Water Quality Assessment
Riley-Maze Creek
Arab, Alabama
Cullman County

June 1998

Environmental Indicators Section
Field Operations Division
Alabama Department of Environmental Management
Report Date: March 1999

Introduction

The city of Arab located in Marshall County has an NPDES permit (AL0020303) to discharge treated wastewater to Riley Maze Creek located in Cullman County just upstream of the U.S. Highway 231 road crossing. Riley Maze Creek is a tributary to Tibb Creek. Both of these streams are classified as Fish and Wildlife (F&W). Tibb Creek is a tributary to the Mulberry Fork of the Black Warrior River, which is located in the Black Warrior River basin.

Two intensive water quality studies were conducted to assess the effects of an upgrade at this WWTP during 1988 and 1990. The results of these studies were summarized in the Water Quality Demonstration Study - Riley Maze Creek Arab, AL report (Alabama Department of Environmental Management 1991).

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 in-stream macroinvertebrate community of Riley-Maze Creek. This effort included aquatic macroinvertebrate sampling, toxicity testing and chemical analyses.

The aquatic macroinvertebrate sampling, habitat assessments and chemical sample collection were conducted on June 3, 1998. The bioassay portion of the study was initiated on April 22, 1998.

Sampling Locations and Methodology

The following sampling locations were chosen for Riley Maze 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. The station names and locations are the same as those used in the 1988 and 1990 studies.

RMA-1 Riley Maze Creek approximately 0.25 miles upstream of treatment plant.
Lat 034° 17’ 45.6” Lon 086° 29’ 35.6”
T8S, R1E, S36, SW1/4, NW1/4, NW1/4

RMA-2 Riley Maze Creek approximately 100 feet downstream of treatment plant.
Lat 034° 17’ 26.1” Lon 086° 29’ 48.8”
T8S, R1E, S35, SE1/4, SE1/4, SE1/4

RMA-3 Riley Maze Creek approximately 1.25 miles downstream of treatment plant at New Harmony Road crossing.
Lat 034° 17’ 04.2” Lon 086° 31’ 01.9”
T9S, R1E, S3, NE1/4, SW1/4, SE1/4

RMA-4 Tibb Creek approximately 1.75 miles downstream of treatment plant at Red Hill Road crossing.
Lat 034° 16’ 36.9” Lon 086° 31’ 07.5”
T9S, R1E, S3, SE1/4, SW1/4, SW1/4

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). The laboratory methods for this procedure were modified to include the identification of the three generally pollution sensitive organism orders Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly). Habitat quality was assessed using the modified Barbour & Stribling (1996) habitat assessment form. 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 AL0020303 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 sample reaches were estimated to have 60%–80% hardwood canopy cover with moderately stable banks. Riley Maze Creek is a slow moving stream comprised of sandy/rocky substrate with run depths of approximately 1-2 feet and pool depths of approximately 2 feet.

The ecoregional reference site BLVC-1 was similar to the study stations in characteristics (bottom substrate) and habitat types. The CPOM and rootbank habitat types were not present at RMA-2 and were very poor at all other sampling locations. The habitat quality of the three study locations was between 89 and 108 percent of the ecoregional reference chosen (Figure 3 (habitat assessment) & Table 1).

The upstream station RMA-1 could not be sampled since the creek was essentially dry above the discharge point. Due to the lack of flow above the discharge, the creek was 100% effluent during the sampling period. As evidenced by sewage odor and sludge deposits, the bottom substrates at RMA-2 and RMA-3 were obviously impacted by the effluent discharge.

B. Chemical

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 2 & Figure 2). However, the conductivity did appear to be elevated downstream of the WWTP discharge as compared to the reference site.

Water samples were also collected for laboratory analyses and results are provided in Table 2. Chloride and Total Alkalinity levels downstream of the discharge were elevated as compared to the reference site. The increased Chloride concentrations are supported by increased conductivity readings. Nutrient levels downstream of the discharge were also elevated as compared to the reference site.

