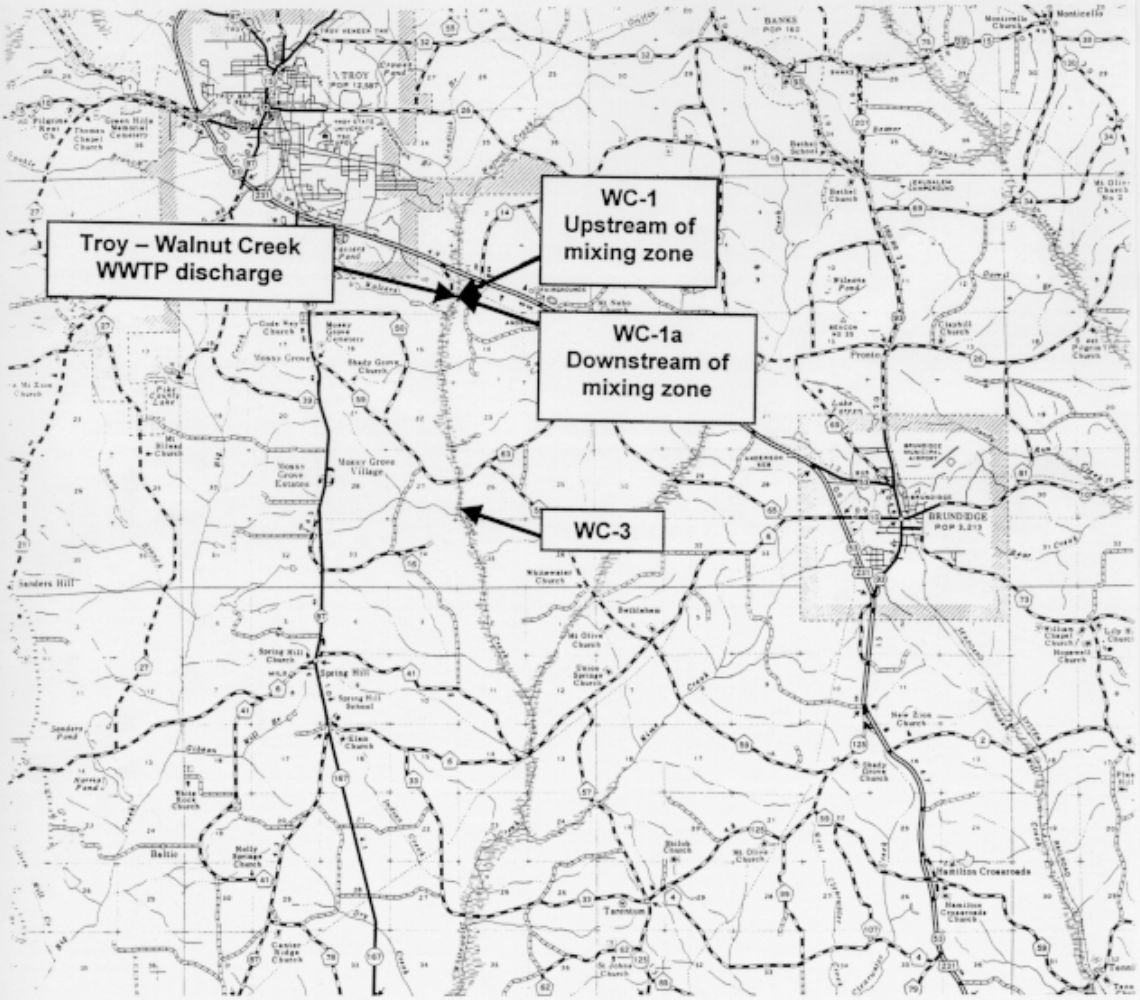

Figure 2
Field Parameters

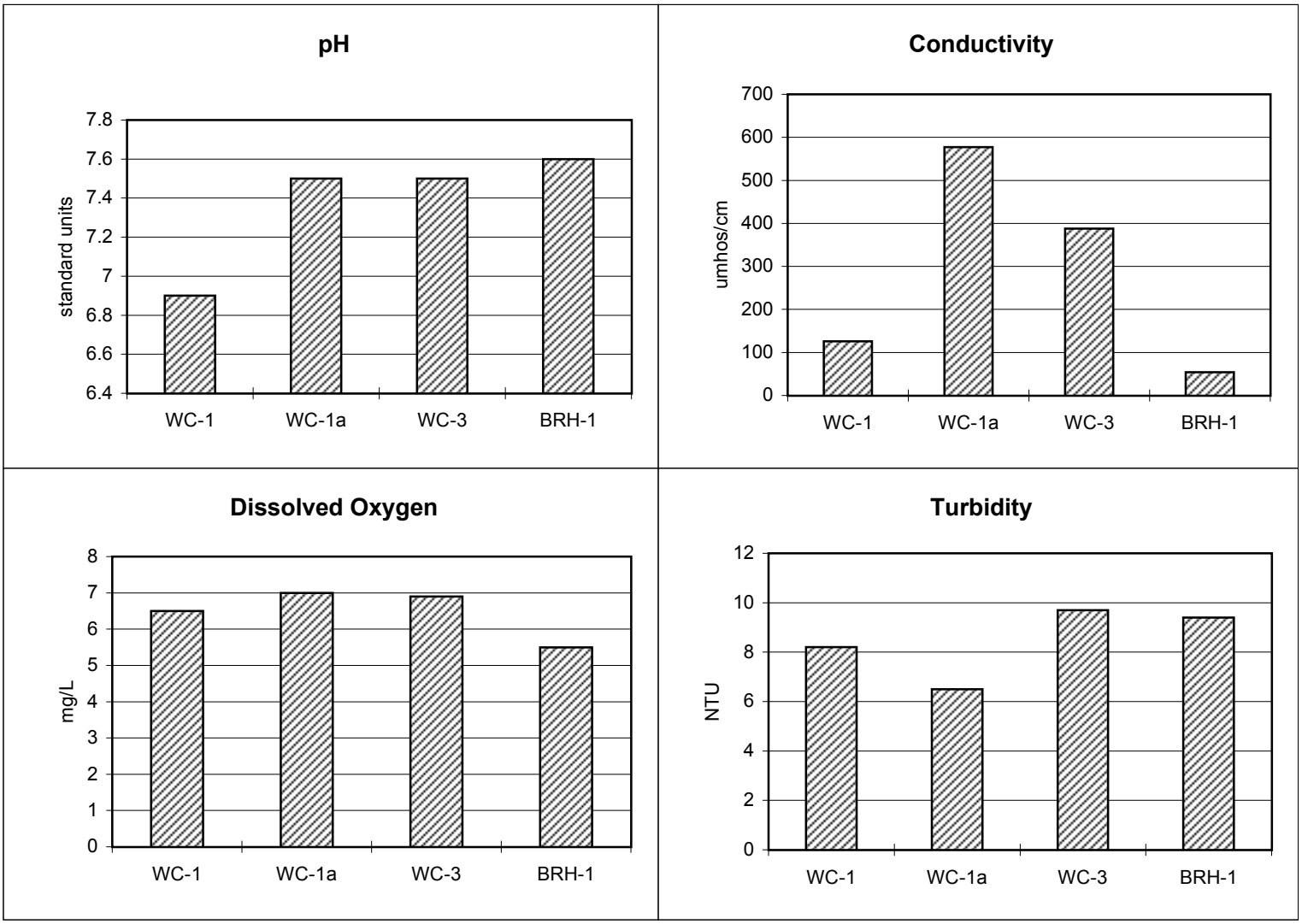

Figure 3
Individual Metrics

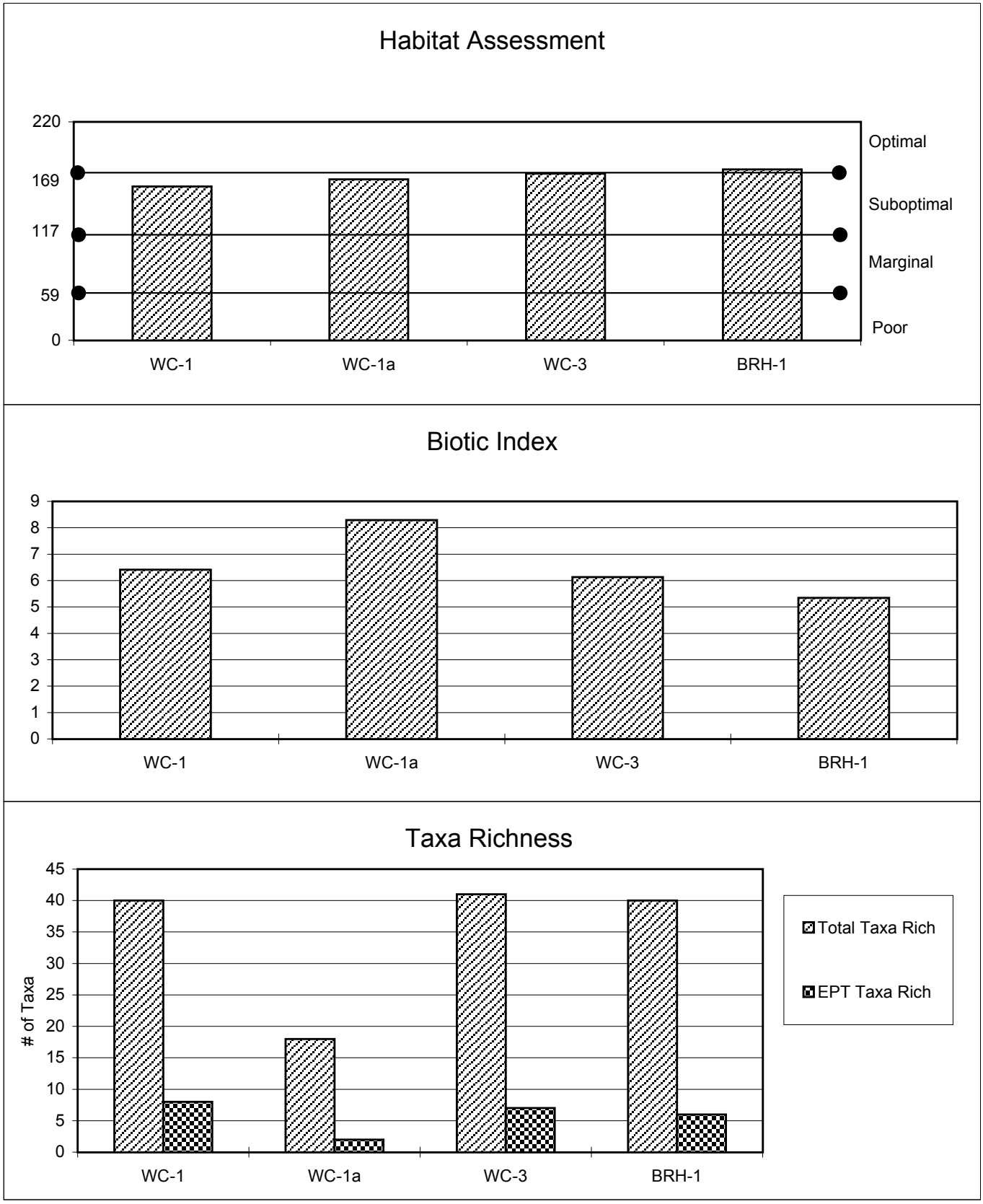

TABLE 1
Biometric Interpretation

METRIC	RANGE	INTERPRETATION
Habitat Assessment	170-220 118-169 60-117 0-59	Optimal Sub-optimal Marginal Poor
Total Taxa Richness EPT Taxa Richness		Generally Increases with Increasing Water Quality
Biotic Index		Generally Increases With Decreasing Water Quality
% Contribution of Functional Feeding Types %Shredders %Scrapers %Predators %Collector Gatherers %Collector Filterers %Macrophyte Piercers %Others		Percentages and Composition Should be similar to background station for similar stream sizes and habitat composition

BIOLOGICAL CONDITION SCORING CRITERIA

% Comparison to Reference Score	Biological Condition Category	Attributes
>81%	**Nonimpaired**	Comparable to best situation within ecoregion. Balanced trophic structure Optimum community structure for stream size and habitat
82-52%	**Slightly impaired**	Community structure less than expected Composition lower than expected due to loss of intolerant spp % contribution of tolerant forms increases
52-19%	**Moderately impaired**	Fewer species due to loss of most intolerant forms Reduction in EPT index
<19%	**Severely impaired**	Few species present

