TMDL INVESTIGATION

OF

WATER QUALITY IMPAIRMENTS

TO

UNNAMED TRIBUTARY TO FLAT CREEK

UNION COUNTY, ARKANSAS

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INTRODUCTION

The total maximum daily load (TMDL) process was established by Section 303(d) of the Clean Water Act and promulgated in 40 CFR 130.7(b). A TMDL is a process where parameters which result in an impairment of a waterbody are identified and quantified, and an implementation program is developed to remediate the impairment.

In 1994, the El Dorado Chemical Company (ELCC) submitted a request for modification of the Water Quality Standards (WQS) for ELCC unnamed tributary, Flat Creek, Haynes Creek, Salt Creek and Smackover Creek. Water quality data included in the request raised concerns within the Department regarding elevated concentrations of ammonia, nitrate-nitrogen, and sulfates in the waters downstream of the ELCC discharge. These concerns prompted the initiation of this study.

The unnamed tributary of Flat Creek is the receiving stream for process water and storm water from ELCC. A TMDL investigation was conducted in order to determine the level of impact this discharge is having on the water quality and aquatic inhabitants of the receiving stream. This investigation was conducted over a three year period. Monthly water quality samples were collected from four locations from January 1995 to July 1996. During 1997, water was collected from four stations in the study area for the purpose of conducting in-stream toxicity tests. On June 2-3, 1997 the Department collected fish and macroinvertebrate and again retrieved water quality samples. This assessment was conducted in Flat Creek, its tributaries, and in Salt Creek.

HISTORICAL DATA

Waterway Description

Flat Creek is located near the city of El Dorado in north central Union County. The unnamed tributary that receives the discharge from ELCC originates southwest of the facility and flows in a north-easterly direction through approximately 5.5 miles of mostly forested land to its confluence with Flat Creek. Flat Creek flows another mile to its confluence with Haynes Creek which flows through approximately three miles of north Union County to its confluence with Smackover Creek. The watershed size of Flat Creek and its unnamed ELCC tributaries is approximately 29 mi^2 at the confluence of Flat Creek and Haynes Creek. Flat Creek has a stream gradient of 5 feet/mile. The substrate composition of the study area was comprised of sand with areas of mud/silt and hard clay.

Flat Creek is in the Gulf Coastal Plain ecoregion and is classified as a perennial Gulf Costal fishery. Due to the discharge provided by ELCC, the unnamed tributary receiving the discharge also falls under the same classification. The minimum dissolved oxygen standard for these streams for the primary and critical seasons are 5 mg/L and 3 mg/L, respectively.

Designated beneficial uses of Flat Creek, in addition to the previously mentioned fishery use, consist of secondary contact recreation and source water for domestic, industrial, and agricultural uses.

Previous Studies

In October of 1994, ELCC submitted to the Department a request to modify the water quality standards on several waterbodies within the lower Smackover Creek drainage as follows.

Waterbody	Chlorides From	To	Sulfates From	To	TDS From	To
Unnamed tributaries	19	250	41	550	123	1100
Flat Creek	19	1000	41	550	123	2000
Salt Creek	19	3000	41	50	123	6000
Haynes Creek	19	1500	41	500	123	3000
Smackover Creek	250	800	30	70	500	500

It was also requested that the ammonia nitrogen limit for ELCC discharge be established at 28 mg/L during the critical season and 38 mg/L during the primary season and that the Domestic and Industrial drinking water uses be removed from ELCC unnamed tributary, Flat Creek, Haynes Creek, and Smackover Creek. The Department denied the request citing aquatic life use impairment in the unnamed tributary below the ELCC discharge. In addition to this impairment, the Department was concerned about elevated concentrations of ammonia and nitrates at several locations downstream of the facility and suggested that corrective action be taken to eliminate the water quality impairments.

On October 16, 1996, the Department conducted a survey of the macroinvertebrate community of the unnamed tributary to Flat Creek that receives the discharge of ELCC. Two stations were chosen for the survey. One station was located approximately 300 yards below outfall 001 (Lake Killdeer). It was compared to a reference station which was located at a nearby stream that receives no impact from point source discharges. The reference sample was collected from a habitat comparable to the habitat of the receiving stream. The data were evaluated by the multi metric approach used in the Rapid Bioassessment (RBA) protocols. The evaluation of the receiving stream community below the discharge was found to be "severely impaired".

Discharge Monitoring Reports (DMR) submitted by ELCC were retrieved for years 1996-1997. The evaluation of this data did not reveal any significant periods of excursion from the very limited NPDES permit requirements which are shown below.

	Mass (lbs/day)		Concentration	
	30 day Avg	Daily Max	30 day Avg	Daily Max
Outfall 001- (Lake Killdeer)				
TSS	280	420	30 mg/L	45 mg/L
NH_3-N	1852	3505	Report	Report
NO_3-N	2043	4160	Report	Report
D.O.	(June-Oct)		4 mg/L minimum	
	(Nov-May)		6 mg/L minimum	
Sulfates	Report	Report	Report	Report
Temp.			30° C max.	
Biomonitoring to be performed quarterly.				
Outfall 002-(Stormwater)				
Oil/Grease			10 mg/L	15 mg/L
NH_3-N				Report
TSS				Report
Outfall 003-(Treated domestic wastewater)				
CBOD	3.5	5.4	25 mg/L	38 mg/L
TSS	4.3	6.4	30 mg/L	45 mg/L
NH_3-N				
(May-Oct)	1.4	2.1	10 mg/L	15 mg/L
(Nov-Apr)	2.1	3.3	15 mg/L	23 mg/L
Fecal Col.			1000/100ml	2000/100ml
Outfall 004-(Stormwater)				
Oil/Grease			10 mg/L	15 mg/L

CURRENT STUDY

Data Acquisition

The Flat Creek survey was initiated in January 1995 with the collection of water quality samples at four locations. These collections continued on a monthly basis until July 1996. Two stations were located on the ELCC unnamed tributary to Flat Creek, on Flat Creek above the confluence with ELCC tributary and on Salt Creek at O'Rear Road.

On June 2, 1997, a more intensive phase of the survey was initiated with the collection of fish community samples at two locations on the ELCC unnamed tributary. Collections were made at the 19th street bridge upstream of the ELCC discharge and at the Hwy 7 spur bridge downstream of the discharge. Also on June 2, 1997, macroinvertebrates were collected at all biological sampling points. On June 3, fish community samples were collected at selected biological

stations. Stream flow and water quality samples were collected from all sites. Fish and macroinvertebrate community collections were to be sampled at the same locations. However, on June 3, very turbid water conditions made fish collection an impossibility at Flat Creek on O'Rear road. The collection was made south of that point on Flat Creek at a county road off of Hwy 167. Physical habitat assessments were completed in conjunction with the biological sampling. Also in 1997, four stations were sampled quarterly for the purpose of determining in-stream toxicity to aquatic organisms.

Parameters

The water samples were analyzed for dissolved oxygen, temperature, pH, flow, chlorides, total organic carbon (TOC), five day biochemical oxygen demand (BOD5), total suspended solids (TSS), total dissolved solids (TDS), ammonia nitrogen (NH_3N), nitrite+nitrate nitrogen (NO_2 + NO_3), orthophosphorus, and total phosphorus. The dissolved and total metals sampling included aluminum, boron, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, potassium, magnesium, manganese, sodium, nickel, lead, vanadium, and zinc. In addition to the above parameters, water grab samples were collected quarterly during 1997 at four stations for the purpose of conducting toxicity tests using Ceriodaphnia dubia and fathead minnow larvae as the test organisms.

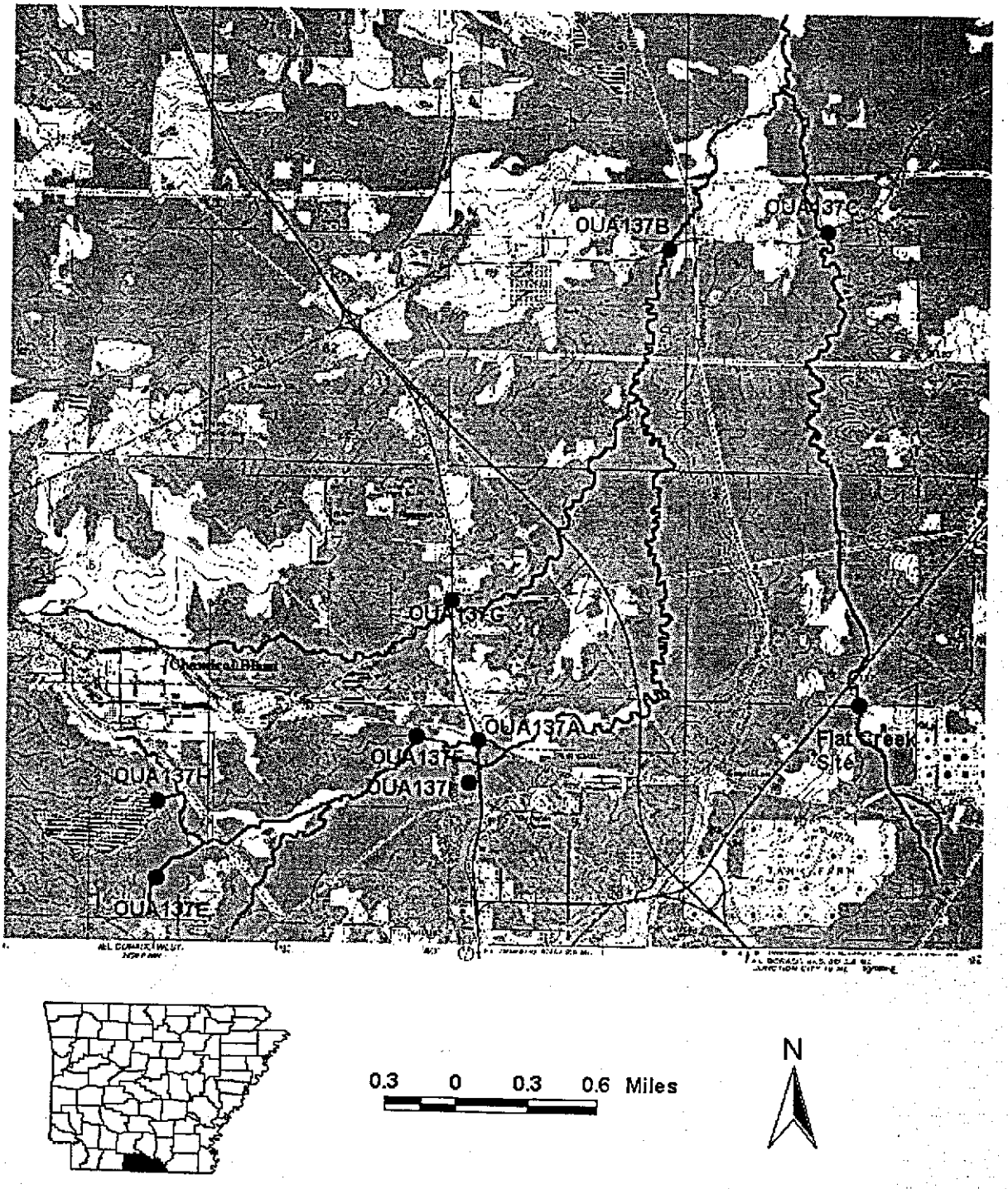
Collection, Preservation and Measurements