C. Aquatic Macroinvertebrate Assessment

Aquatic macroinvertebrate data were analyzed according to in-house draft ecoregional evaluation guidelines. RMA-2, RMA-3 and RMA-4 were evaluated as severely impaired, due to a low number of EPT taxa present (EPT taxa richness). The ecoregional reference station BLVC was evaluated as unimpaired (Table 1 & Figure 3).

D. Bioassay

Short-term chronic toxicity tests conducted on the Arab, Riley Maze Creek WWTP effluent indicated that there was a significant difference to *Ceriodaphnia dubia* reproduction when exposed to a 100% effluent concentration (Appendix A).

Effluent samples were also collected for laboratory analyses in conjunction with the toxicity test. Results summarized in Appendix B showed that pesticide and metal concentrations were all below detectable limits.

Conclusions

The results of this study indicate that Riley Maze Creek below the Arab WWTP is severely impaired. Degradation to the macroinvertebrate community below the discharge was evidenced by low EPT taxa richness. The impairment is probably due to a combination of effluent toxicity and the presence of sewage solids on the streambed. The data from RMA-4, further downstream from the WWTP, suggest that the stream had not yet recovered from the adverse impacts of the WWTP.

In comparison to historic biological data (EPT taxa richness), the current study shows degraded stream conditions from 1990. The data collected in 1990 (post-upgrade) indicated an improvement in stream condition from 1988 (pre-upgrade).

The Water Use Classification for Riley Maze Creek is Fish & Wildlife, which specifies the best usage of 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). Based on the limited data available, Riley Maze Creek at each of the sampling locations does appear to be meeting the chemical/physical parameters of the Fish & Wildlife Water Use Classification Criteria. However, according to biological data collected during this study and repeated Whole Effluent Toxicity test failures, Riley Maze Creek at the study locations does not meet the General Conditions Applicable to All Water Quality Criteria (Ch. 335-6-10-.05 (1); …quality of any waters receiving sewage…will not cause the best usage(propagation of aquatic life)…to be adversely affected by such sewage…). The study stations RMA-2 and RMA-3 are also in violation of the Minimum Conditions Applicable to All State Waters (Ch. 335-6-10-.06 (a); …shall be free from substances attributable to sewage…that will settle to form bottom deposits which are unsightly, putrescent…).

TABLE 1

Aquatic Macroinvertebrate Data (June 1998)

	RMA-2	RMA-3	RMA-4	BLVC-1 (Reference)
Habitat Assessment Score	172	142	154	159
Habitat Quality (% comparability to Reference site)	108%	89%	97%	
EPT Taxa Richness	--	3	4	20
Stream Condition Category (based on EPT taxa richness)	Poor	Poor	Poor	Excellent

Historical Aquatic Macroinvertebrate Data

	RMA-1	RMA-2	RMA-3	RMA-4	BLVC-1 (Reference)
July 1990 EPT TR/Condition[+]	8 / Fair	3 / Poor	10 / Fair	13 / Good	--
September 1988* EPT TR/Condition[+]	--	0 / Poor	3 / Poor	4 / Poor	--

[+] EPT Taxa Richness / Stream Condition Category (based on EPT taxa richness).
* Used Hester-Dendy Modified Multiplate Sampler Method in 1988.

Biometric Interpretation

METRIC	RANGE	INTERPRETATION
Habitat Assessment	170-220 118-169 60-117 0-59	Optimal Sub-optimal Marginal Poor
EPT Taxa Richness	>18 18-12 11-7 <7	Excellent Good Fair Poor