TABLE 2
Aquatic Macroinvertebrate Data

	WC-1 (Control)	WC-1a	WC-3	BRH-1 (Ref)
Habitat Assessment	155	162	168	172
Habitat Quality (% comparability to Reference site)	90%	94%	98%	
Taxa Richness	40	18	41	40
Biotic Index	6.41	8.29	6.13	5.34
EPT/EPT+Chiro.	0.14	0.01	0.15	0.35
%Contrib. Dom. Taxa	41	50	23	18
EPT Index	8	2	7	6
Shredders/Total	0.48	0.01	0.56	0.20
Community Loss Index Compared to Control		1.66	0.36	
Community Loss Index Compared to Reference	0.40	1.55	0.48	
Biological Condition (Category) Compared to Control		**Moderately Impaired**	**Non-Impaired**	
Biological Condition(Category) Compared to Reference	**Slightly Impaired**	**Moderately Impaired**	**Non-Impaired**	

TABLE 3
Chemical Analyses & Field Parameters

Parameter	WC-1	WC-1a	WC-3	BRH-1
Organics (ug/L)				
Diazinon	<mdl	0.2400	<mdl	<mdl
Ethion	<mdl	<mdl	<mdl	<mdl
Malathion	<mdl	<mdl	<mdl	<mdl
Methyl Parathion	0.2700	<mdl	<mdl	<mdl
Paration	<mdl	<mdl	<mdl	<mdl
Phosdrin	<mdl	<mdl	<mdl	<mdl
Miscellaneous Inorganics (mg/L)				
Total Alkalinity	28.0	139.0	95.0	19.0
Hardness	43.0	70.0	65.4	16.4
BOD	1.0	2.5	1.0	1.2
Hexavalent Chromium	<mdl	<mdl	<mdl	<mdl
Total Dissolved Solids	77	367	242	44
Total Suspended Solids	4	4	2	1
Chloride	6.6	41.7	25.2	6.6
Nutrients (mg/L)				
Ammonia	<mdl	<mdl	<mdl	<mdl
Nitrate	0.10	0.08	0.33	0.16
Phosphate	0.01	0.26	0.11	0.06
Total Kjeldahl Nitrogen	<mdl	0.91	0.37	0.17
Total Organic Nitrogen	<mdl	0.91	0.37	0.17
Trace Metals (mg/L)				
Arsenic	<mdl	<mdl	<mdl	<mdl
Cadmium	<mdl	<mdl	<mdl	<mdl
Calcium	15.0	25.3	22.2	4.0
Chromium	<mdl	<mdl	<mdl	<mdl
Copper	<mdl	<mdl	<mdl	<mdl
Lead	<mdl	<mdl	<mdl	<mdl
Magnesium	1.356	1.652	2.427	1.569
Mercury	<mdl	<mdl	<mdl	<mdl
Nickel	<mdl	<mdl	<mdl	<mdl
Silver	<mdl	<mdl	<mdl	<mdl
Zinc	0.052	0.174	0.066	<mdl
Fecal Coliform (colonies/100mL)				
Fecal Coliform Bacteria	260	250	110	120
Field Parameters				
pH (standard units)	6.9	7.5	7.5	7.6
Conductivity (umhos/cm)	126	577	388	54
Dissolved Oxygen (mg/L)	6.5	7.0	6.9	5.5
Turbidity (NTU)	8.2	6.5	9.7	9.4
Water Temperature (C)	20	22	19	22

APPENDIX A

Toxicity Test Report

ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
FIELD OPERATIONS DIVISION
ENVIRONMENTAL INDICATORS SECTION
BIOASSAY UNIT

TOXICITY TEST REPORT

1. GENERAL

NPDES PERMIT NO.: 0032310 DSN: 001 COUNTY: Pike
Facility Name: Troy - Walnut Creek WWTP
Receiving Water: Walnut Creek Design Flow: ---
Total 24-Hour Flow: (1) 4.8 MGD (2) 4.3 MGD (3) 4.7 MGD
Test Type: Short-term Chronic Screening
Test Id. #: 971118-01