Water quality grab samples were collected, preserved, and analyzed according to the 18th Edition of Standard Methods for Examination of Water and Wastewater. Analysis was conducted under ADPC&E's existing Quality Assurance Program. Dissolved oxygen and stream temperature were measured using an Orion Model 840 portable dissolved oxygen meter, which was calibrated according to the manufacturers instructions prior to use. Stream flow was measured using a Marsh-McBirney Model 2000 Flow Mate meter by obtaining a representative number of velocities and depths across suitable stream locations.

Water grab samples were taken in the unnamed tributary to Flat Creek above the ELCC outfall (OUA137E) and downstream of the outfall at the Hwy 7 spur bridge (OUA137A). Water was also collected at another Hwy 7 spur bridge crossing a tributary that receives stormwater runoff from the north side of the facility (OUA137G) and from another unnamed tributary which drains urban El Dorado (OUA137I). Other water collection stations were located at three places on O'Rear Road; these were from the ELCC unnamed tributary prior to its confluence with Flat Creek (OUA137B), from Flat Creek (OUA137C) and from Salt Creek (OUA137D). Figure 1.

Biological samples were collected in the unnamed tributary above the discharge at 19th street, at Hwy 7 spur, and at O'Rear Road. In Flat Creek, macroinvertebrates were collected at O'Rear Road and fish community was collected at the county road off of Hwy 167. No biological collections were made at the station on Salt Creek. Macroinvertebrates were collected using a

Figure 1-Flat Creek Study Area



Turtox Indestructible benthos net. An attempt was made to sample similar structure and habitat at each location so that data collected would be comparable. The fish community was sampled by use of a Smith-Root Model 15-B DC backpack electrofisher. Riffle areas were sampled by driving the fish into a seine, while the fish in the pools were collected by electroshocking favorable habitat areas. The smaller specimens and those unidentifiable in the field were preserved in a ten percent (10%) formalin solution and returned to the lab for identification.

Toxicity tests were conducted by USEPA Region 6 personnel of the Houston Texas laboratory. Analyses included Pimephales promelas, 7-day embryo-larval survival and teratogenicity and Cerodaphnia dubia 7-day survival and reproduction tests. Quality assurance and test protocols were in accordance with "Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms", EPA-600-4-91-002.

Station Description

A total of eight water chemistry stations were established in Flat Creek and its tributaries. These eight stations include one reference station upstream of the discharge of ELCC and one station that characterized the water chemistry of a tributary that flowed from the city of El Dorado. One additional station was established on Salt Creek. The station locations and descriptions are as follows:

Station

OUA137A- Unnamed tributary to Flat Creek at Hwy 7 spur bridge approximately 1.75 stream miles below the ELCC Lake Killdeer discharge. Water quality and biological community collected. Approximate watershed size of 8 mi^2.

OUA137B- Unnamed tributary to Flat Creek south of Norphlet on O'Rear Road. Approximately 4.25 stream miles below the ELCC Lake Killdeer discharge. Water quality and biological community collected. Watershed size 12 mi^2.

OUA137C- Flat Creek south of Norphlet on O'Rear Road, approximately 0.75 miles upstream of the confluence with the tributary that receives the ELCC Lake Killdeer discharge. Water quality and macroinvertebrates collected.

OUA137D- Salt Creek south west of Norphlet on O'Rear Road. Water quality collected.

OUA137E- Unnamed tributary to Flat Creek at the 19th street bridge. Approximately 0.25 miles upstream of the Lake Killdeer discharge. Water quality, biological community, quarterly toxicity with water quality collected. Approximate watershed size of 2 mi^2.

OUA137F- Unnamed tributary to Flat Creek at the pipe-line crossing approximately 1000 ft upstream of OUA137A. Approximately 1.5 miles downstream of the Lake Killdeer discharge. Quarter toxicity with water quality collected.

OUA137G- Unnamed tributary to Flat Creek at the Hwy 7 spur bridge. This station was established to characterize the storm water drainage from the north boundary of ELCC property. Approximately 1.0 stream mile downstream of the facility. Water quality and quarterly toxicity with water quality collected.

OUA137H- Located within 25 meters of the Lake Killdeer discharge. Quarterly toxicity with water quality collected.

OUA137I- Unnamed tributary to Flat Creek. Unimpacted by ELCC, drains urban El Dorado. Located at Hwy 7 spur bridge. Water quality collected only.

Flat Creek- Fish collection only. Established on 6/3/97 due to poor water conditions at OUA137C. The only fish collection station on Flat Creek. County road bridge off of US Hwy. 167 approximately 2 miles east of Hwy. 7 spur. Referred to as "Flat Creek" in the Fish Community section of this report.

DATA RESULTS

pH and Flow

The pH values recorded during the monthly sampling (1995-96) ranged between 3.7 and 7.0. The lowest pH value recorded during the monthly sampling (3.7) was recorded in Salt Creek on June 18, 1996. During 1997, water quality data was collected during quarterly toxicity screening and during an intensive survey on June 3, 1997. These data will be referred to as the 1997 data throughout the remainder of this report. The pH values recorded during 1997 ranged from 5.2 to 9.3. The lowest value was recorded in Salt Creek on June 3. The pH of 9.3 was recorded on March 10 at OUA137F. Instream flows were recorded at seven stations during the intensive survey of June 3, 1997. An instream flow of 2.27 cfs was recorded at the upstream station (OUA137E). At OUA137I, the tributary from El Dorado, the flow was recorded as 0.5 cfs. At OUA137A, instream flow was recorded as 5.22 cfs. The increase in flow from the upstream station (OUA137E) is due to the discharge flow from ELCC at Lake Killdeer. The flow was 6.43 cfs at OUA137B. This station is located in the ELCC tributary just upstream of its confluence with Flat Creek. Instream flow recorded in Flat Creek was 8.95 cfs; in Salt Creek (OUA137D) it was 5.95 cfs.

Chlorides, Sulfates and Total Dissolved Solids

Chloride concentrations were elevated to some extent at all stations throughout this survey. During the 1995-96 sampling events, the mean chloride concentration at OUA137A was 39.7 mg/L with a range of 20.1 mg/L to 71.9 mg/L. Downstream, at OUA137B, the mean concentration was 33.5 mg/L with a range of 15 mg/L to 63.6 mg/L. The mean chloride concentration in Flat Creek upstream of the ELCC tributary was 445.2 mg/L. The elevated chlorides of Flat Creek are likely due to oil and gas operations in the area. These values represent the mean of eleven sampling events between January 1995 and July 1996 (Figure 2). The 1997 data shows only slightly elevated

concentrations of chlorides, because Flat Creek and Salt Creek were not sampled (Figure 3). During the intensive survey of June 3, 1997, the chloride concentration at the upstream reference station (OUA137E) was 26.1 mg/L . At OUA137A, downstream of the discharge of ELCC, the concentration was comparable at 25.5 mg/L. At the Flat Creek and Salt Creek sites, chlorides were 254.4 mg/L and 771 mg/L, respectively.