TABLE 2
Chemical Analyses & Field Parameters

Parameter	RMA-WWTP	RMA-2	RMA-3	RMA-4	BLVC-1
Organics (ug/L)					
Diazinon	<mdl	<mdl	<mdl	<mdl	<mdl
Miscellaneous Inorganics (mg/L)					
Total Alkalinity	250.0	235.0	161.0	120.0	15.0
Hardness	86.9	85.1	61.6	53.4	14.1
BOD	2.4	4.6	2.7	3.3	2.6
CBOD Ultimate	6.81	---	---	---	---
Hexavalent Chromium	<mdl	<mdl	<mdl	<mdl	<mdl
Total Dissolved Solids	688.0	640.0	520.0	460.0	70.0
Total Suspended Solids	2.0	2.0	18.0	1.0	26.0
Cyanide	<mdl	<mdl	<mdl	<mdl	<mdl
Chloride	303.89	292.18	44.32	36.7	4.12
Nutrients (mg/L)					
Ammonia	<mdl	0.04	<mdl	<mdl	<mdl
Nitrate	0.62	1.36	1.00	0.61	0.306
Phosphate	0.54	1.11	0.93	0.81	0.01
Total Kjeldahl Nitrogen	1.68	1.42	<mdl	0.46	0.18
Total Organic Nitrogen	1.68	1.38	<mdl	0.46	0.18
Trace Metals (mg/L except those noted)					
Arsenic (ug/L)	<mdl	<mdl	<mdl	<mdl	<mdl
Cadmium	<mdl	<mdl	<mdl	<mdl	<mdl
Chromium	<mdl	<mdl	<mdl	<mdl	<mdl
Copper	<mdl	<mdl	<mdl	<mdl	<mdl
Lead (ug/L)	<mdl	<mdl	<mdl	<mdl	<mdl
Mercury (ug/L)	<mdl	<mdl	<mdl	<mdl	<mdl
Nickel	<mdl	<mdl	<mdl	<mdl	<mdl
Silver	<mdl	<mdl	<mdl	<mdl	<mdl
Zinc	<mdl	<mdl	<mdl	<mdl	<mdl
Dissolved Metals (all metals identified above)	<mdl	<mdl	<mdl	<mdl	<mdl
Fecal Coliform (colonies/100mL)					
Fecal Coliform Bacteria	est. 5	180	120	140	>1290
Field Parameters					
pH (standard units)	7.2	7.6	7.5	7.4	7.6
Conductivity (umhos/cm)	1039	856	613	522	44
Dissolved Oxygen (mg/L)	4.6*	7.4	5.7	6.1	7.3
Turbidity (NTU)	2.75	3.76	1.54	2.23	11.9
Water Temperature (C)	22.3	23.0	23.1	22.4	24.3
Air Temperature (C)	31	34	33	32	33
Flow (cfs)	0.72	0.662	0.994	1.388	0.652

* D.O. measurement was taken before the cascade aeration.