Test Organism	Date/Time Started YYMMDD HHMM	Date/Time Ended YYMMDD HHMM	Control Validity (Acceptable/Unacceptable)
Ceriodaphnia dubia	971118 1614	971122 1406	Acceptable
Pimephales promelas	971118 1415	971125 1320	Acceptable

2A. SUMMARY OF RESULTS FOR SCREENING TEST

Test Org.	Effluent Conc.	Test Number (1) Surv	(1) Repro	(1) Grow	(2) Surv	(2) Repro	(2) Grow	(3) Surv	(3) Repro	(3) Grow	(4) Surv	(4) Repro	(4) Grow
C. d.	66%	FAIL	N/A	N/A	-----	-----	-----	-----	-----	-----	-----	-----	-----
P. p.	66%	PASS	N/A	PASS	-----	-----	-----	-----	-----	-----	-----	-----	-----

3. LABORATORY ANALYSES OF UNDILUTED SAMPLES(S)

Sample Id.	pH su	Alkalinity mg/L as CaCO3	Hardness mg/L as CaCO3	Conductivity umhos/cm @ °C	TRC mg/L
971118-01	7.8	143	119	713 at 24.2	0.025
971120-01	8.2	146	91	759 at 29.1	-----
971122-01	7.8	160	78	671 at 24.5	-----

4. SAMPLE COLLECTION:

Were split samples collected?: no
Were samples collected as specified in NPDES Permit (Location and/or Type)? yes

Sample Id.	Sample(s) Collected YYMMDD HHMM to YYMMDD HHMM	Arrival Temp (°C)	Used in Test(s) YYMMDD to YYMMDD
971118-01	971117 0900 to 971118 0845	4	971118 to 971119
971120-01	971119 0700 to 971120 0645	2	971120 to 971121
971122-01	971121 0700 to 971122 0645	3	971122 to 971124

5.CONTROL/DILUTION WATER

Carboy #	Preparation YYMMDD	Begin Use YYMMDD	Initial Water Chemistries pH (su)	Alkalinity (mg/L)	Hardness (mg/L)	Conductivity @ °C (umhos/cm)
C-4	971117	971118	8.2	69	70	153 at 22.6
C-5	971117	971121	8.2	64	65	148 at 22.3
C-1	971120	971124	8.3	62	76	164 at 25.7

PERMITTEE: Troy - Walnut Creek WWTP NPDES #: 0032310 DSN: 001 TEST Id #: 971118-01

6. TOXICITY TEST INFORMATION

Test Organism	Organism Age	Organism Source	Org./Test Vessel	Replicates/Conc.
C.d.	<8h	ADEM In-house cultures	1	10
P.p.	<24h	ADEM In-house cultures	10	4

Test Organism	Temperature Range (°C)	D.O. Range (mg/L)	pH Range (su)	Light Intensity Average (ft-c)
C.d.	24.0 - 25.7	7.8 - 9.5	7.8 - 8.5	71
P.p.	24.0 - 25.7	4.2 - 9.5	7.5 - 8.0	67

7. FEEDING: Fed Daily

Brine Shrimp Fed 0.15 mL Suspension of Newly Hatched Larvae 2 Times Daily.
YCT Fed 0.15 mL Suspension Containing 1800 mg/L TSS Daily.
Algae Fed 0.15 mL Suspension Containing 3.3×10^7 Algal Cells/mL Daily.

8. REFERENCE TOXICANT TESTS

TOXICANT - Sodium Chloride (NaCl)

Test Organism	Test Date YYMMDD	Results LC50 (mg/L)	95% Confidence Interval (mg/L)
C.d.	971118	1945.00	1802.59/2098.66
P.p.	971119	7256.43	6995.63/7526.96

9. TEST CONDITION VARIABILITY

A. Deviations From Standard Test Conditions: Light intensity was not recorded on 971118. This deviation did not adversely affect the test results.