Water quality data collected in 1997 during the sampling for toxicity showed elevated concentrations of sulfates below the discharge of ELCC (Figure 4). At the upstream reference station (OUA137E), the mean sulfate concentration was 11.5 mg/L with a range of 4.0 mg/L to 16.2 mg/L. Below the discharge (OUA137F) the mean concentration was 154 mg/L with a range of 49.8 mg/L to 412.0 mg/L. This increase in instream sulfate concentration is the result of mean concentrations of 300.7 mg/L from the outfall of ELCC at Lake Killdeer (OUA137H). Sulfates at this station ranged from 183.6 mg/L to 553.0 mg/L. Concentrations recorded at OUA137G were also elevated but not to the extent as those recorded below the discharge. OUA137G is located downstream of ELCC in the unnamed tributary to Flat Creek that receives stormwater runoff from the north side of the facility. The mean sulfate concentration at this station was 41.5 mg/L with a range of 12.5 mg/L to 74.2 mg/L. Monthly sampling during 1995 and 1996 (Figure 5) also showed elevated concentrations of sulfates below the discharge of ELCC. During the 11 sampling events in 1995-96, mean sulfate concentrations downstream of the ELCC discharge were 202 mg/L and 171 mg/L at OUA137A and B, respectively. The maximum sulfate concentration recorded during this period was 700.0 mg/L. This was from OUA137A. This pattern of elevated sulfate concentrations was also observed during the June 3, 1997 intensive survey. Upstream of the discharge of ELCC (OUA137E), the sulfate concentration was 11.1 mg/L. Downstream of the facility at OUA137A, the sulfate concentration had elevated to 73.6 mg/L. Further downstream in the ELCC tributary, at OUA137B, the concentration had dropped to 50.8 mg/L. The sulfate concentration in Flat Creek was 70.9 mg/L. In Salt Creek (OUA137D), the concentration was 1.7 mg/L.

Analyses for total dissolved solids (TDS) concentrations exhibited similar increases as chlorides and sulfate below the ELCC discharge. Samples collected at OUA137E during the 1997 toxicity sampling events had a mean TDS concentration 145.3 mg/L with a minimum value of 110 mg/L and a maximum of 174.0 mg/L (Figure 6). The outfall at Lake Killdeer had a nine fold increase with a mean concentration of 1244.8 mg/L. The maximum concentration recorded at this station during the four sampling events was 1769 mg/L. Further downstream at OUA137F the mean concentration had fallen to 597.3 mg/L. The mean concentration at station OUA137G for the four sampling events was 234.5 mg/L. Monthly sample collection in 1995-96 (Figure 7) reflects the same situation at the downstream stations. Samples collected at OUA137A and OUA137B downstream of the facility had mean concentrations of 675.9 mg/L and 567.9 mg/L, respectively. Concentrations of TDS in Flat Creek at OUA137C were comparable with a mean of 917.7 mg/L. Figure 8 represents the mineral data from the June 3, 1997 intensive survey.