Riley Maze Creek
Arab, AL

Figure 1

Station Location Map

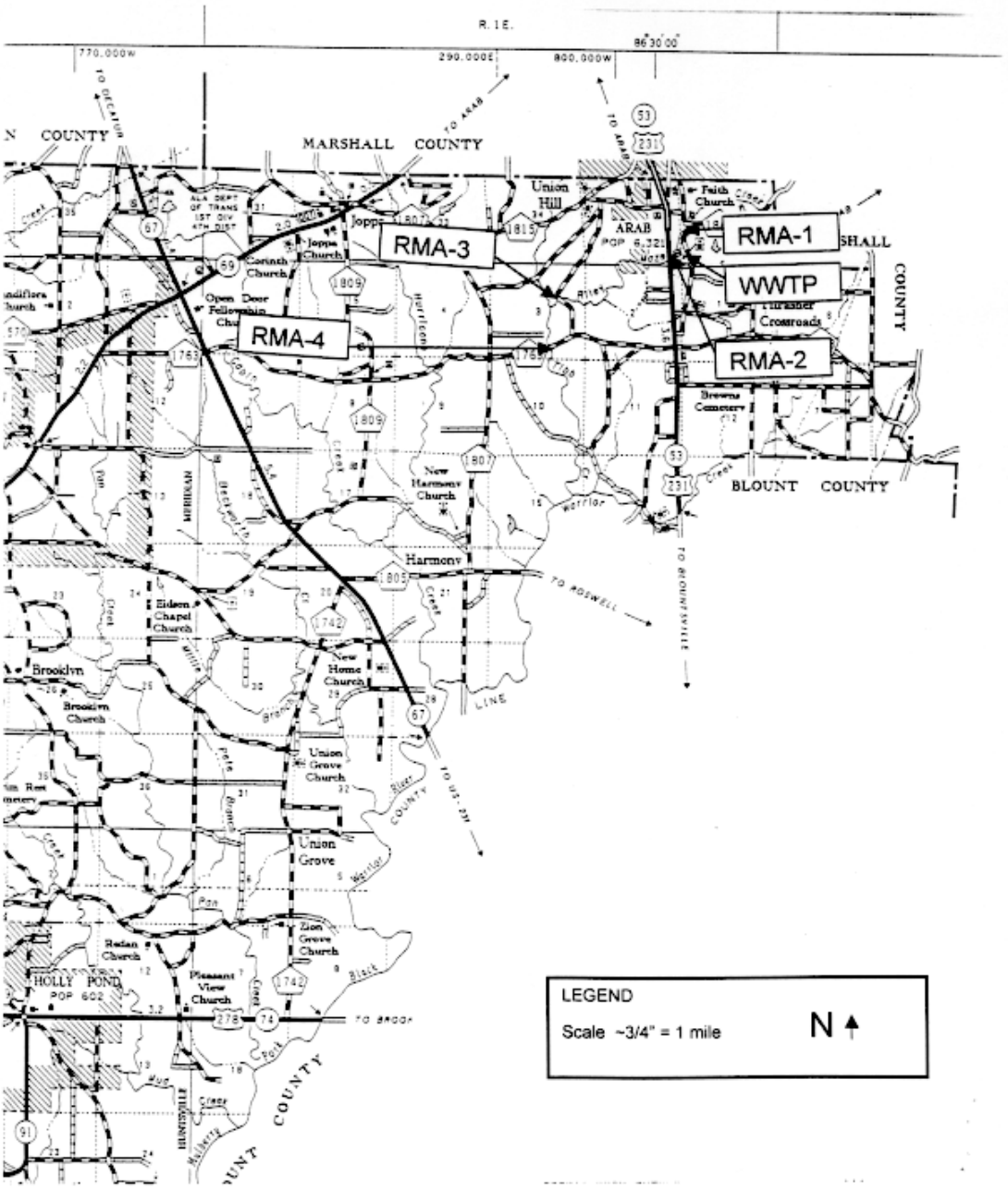