B. Test Solution Manipulations or Test Modifications

- ☐ Dechlorination
- ☐ Aeration during the test
- ☐ Aeration prior to test initiation or sample renewal
- ☐ Filtration
- ☐ pH adjustment
- ☒ NO sample modifications

PERMITTEE: Troy - Walnut Creek WWTP NPDES #: 0032310 DSN: 001 TEST Id #: 971118-01

11. CHRONIC SCREENING TOXICITY TESTS RESULTS **TEST ORGANISM: Ceriodaphnia dubia**

Test Validity:
Is survival in the CONTROL ≥ 80%? Yes
Are Average Neonates/Surviving Female in the CONTROL ≥ 15.0? N/A
Did 60% of the CONTROL Females Produce Their Third Brood? N/A

MORTALITY **CHRONIC TOXICITY INDICATED? FAIL**

Solution Concentration (%)	% Survival at 7 days
Control (0%)	100
66	0

STATISTICAL ANALYSES (Using proportion surviving):	COMMENTS:
☒ No Statistical Analysis Necessary	There was 100% mortality in the effluent solution on day four.

11. CHRONIC SCREENING TOXICITY TESTS RESULTS **TEST ORGANISM: Pimephales promelas**

Test Validity: Is survival in the CONTROL ≥ 80%? Yes
Is mean dry weight of surviving CONTROL fish ≥ 0.25mg? Yes

MORTALITY **CHRONIC TOXICITY INDICATED? PASS**

Solution Concentration (%)	% Survival at 7 days
Control (0%)	98
66	98

STATISTICAL ANALYSES (Using Survival data as proportion surviving that is arc sine transformed):	COMMENTS:
☒ No Statistical Analysis Necessary	

GROWTH **CHRONIC TOXICITY INDICATED? PASS**

Solution Concentration (%)	Mean dry weight (mg)
Control (0%)	0.723
66	0.650

STATISTICAL ANALYSES (Using mean dry weights):	COMMENTS:
Shapiro Wilk's Test (Normality) Test Statistic: 0.939 Critical Value: 0.749 (Parametric) Normally Distributed ☒ Yes (if test stat is > critical value) GOTO VARIANCE F-TEST ☐ No (if test stat is < critical value) GOTO WILCOXON RANK SUM TEST F-TEST F Statistic: 1.755 Critical F: 47.50 Variance ☒ Equal (if f stat is < critical f) GOTO T-TEST ☐ Unequal (if f stat is > critical f) GOTO MODIFIED T-TEST T-TEST t Statistic: 1.258 Critical t value: 1.94 Significant Difference ☐ YES (if t stat is > critical t) FAIL ☒ NO (if t stat is < critical t) PASS	

Signature: _____ Date: _____

APPENDIX B

Chemical Analyses of Samples Collected for Toxicity Testing

Chemical Analysis of Samples Collected for Toxicity Testing

Facility Name: Troy - Walnut Creek WWTP
Location: Pike
NPDES #: 0032310 DSN: 001
Collection Date: 11/18/97

PARAMETER	Result		
Diazinon	U	0.0100	ug/L
Ethion	U	0.0100	ug/L
Malathion	U	0.0300	ug/L
Methyl Parathion	U	0.0120	ug/L
Parathion	U	0.0150	ug/L
Phosdrin	U	0.0500	ug/L

PARAMETER	Result		
Arsenic by Graphite Furnace	U	0.0100	mg/l
Cadmium by ICP	U	0.0030	mg/l
Chromium by ICP	U	0.015	mg/l
Copper by ICP	U	0.020	mg/l
Hexavalent Chromium	U	0.020	mg/l
Lead by Graphite Furnace		0.0048	mg/l
Mercury-Automated-Cold-Vapor	U	0.0005	mg/l
Nickel by ICP	U	0.030	mg/l
Silver using ICP	U	0.015	mg/l
Zinc by ICP		0.204	mg/l
Dissolved Arsenic	U	0.0100	mg/l
Dissolved Cadmium	U	0.0030	mg/l
Dissolved Chromium	U	0.015	mg/l
Dissolved Copper	U	0.020	mg/l
Dissolved Lead		0.002	mg/l
Dissolved Mercury	U	0.0005	mg/l
Dissolved Nickel	U	0.009	mg/l
Dissolved Silver	U	0.015	mg/l
Dissolved Zinc		0.196	mg/l

BOD		2.0	mg/l
TSS		5	mg/l
Ammonia	U	0.3	mg/l
CN	U	0.004	mg/l

U denotes results less than instrument detection limit.