Figure 2

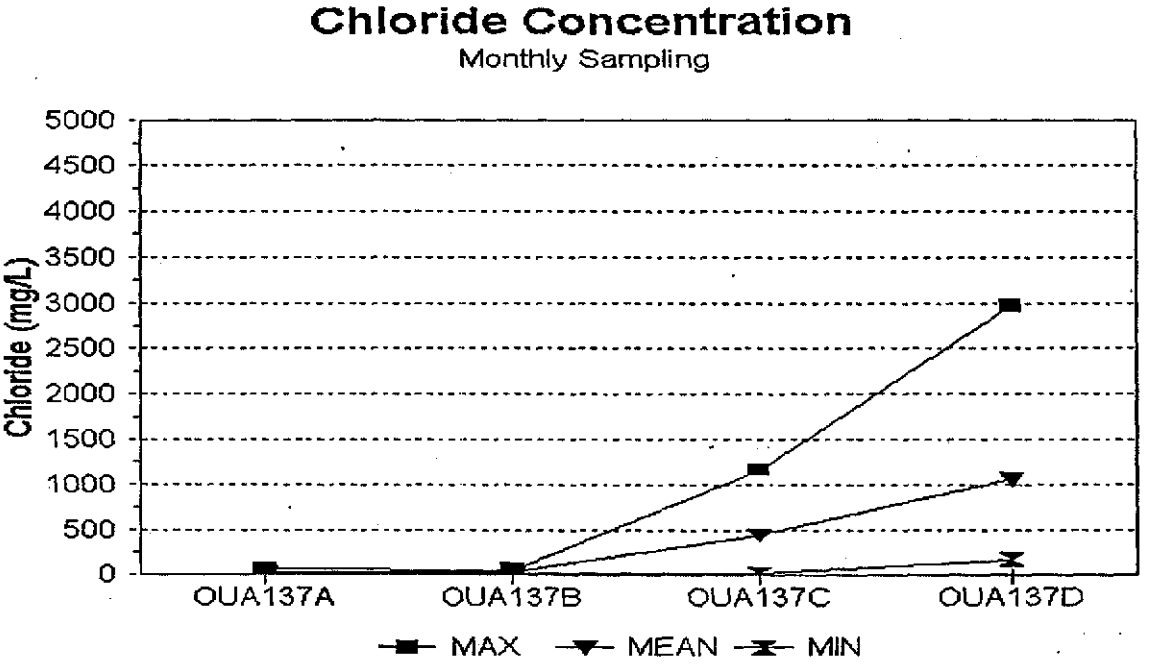


Figure 3

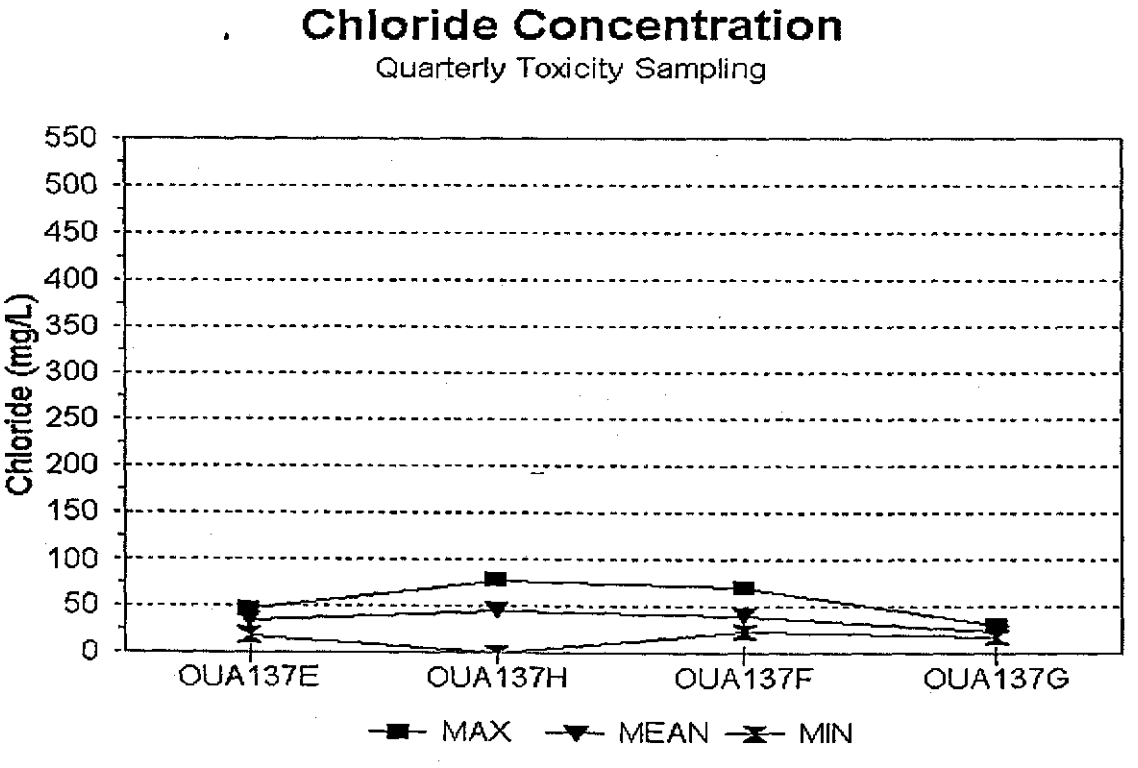


Figure 4

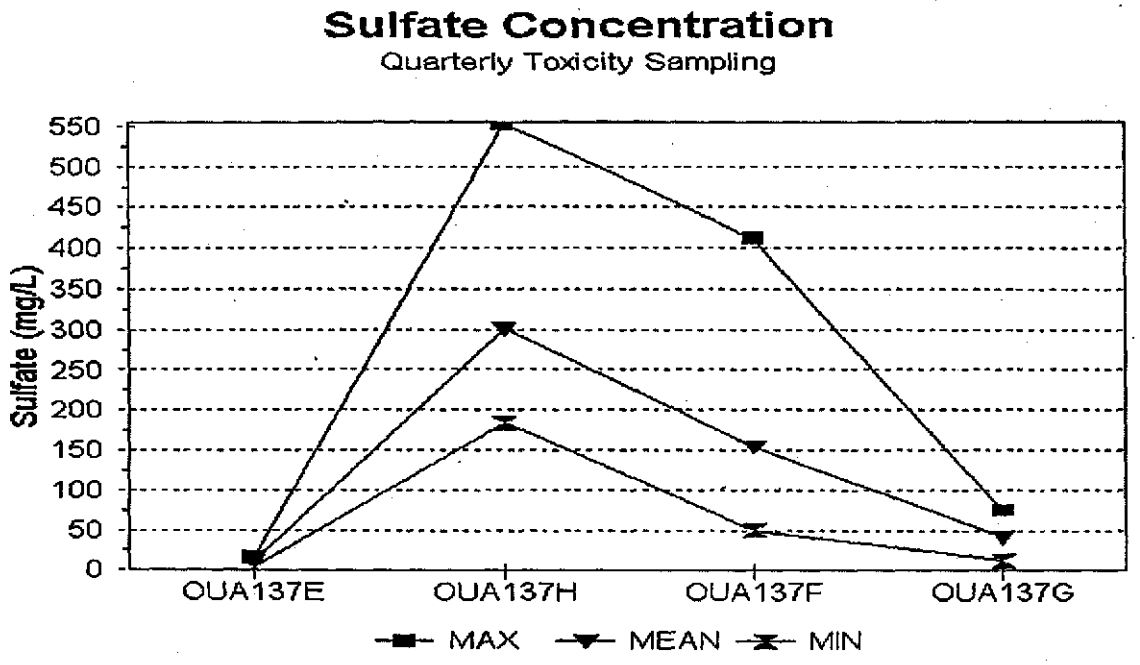


Figure 5

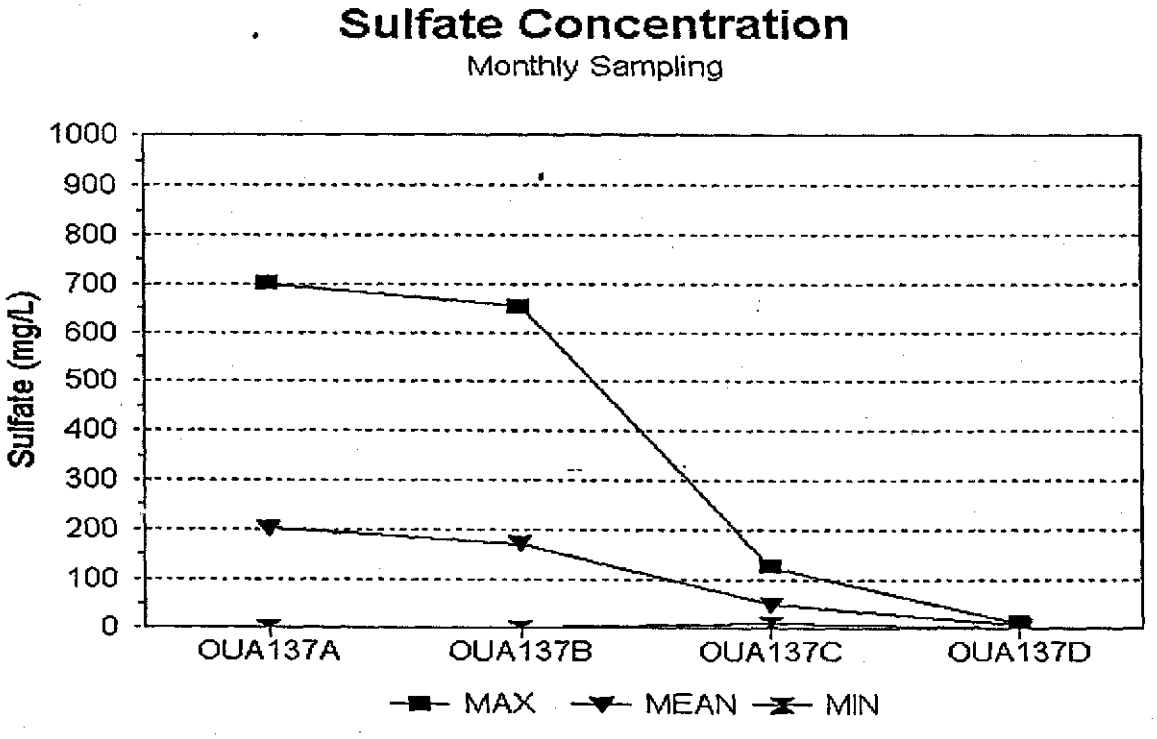


Figure 6

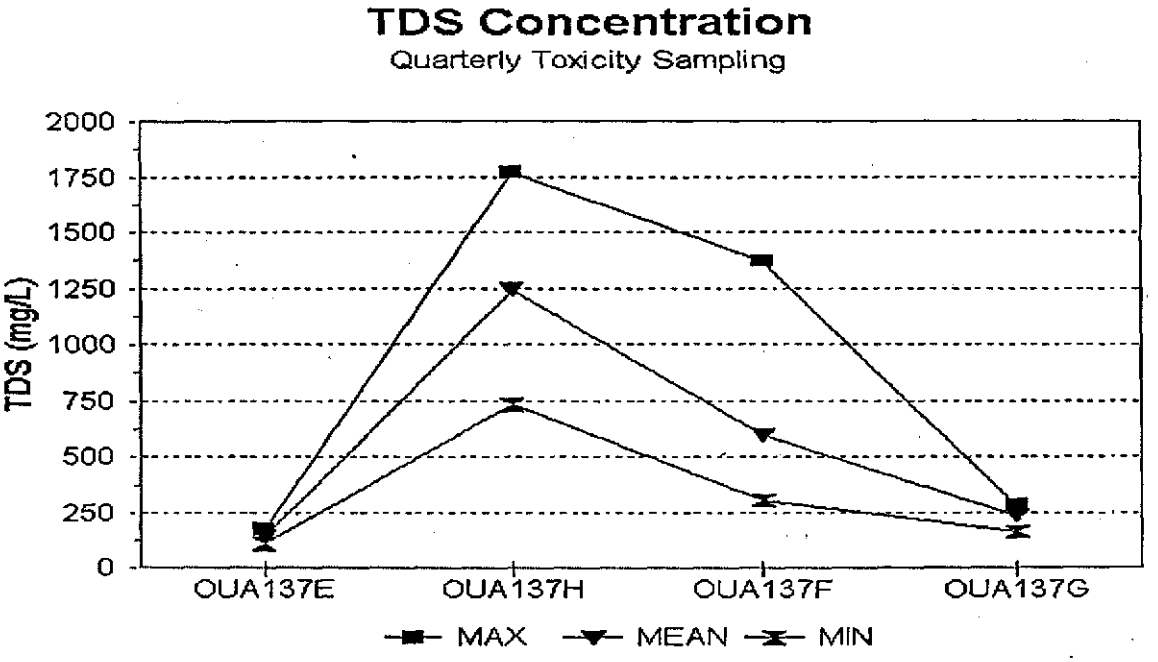


Figure 7

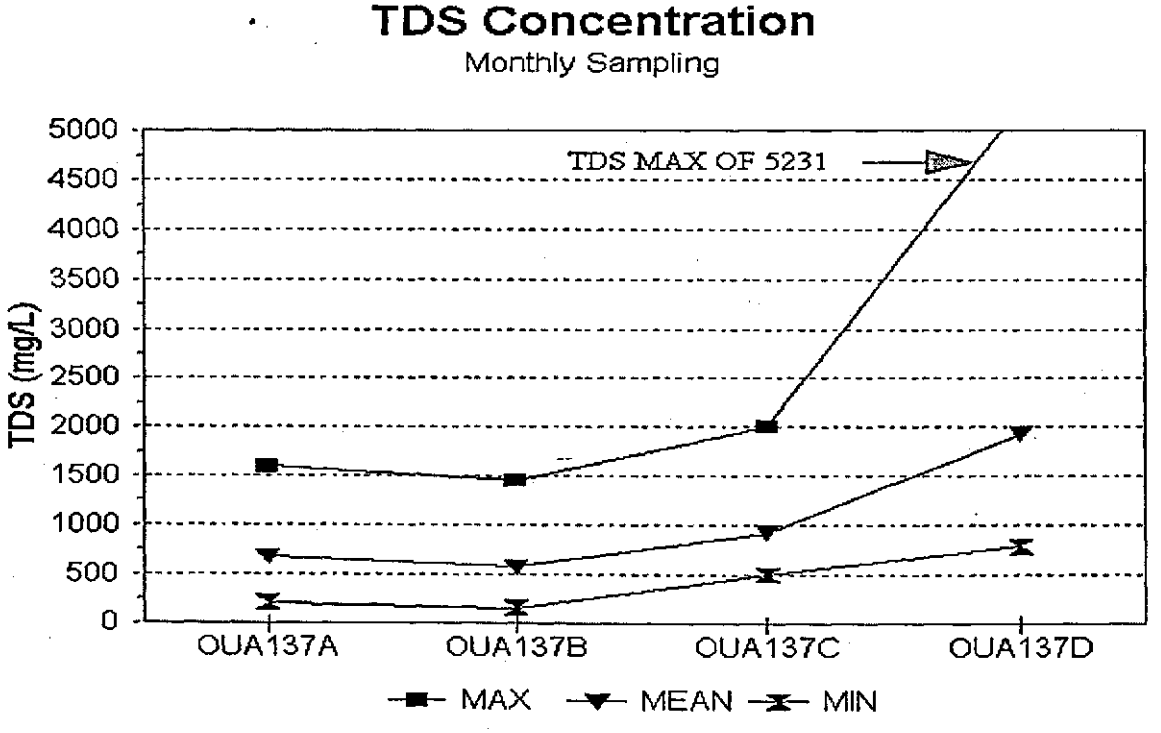
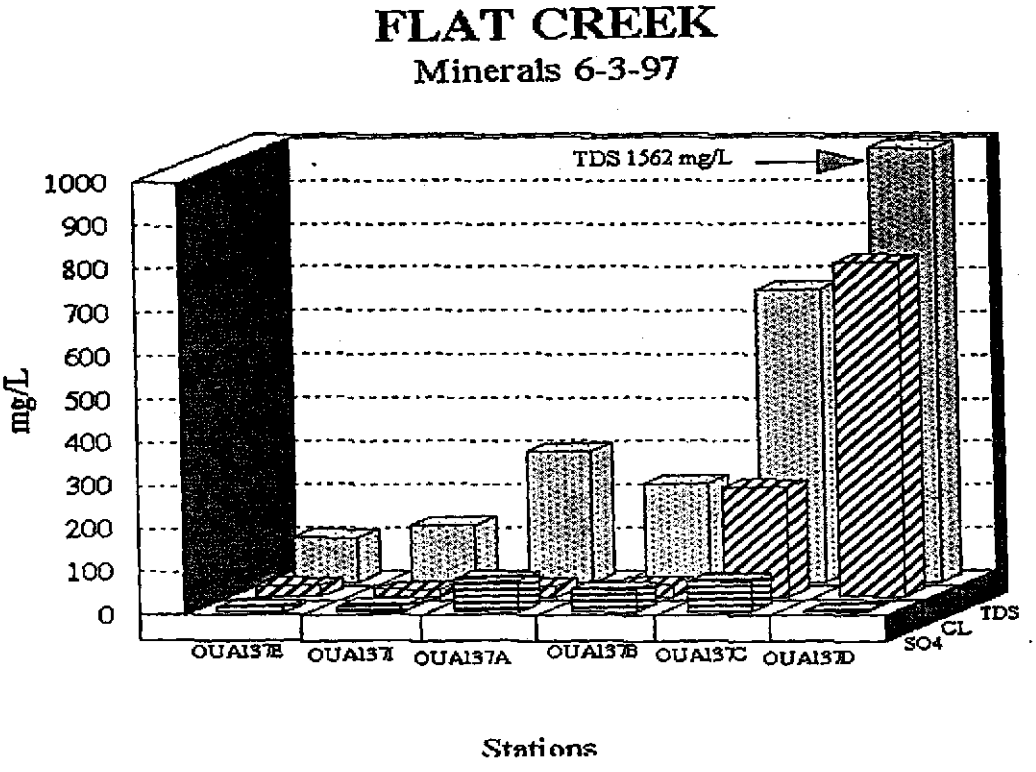