Figure 2
Field Parameters

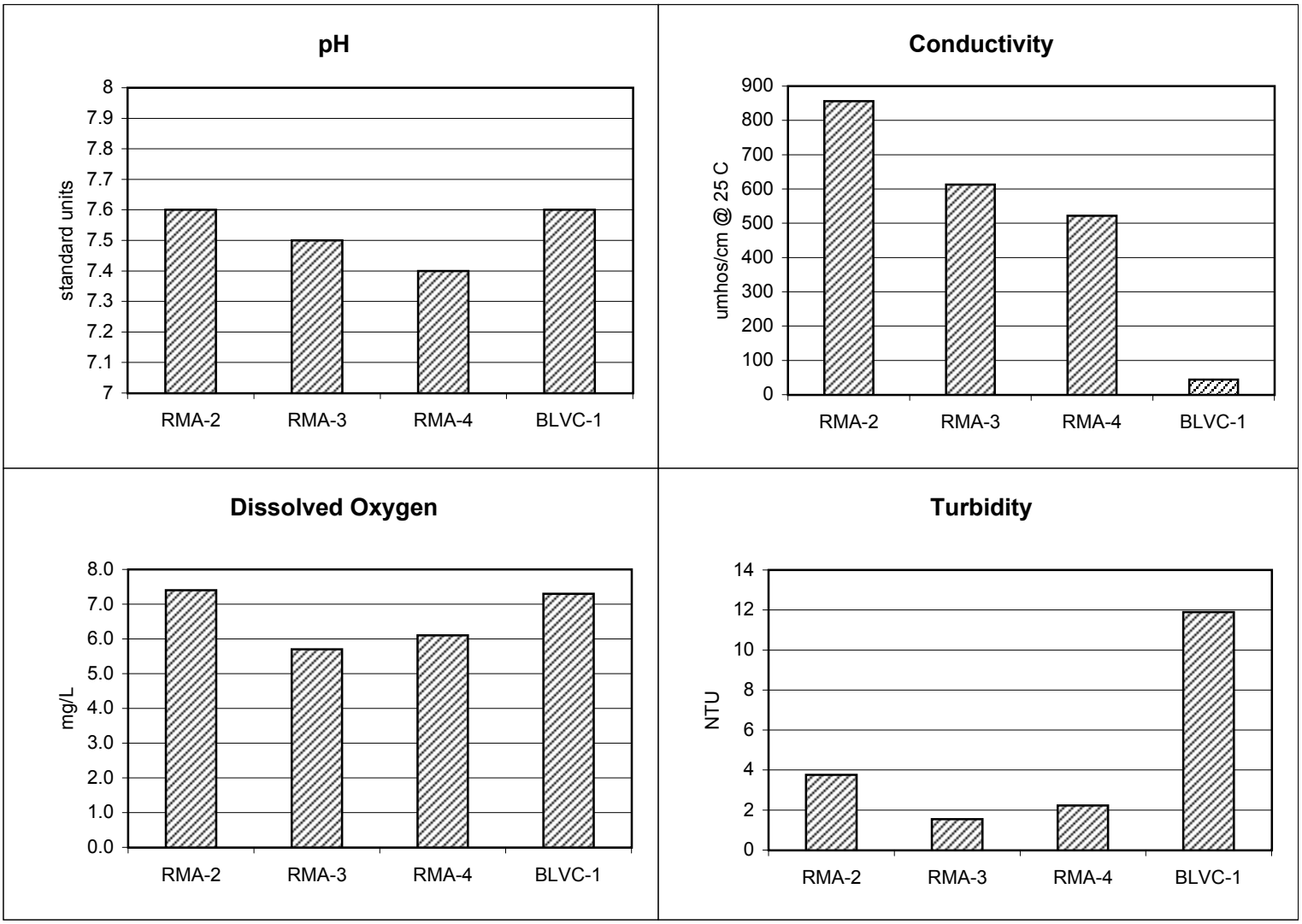
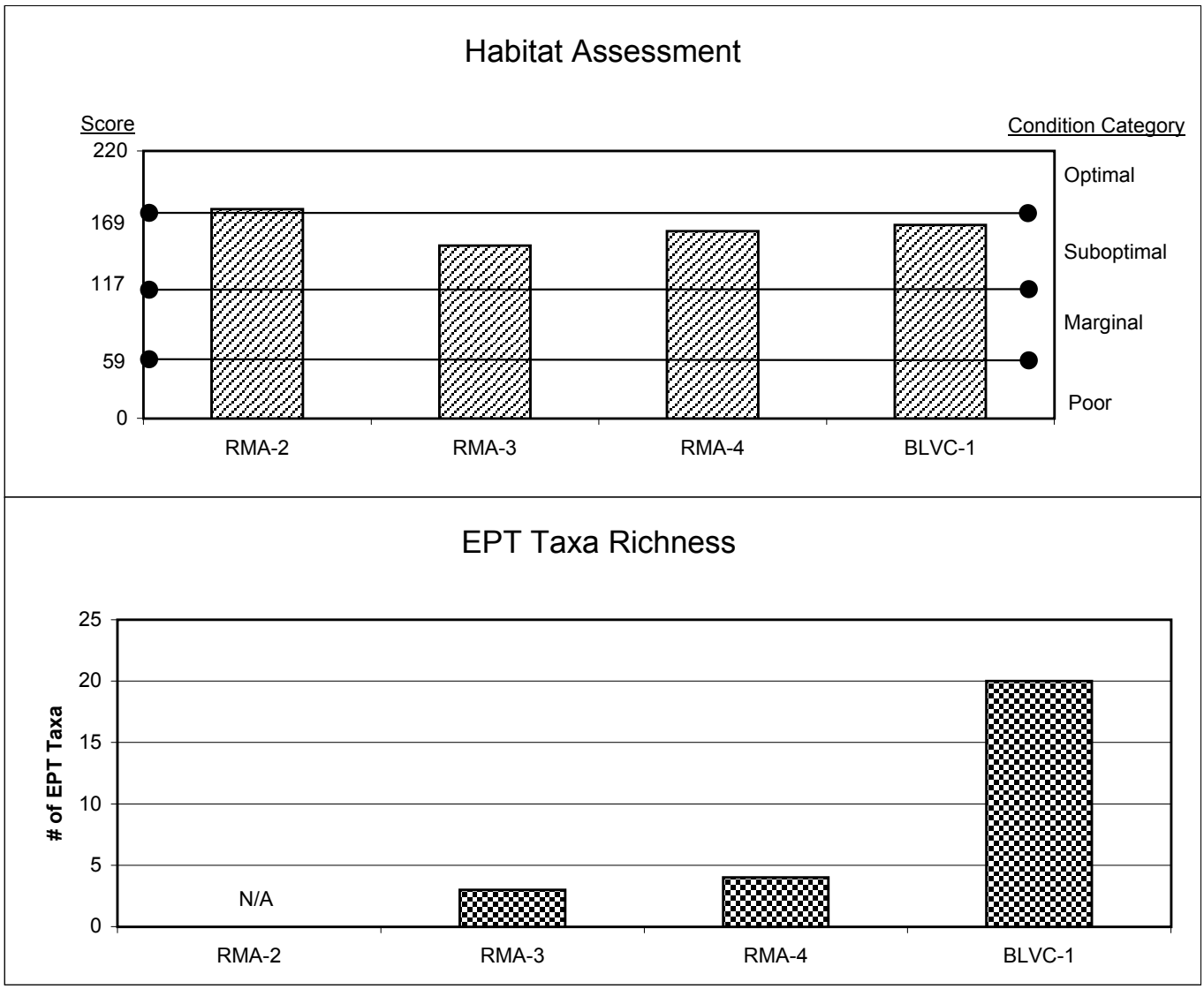


Figure 3
Aquatic Macroinvertebrate Data



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.: 0020303 DSN: 001 COUNTY: Cullman
Facility Name: Arab, Riley-Maze WWTP
Receiving Water: Riley-Maze Creek
Total 24-Hour Flow: (1) 1.742 MGD (2) 1.52 MGD (3) 1.386 MGD
Test Type: Short-term Chronic Screening
Test Id. #: 980421-02

Test Organism	Date/Time Started YYMMDD HHMM	Date/Time Ended YYMMDD HHMM	Control Validity (Acceptable/Unacceptable)
Ceriodaphnia dubia	980422 1430	980429 1334	Acceptable
Pimephales promelas	980422 1420	980429 1345	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.	100%	PASS	FAIL	N/A	-----	-----	-----	-----	-----	-----	-----	-----	-----
P. p.	100%	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
980421-02	7.3	99	89	251 at 24.3	-----
980423-02	7.5	159	84	422 at 24.8	-----
980425-02	7.4	138	80	395 at 24.7	-----

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
980421-02	980420 1209 to 980421 1154	4	980422 to 980423
980423-02	980422 0900 to 980423 0845	1	980424 to 980425
980425-02	980424 0900 to 980425 0845	1	980426 to 980428

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-3	980420	980422	8.2	68	75	282 at 23.9
C-5	980422	980427	8.1	68	75	283 at 24.6

PERMITTEE: Arab, Riley-Maze WWTP NPDES #: 0020303 DSN: 001 TEST Id #: 980421-02

6. TOXICITY TEST INFORMATION

Test Organism	Organism Age	Organism Source	Org./Test Vessel	Replicates/Conc.
C.d.	6 hrs.	ADEM In-house cultures	1	10
P.p.	<24 hrs.	ADEM In-house cultures	12	4

Test Organism	Temperature Range (°C)	D.O. Range (mg/L)	pH Range (su)	Light Intensity Average (ft-c)
C.d.	*23.6 - *26.6	6.4 - 8.6	7.3 - 8.6	64
P.p.	24.0 - *26.6	4.9 - 8.2	7.3 - 7.9	64