Figure 8



Nutrients

Analyses for phosphorous yielded very low concentrations at all stations. The maximum concentrations recorded for either o-phosphorus or total phosphorous during any of the three phases of water quality sampling was 0.5 mg/L. Ammonia-nitrogen concentrations at the upstream station in the ELCC tributary to Flat Creek were all less than 0.5 mg/L. Samples collected during the sampling for toxicity testing at the station 1.5 miles below the Lake Killdeer discharge (OUA137F) revealed ammonia concentrations ranging from 6.8 mg/L to 56.9 mg/L with a mean concentration of 27.4 mg/L. Concentrations at the Lake Killdeer discharge (OUA137H) ranged from 12.7 mg/L to 246.0 mg/L for ammonia and averaged 80.9 mg/L. Samples collected from the stormwater receiving stream (OUA137G) had a mean concentration of 31.3 mg/L ammonia and a maximum of 114 mg/L (Figure 9). Concentrations of ammonia during the 1995-96 monthly sampling were also consistently elevated by the discharge from ELCC. The mean concentrations at stations downstream from the discharge (OUA137A and B) were 25.8 mg/L and 17.1 mg/L, respectively. The maximum concentration of ammonia recorded during the monthly sampling was 54.1 mg/L at OUA137A on May 28, 1996. Ammonia concentrations from Flat and Salt Creeks are compared with the ELCC tributary values in Figure 10. Concentrations recorded from these sites normally did not exceed 0.5 mg/L although one value during the 11 month period was 4.7 mg/L. Elevated ammonia concentrations were also seen during the June 3, 1997 intensive survey but not at the magnitude of those from the monthly collection. The ammonia concentration at the upstream

Figure 9

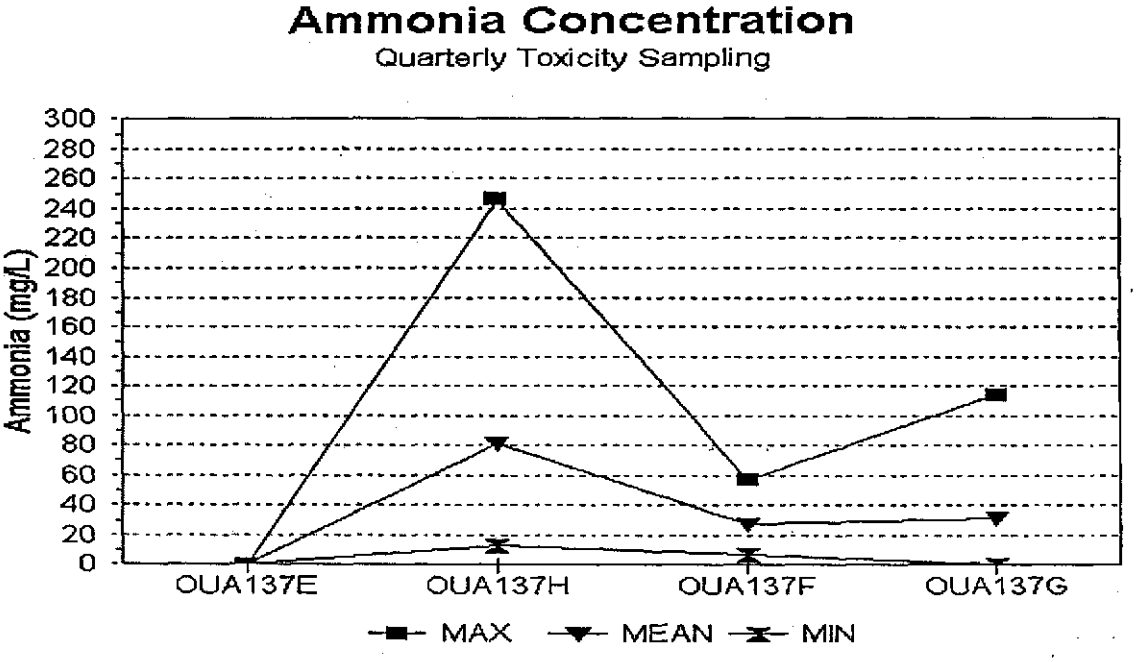
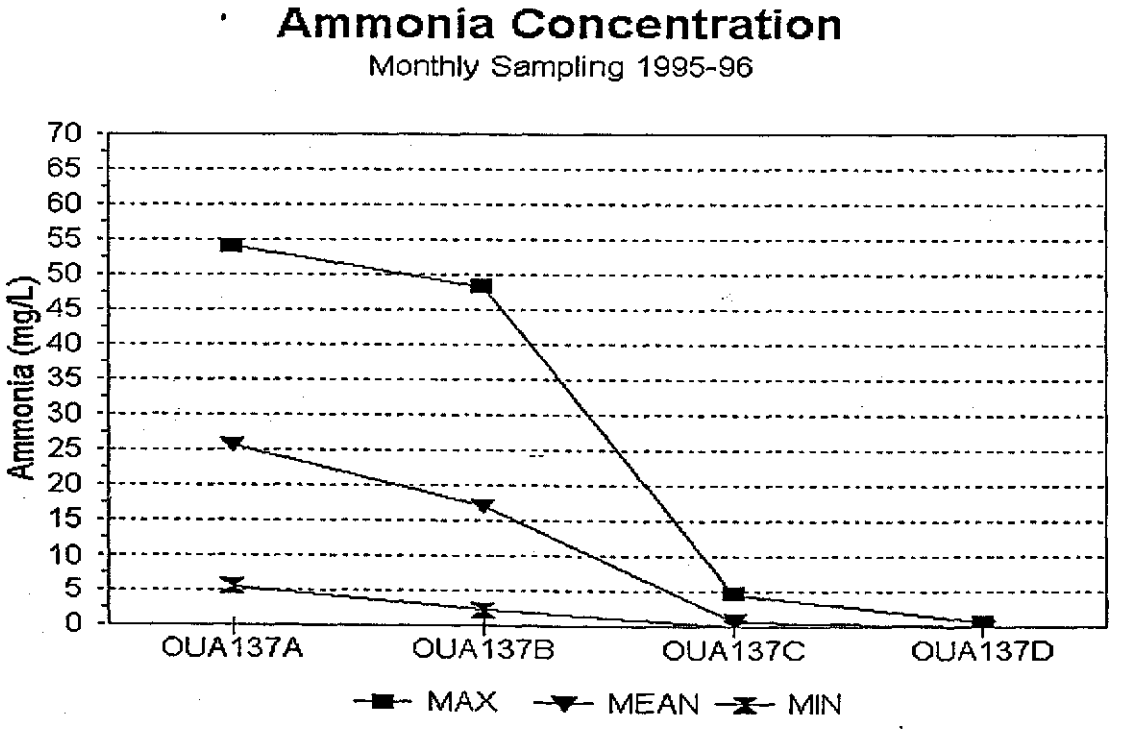


Figure 10



station (OUA137E) during the intensive survey was 0.3 mg/L but had increased to 11.0 mg/L at OUA137A downstream of the ELCC discharge. Further downstream at OUA137B the ammonia concentration had further reduced to 5.6 mg/L. On June 3, 1997, as was the case during the monthly sampling, ammonia concentrations were very low at the upstream station on Flat Creek and in Salt Creek. The ammonia concentrations at these stations were only 0.2 mg/L.

The nitrate concentrations of Flat Creek and its tributaries reflect the same patterns of elevation as was seen in the ammonia concentrations. Very high concentrations of nitrates were seen in the discharge of ELCC and immediately below. There was some degree of recovery downstream. Samples collected during the 1997 events(Figure 11&13) showed very low concentrations of nitrates upstream in the ELCC tributary at OUA137E. Nitrate concentrations at this station ranged from 0.2 mg/L to 0.4 mg/L. Nitrate concentrations in the effluent of ELCC ranged from 65.0 mg/L to 380.0 mg/L with a mean concentration of 170.6 mg/L. The effect of this discharge of nitrates can be seen downstream at OUA137F and OUA137A. OUA137F nitrate levels ranged from 22.2 mg/L to 105 mg/L with a mean concentration of 64.0 mg/L for the four samples taken. Some recovery can be seen at the most downstream station on the ELCC tributary (OUA137B). The nitrate concentration on June 3, 1997 was 16.5 mg/L. Upstream in Flat Creek and also in Salt Creek, very low nitrate concentration were found. On June 3, 1997, OUA137C and OUA137D had nitrate concentrations of 2.1 mg/L and <0.02 mg/L, respectively. The nitrate concentrations at OUA137G were not elevated to the extent of some of the other stations, except on December 1, 1997 the value was 40.8 mg/L. This would be due to stormflow run-off from thundershowers the morning of December 1. Nitrate concentrations during the monthly sampling of 1995-96 show the same elevated values downstream of the ELCC discharge (Figure 12). Mean nitrate concentrations at OUA137A and OUA137B were 52.5 mg/L and 40.2 mg/L, respectively. These values contrast sharply with least-disturbed ecoregion stream values which are normally about 0.01 mg/L. The Flat Creek (OUA137C) mean concentration was about 2.0 mg/L and in Salt Creek nitrates were consistently less than 0.2 mg/L. Figure 13 shows the respective concentrations of nutrients in the Flat Creek study area.

Dissolved Metals

Samples were analyzed from each of the water quality sampling stations for dissolved and total metals on each sampling event during 1997 and on one sampling event during the monthly collections in 1995-96. At the discharge from Lake Killdeer elevated levels of copper, zinc and nickel were found. Also high values of sodium were found in association with the high sulfate values. Calcium and magnesium levels were also noticeably higher than background (upstream) or ecoregion values, resulting in higher than typical hardness levels. This becomes significant to the toxicity values in light of the elevated metals. Vanadium was also detected at the outfall of Lake Killdeer (OUA137H). Vanadium was detected on all four occasions sampled at this station. The maximum concentration recorded was 21.6 μg/L on September 22, 1997. This is one of very few places in the state where vanadium has been found above detection levels.

The amount of copper found is of concern both downstream of the discharge and in the stormwater discharge stream. Above the discharge, in the ELCC tributary copper levels were very low with a

Figure 11

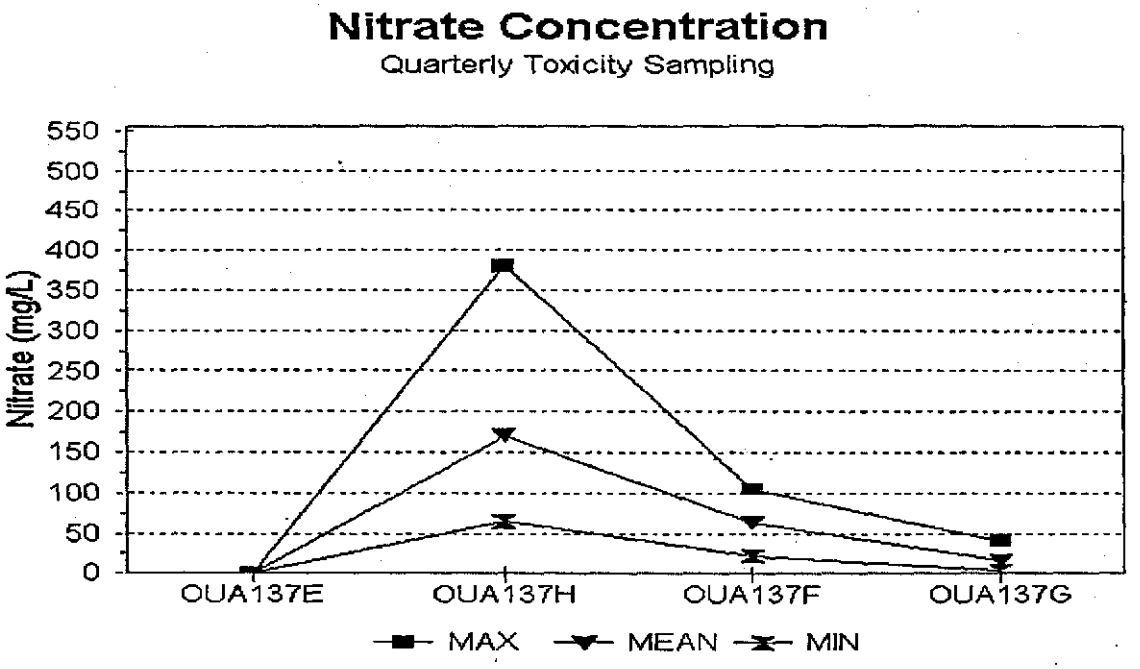


Figure 12

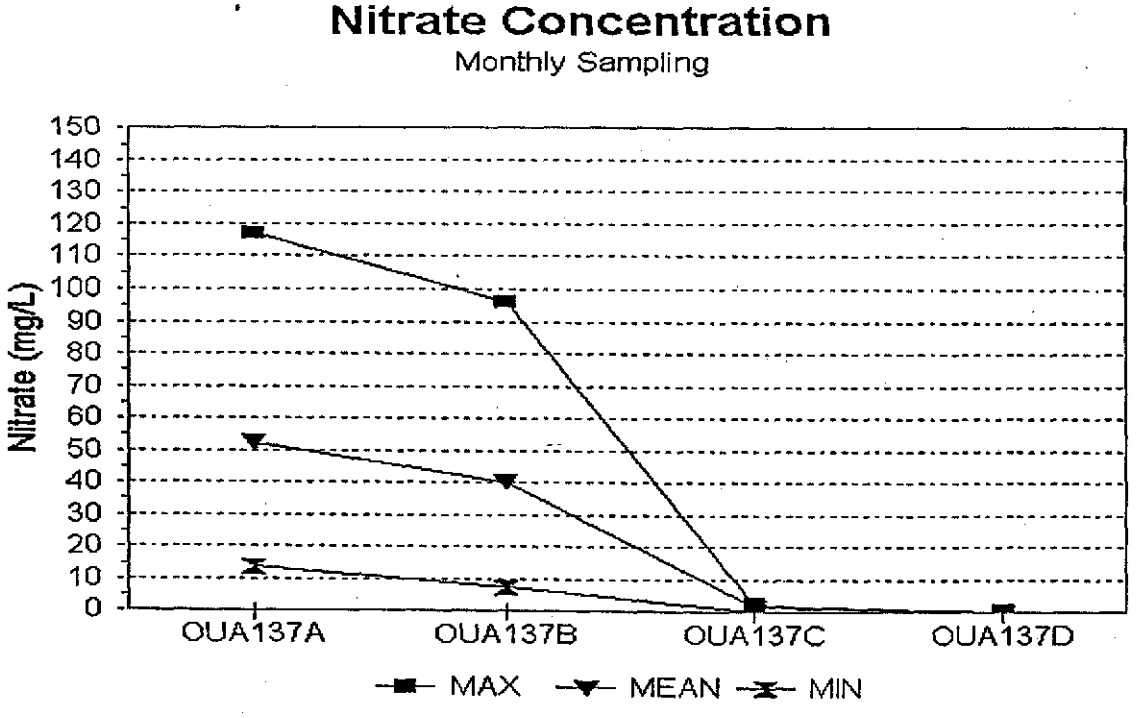
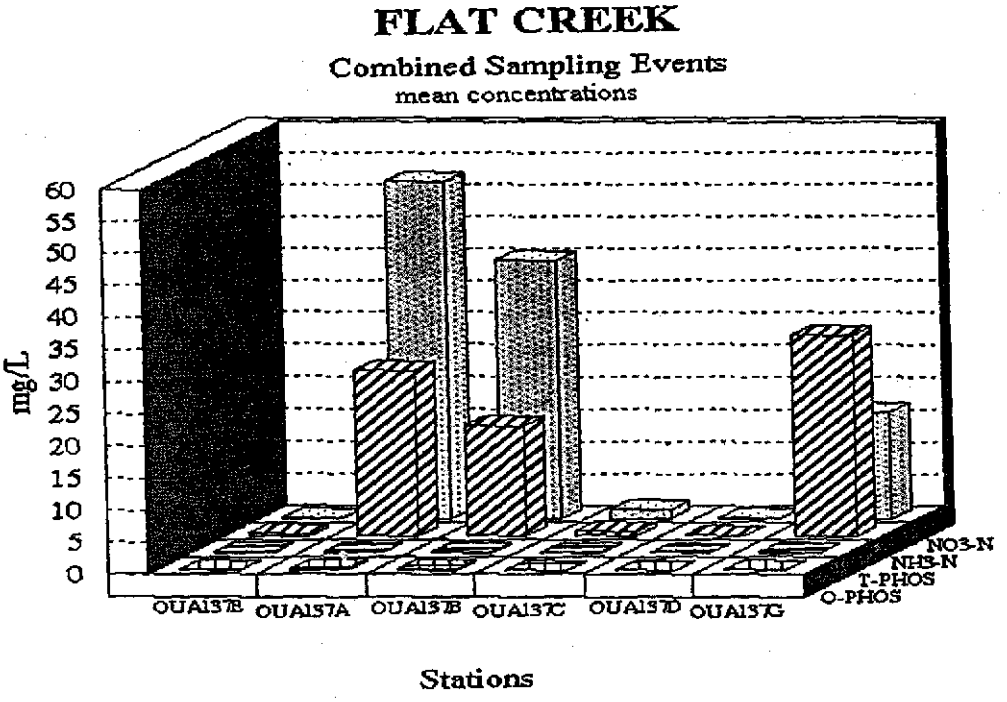