*out of recommended test temperature range

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 3.4×10^7 Algal Cells/mL Daily.
*3.2×10^7 algal cells/ml on 980427-980428

8. REFERENCE TOXICANT TESTS

TOXICANT - Sodium Chloride (NaCl)

Test Organism	Test Date YYMMDD	Results LC50 (mg/L)	95% Confidence Interval (mg/L)
C.d.	980331	1530.4	1354.09/1729.67
P.p.	980331	6701.66	6451.19/6961.85

9. TEST CONDITION VARIABILITY

A. Deviations From Standard Test Conditions: The test temperature was slightly above and slightly below the recommended test temperature range. There was a 20 minute power outage on 4/22/98. These deviations did not appear to affect 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: Arab, Riley-Maze WWTP NPDES #: 0020303 DSN: 001 TEST Id #: 980421-02

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? Yes
Did 60% of the CONTROL Females Produce Their Third Brood? Yes

MORTALITY **CHRONIC TOXICITY INDICATED? PASS**

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

STATISTICAL ANALYSES (Using proportion surviving):	COMMENTS:
☒ No Statistical Analysis Necessary	

REPRODUCTION **CHRONIC TOXICITY INDICATED? FAIL**

Solution Concentration (%)	Reproduction (Average # young /female)
Control (0%)	33.5
100%	23.9

STATISTICAL ANALYSES (Using number of neonates):

☐ No Statistical Analysis Necessary

Shapiro Wilk's Test (Normality)
Test Statistic: 0.9146 Critical Value: 0.8680 (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: 14.2571 Critical F: 6.5411
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: 3.7577 Critical t value: 1.7341
Significant Difference ☒ YES (if t stat is > critical t) FAIL
☐ NO (if t stat is < critical t) PASS

COMMENTS:

There was a significant difference to *Ceriodaphnia dubia* reproduction at the IWC of 100%.

PERMITTEE: Arab, Riley-Maze WWTP NPDES #: 0020303 DSN: 001 TEST Id #: 980421-02

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%)	96
100%	96

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

GROWTH **CHRONIC TOXICITY INDICATED? PASS**

Solution Concentration (%)	Mean dry weight (mg)
Control (0%)	0.733
100%	0.683

STATISTICAL ANALYSES (Using mean dry weights):

Shapiro Wilk's Test (Normality)
Test Statistic: 0.9640 Critical Value: 0.7490 (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: 2.7582 Critical F: 47.4672
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: 1.8732 Critical t value: 1.9432
Significant Difference ☐ YES (if t stat is > critical t) FAIL
☒ NO (if t stat is < critical t) PASS

COMMENTS:

Signature: _____ Date: _____

APPENDIX B

Chemical Analyses of Samples Collected for Toxicity Testing

Chemical Analysis of Samples Collected for Toxicity Testing

Facility Name: Arab – Riley Maze WWTP
Location: Cullman
NPDES #: 0020303 DSN: 001
Collection Date: 4/21/98

PARAMETER	Result	
Diazinon	U 0.02	µg/l
Ethion	U 0.02	µg/l
Malathion	U 0.06	µg/l
Methyl Parathion	U 0.024	µg/l
Parathion	U 0.03	µg/l
Phosdrin	U 0.100	µg/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	U 0.002	mg/l
Mercury-Automated-Cold-Vapor	U 0.0005	µg/l
Nickel by ICP	U 0.030	mg/l
Silver using ICP	U 0.015	mg/l
Zinc by ICP	U 0.030	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	U 0.0020	mg/l
Dissolved Mercury	U 0.0005	µg/l
Dissolved Nickel	U 0.030	mg/l
Dissolved Silver	U 0.015	mg/l
Dissolved Zinc	U 0.030	mg/l

BOD	92.0	mg/l
TSS	6	mg/l
Ammonia	U 0.3	mg/l
CN	U 0.004	mg/l

U denotes results less than instrument detection limit.