Figure 13



maximum recorded concentration of 2.8 μg/L. Copper concentrations in Flat Creek (OUA137C) and Salt Creek (OUA137D) were below the laboratory detection limit of 2.0 μg/L. Copper concentrations in the effluent of ELCC (OUA137H) were present at a mean concentration 11.2 μg/L with a maximum of 14.7 μg/L. Copper was also found in similar concentrations at downstream stations in this tributary. There were two sampling events for copper at OUA137B, approximately 4.25 miles downstream of the ELCC outfall. One event was in 1995 and another in 1997. Copper concentrations of 10.0 μg/L and 11.1 μg/L were found. Zinc was also found in the effluent at concentrations considerably elevated above background levels. The mean zinc concentration was 57.3 μg/L in the discharge of ELCC compared to a mean concentration of 12.8 μg/L at the upstream station (OUA137E). Further downstream at OUA137B, the mean concentration of zinc remained elevated on the two sampling events. Zinc concentrations were found to be 25.8 μg/L on April 4, 1995 and 21.7 μg/L on June 3, 1997, at this station. Elevated concentrations of some metals were also noted at the station on the unnamed tributary that receives stormwater drainage from the north side of ELCC (OUA137G). Again, copper and zinc were found in concentrations that warrant concern. The mean concentration of copper found at this station was 6.6 μg/L with a range of 3.6 μg/L to 9.7 μg/L. The highest concentration of zinc recorded during this study (108.0 μg/L) was collected at this station.

Calculations of acutely toxic metals values were accomplished using the recently adopted metals criteria from Regulation No. 2 which were previously promulgated in the National Toxics Rule. Using ecoregion hardness values for calculating toxic levels as prescribed in the implementation procedures, copper was found above the acute toxicity level in 12 of 15 total samples from the ELCC

outfall at Lake Killdeer, at stations in the ELCC tributary below the outfall and in the northside stormwater drainage. Since hardness values were elevated in the effluent and for a short distance downstream, toxic values were also calculated using the measured hardness values at these stations. Acute toxicity levels were not exceed in the effluent, but they were exceeded in 50% of the samples 1.5 miles downstream (OUA137F), in 40% of the samples from the northside drainage and at both samples taken near the mouth of ELCC tributary (OUA137B). This resulted from an adjustment of the hardness values at the downstream stations to near typical ecoregion values, but copper values remained relatively high. Several toxic zinc values were also found using ecoregion hardness, but only one toxic value of zinc was found using existing hardness of the sample.

Aquatic Life Toxicity

Aquatic live toxicity tests were conducted by USEPA Region 6 personnel of the Houston Texas laboratory. Analyses included Pimephales promelas, 7-day embryo-larval survival and teratogenicity and Cerodaphnia dubia 7-day survival and reproduction tests. Quality assurance and test protocols were in accordance with "Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms", EPA-600-4-91-002. This type of aquatic toxicity test is different from that required in the NPDES permit. The test method used in this survey uses whole stream samples instead of numerous dilutions of the sample. Also, effects on growth were not measured for Pimephales promelas. Effects on the minnow are reported as "statistically significant effects". These include the combined number of dead embryos (unhatched) and larvae, also, organisms exhibiting gross deformity and abnormal swimming behavior.

During 1997, grab samples were collected in conjunction with water quality samples at four locations in the Flat Creek area. Samples were taken for the purpose of testing for aquatic life toxicity at four stations; OUA137E, OUA137H, OUA137F and OUA137G. Analyses performed on water samples collected on March 10, 1997 at the outfall of Lake Killdeer (OUA137H) exhibited 100% mortality of Pimephales promelas after three days of exposure. Analyses performed using Ceriodaphnia dubia as the test species exhibited 90% mortality after seven days of exposure. In contrast, water samples collected at the outfall on May 27, 1997 produced "no significant effect" on the test species after seven days. Tests performed on water collected from the outfall on September 22, 1997 produced a significant effect on 100% of Pimephales promelas after seven days. Analyses performed using Ceriodaphnia dubia as the test species showed no significant effect. On December 1, 1997 the final water collection was made at the outfall for the purpose of toxicity testing. This water produced 100% mortality to both test species within the first 24 hours of exposure to the ELCC effluent. On March 10, 1997, water samples collected from OUA137F, which is approximately 1.5 stream miles downstream of the outfall of Lake Killdeer, produced 100% mortality of Pimephales promelas after six days of exposure to the stream water. Water collected from the upstream station (OUA137E) produced nonlethal effects on Ceriodaphnia during one sampling event.

Dissolved metals concentrations as well as the ammonia concentrations in the effluent from ELCC are among the probable causes of this toxicity. At a hardness of 31, the average hardness for waters of the Gulf Coastal Plain ecoregion, copper is acutely toxic to aquatic life at 5.6 μg/L. Zinc would be acutely toxic at 42.4 μg/L. Toxicity tests performed on samples taken at OUA137F (1.5 miles below the discharge) on March 10, 1997 resulted in 100 mortality within three days. Water quality samples taken on March 10 at this station had a copper concentration of 7.8 μg/L and a hardness of 28.0 mg/L. Ammonia toxicity was also a factor on the March 10, 1997 sampling event. Figures 14 and 15 show the relationship between ammonia concentration and pH. Ammonia is toxic to aquatic organisms at a concentration of 0.71 mg/L ammonia nitrogen at a pH of 9.3 and 15° C. On March 10, the concentration of ammonia at OUA137F was 11.8 mg/L at a pH of 9.3 and temperature 15° C. This is over 16 times the concentration that would cause toxicity.

During the course of this study (1995-1997), 28 individual ammonia-nitrogen samples were taken downstream of the Lake Killdeer discharge. Eleven samples (39%) had elevated ammonia-nitrogen concentrations that would cause toxicity to aquatic organisms at the ambient pH and temperature. Nine (82%) of those eleven toxic concentrations were elevated more than 50 % over the concentration that would cause toxicity in freshwater. Five samples were taken for ammonia-nitrogen at OUA137G. This site is in the tributary that receives the stormwater drainage of ELCC. Only one sample showed elevated ammonia-nitrogen concentrations that would potentially cause toxicity to aquatic life. This sample was taken on December 1, 1997; it showed 3% of the minnows were affected, but this was not statistically significant.

One point of concern is that the toxicity of dissolved metals is strongly related to water hardness. The effluent of ELCC produces moderately hard water (over 100 mg/L) much of the time. This elevated hardness inhibits the toxicity of dissolved metals. The discharge of elevated levels of dissolved metals with this elevated water hardness may not cause aquatic toxicity near the outfall. However, downstream of the outfall, as the water hardness corrects to near the ecoregion concentrations the water quality conditions are conducive to aquatic toxicity. This situation is evident at OUA137F, 1.5 miles below the discharge, and at OUA137B approximately 4.25 miles downstream of the Lake Killdeer outfall (Appendix W-1). Also, as shown on the March 10, 1997 sample, occasional low hardness values occur in the ELCC effluent.

Figure 14

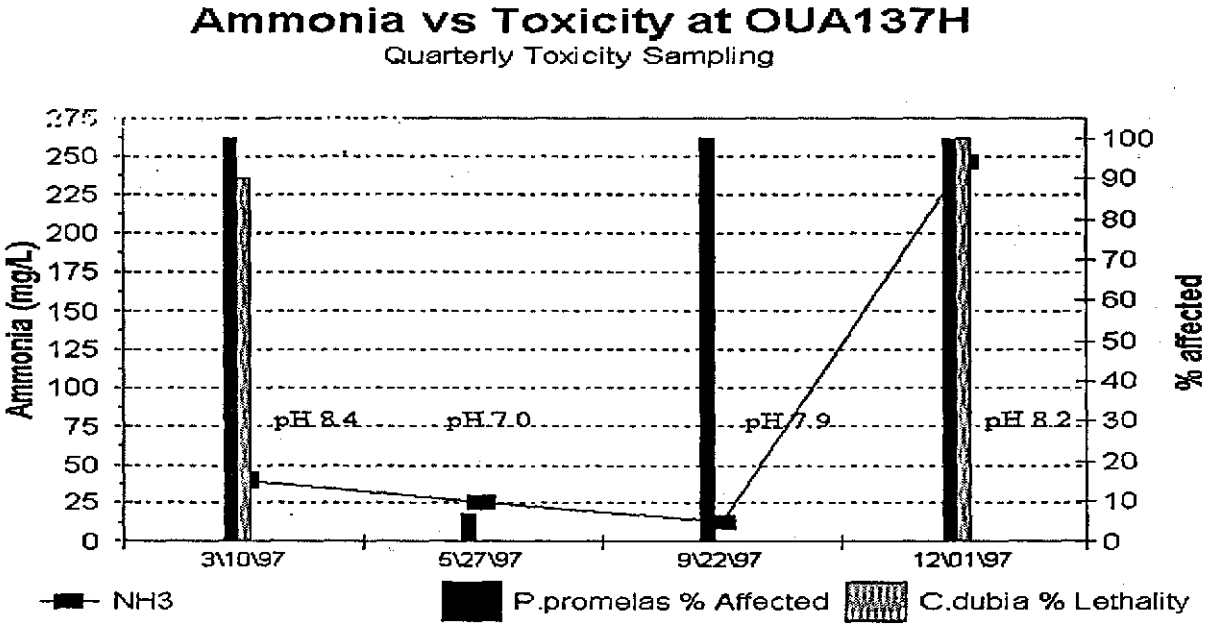
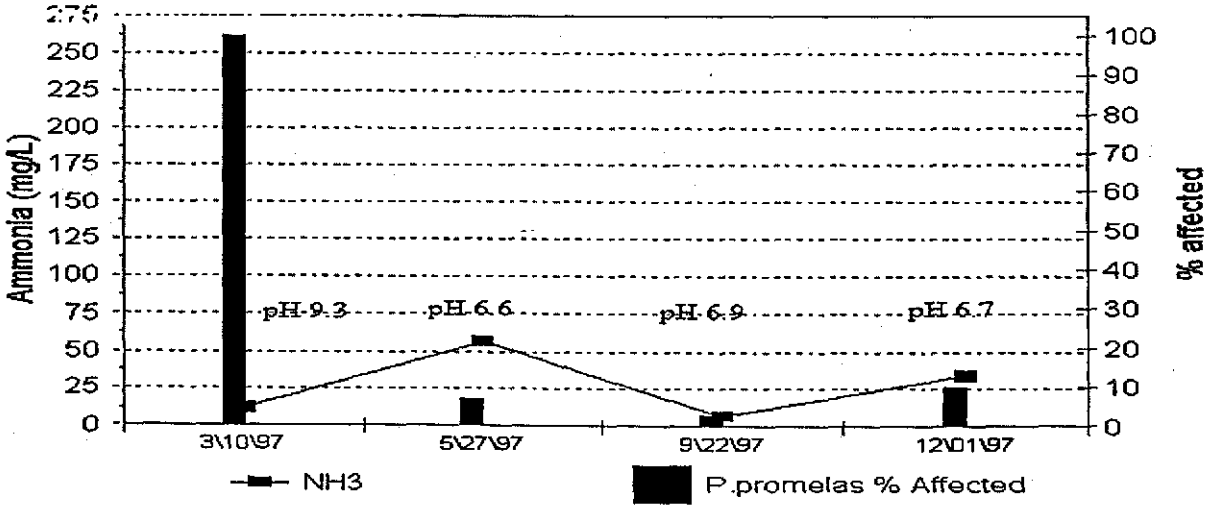


Figure 15



AQUATIC MACROINVERTEBRATES

Aquatic macroinvertebrates were collected at four sites during this survey. The upper site (OUA137E) was in the ELCC tributary above the point source discharges from the plant and it was used as the reference site. The second site (OUA137A) was in the same tributary below the discharge. An additional site (OUA137B) further downstream in the same tributary was also collected. The Flat Creek site (OUA137C) was also sampled.

Collections of aquatic macroinvertebrates were conducted using protocols set forth by the USEPA that consist of disturbing the substrate or any other available habitat and allowing the flowing water to carry all disturbed materials into a macroinvertebrate dip net. The sample was washed through a sieve where all large organic and inorganic debris was removed; it was placed in a 1.0 L jar and preserved with 70% ethanol to be transported to the lab for identification and enumeration.

In the lab, the sample was placed into a 9" x 13" dissecting pan. The pan was swirled to distribute the sample evenly and a 4 inch (10 cm) ring was randomly placed on the sample. Aquatic macroinvertebrates were removed from the ring until the ring was depleted of organisms. If fewer than 100 organisms were encountered in the ring, the sample was swirled again and the ring randomly placed on the sample and the same procedure was followed until a minimum of 95 organisms was removed from the sample. In cases where more than 100 organisms were encountered in a ring, the entire ring was picked to comprise the subsample. Organisms were identified to the lowest feasible taxonomical level, usually genus, enumerated and entered into a spreadsheet for further analysis. Taxonomic determinations were conducted by one person to reduce bias in identifications.

Rapid bioassessment (RBA) scores from multi data summaries (metrics) were derived for each site. Each site's score was compared with the reference site to find a percent comparable estimate (%BCE) and determine the impairment status. Impairment categories are found in Table M-1. Table M-2 lists the metrics evaluated and raw scores calculated for impairment status and Table M-3 lists the final metric scores for all sites.

TABLE M-1

Biological Condition	%BCE	Attributes
No significant impairment	> 83%	Comparable to reference site.
Slight Impairment	54-79%	Community structure less than reference site. Taxa richness lower and tolerant forms are more prevalent.
Moderate Impairment	21-50%	Obvious decline in community structure with loss of intolerant forms. EPT index reduced.
Severe Impairment	< 20%	Community dominated by 1 or 2 taxa, few taxa present.

TABLE M-2

Metric	OUA137E	OUA137A	OUA137B	OUA137C
Taxa Richness	17	23	21	12
Quantitative Similarity Index (Taxa)	NA	16%	11%	18%
Hilsenhoff's's Biotic Index	3.4	3.7	3.6	3.3
% Contribution of Dominant Taxa	54%	19%	24%	20%
Scraper / Scraper + Filterer Abundances	1.0	1.0	1.0	*
Quantitative Similarity Index (Functional Groups)	NA	0.68	0.59	0.78
# Functional Groups Represented	4	4	4	3
Community Loss Index	REFERENCE	0.5	0.6	1.0

* = No filterers found in this sample.

TABLE M-3

Bioassessment Scores	OUA137E	OUA137A	OUA137B	OUA137C
Taxa Richness	6	6	6	4
QSI (taxa)	6	0	0	0
HBI	6	6	6	6
% Contribution Dominant Taxa	0	6	4	4
Scraper Scraper+Filterer Abundances	6	6	6	0
QSI (functional groups)	6	6	4	6
# Functional Groups Represented	6	6	6	6
Total	36	36	32	26
% Comparable Estimate	REF	100	89	72

Taxa Richness is an expression of diversity. A diverse community consists of numerous taxa with the number of organisms dispersed among the taxa somewhat evenly. Quantitative **Similarity Index (taxa)** refers to the number of taxa that are common between the reference and sites in question. The **percent contribution of dominant taxa** is a comparison of the communities based on the percentage of the dominant taxa. Normally communities living in waters of good quality will have lower values for this metric. **Hilsenhoff's Biotic Index** is a scoring mechanism based on tolerance to organic pollution. Its scale is from zero to five and the tolerant organisms are near five. **Scraper/scraper + filter abundance** is another community balance metric involving the feeding mechanisms of the community. An overabundance of one feeding group reflects an unbalanced community that is being affected by an environmental stress. **Quantitative Similarity Index (Functional Groups)** is a measure of the similarity of functional feeding groups in a community. **Community Loss Index** is a metric to evaluate community similarity between sites and is scored on the number of taxa not found at sites in question but found at the reference site.

This RBA also includes physical site evaluations. Physical evaluations are necessary to ensure each site can physically support the community found at the reference or "least impacted" site. Physical parameters are scored and scores are compared with the reference. A %PCE is calculated to decide comparability of stations to the reference. Percent comparable estimates and assessment categories are found in Table M-4.

TABLE M-4

Assessment Category	%PCE
Comparable to Reference	≥90%
Supporting	75-88%
Partially Supporting	60-73%
Non-Supporting	≤58%

Multiple factors are used to determine physical characteristics. Substrate, flow and canopy cover are the primary factors and are conducted along a transect in the reach. Ten points are used along the transect and intervals represent 1/10th of the width of the reach. These variables are weighted heavier than the others due to their relevance to the available habitat. Channel alteration, bottom scour and deposition, sinuosity and lower bank capacity are weighted less but are still important in the quality and quantity of available habitats. These data are calculated over a larger area than the previous three but within the sample site (except sinuosity which encompasses several hundred meters of stream). Bank disruptive pressure, stream side cover and buffer zone are weighted less since they play a much smaller role in quantity and quality of habitats and these data are derived from approximately 100 m upstream and downstream of the sample site. After evaluation, the values are summed for the reference and sites in question to decide the percent physical comparable estimate (%PCE). Physical parameters and raw scores are found in table M-5.

TABLE M-5

Metric	OUA137E	OUA137A	OUA137B	OUA137C
Bottom Substrate	0	0	0	0
Flow	12	16	17	19
Canopy Cover	16	16	16	15
Channel Alteration	12	12	12	12
Bottom Scour-Deposition	8	3	7	10
Sinuosity	10	5	12	9
Lower Bank Capacity	9	5	9	9
Bank Disruptive Pressure	9	9	9	9
Stream side Cover	9	5	5	6
Buffer Zone	9	9	9	9
Total Score	94	80	87	89
% Similar	Reference	85	93	95

Results

Rapid bioassessments are not designed to be exhaustive surveys of benthic communities, only an indicator of impairment in the aquatic environment. To decide the impairment, many metrics are used. No one metric is considered most accurate, but a summation of the cumulative metrics is necessary to determine impairment.

All sites that were sampled could support the community found at the reference site except, OUA137A (Table M-5). At this site, the habitat had lower values for scour and deposition and lower bank capacity. This site however, had a %BCE score of 100 and showed no impairment when compared with the reference. The other two sites, OUA137B and OUA137C, showed no significant impairment and slight impairment, respectively. However, scores for these two sites are used with reservations since fewer than 100 organisms were found in the sample. This might be an indication of impairment.

Discussion

While the community at OUA137A showed no impairment when compared with the reference site, the community was different as shown by the QSI (taxa) which was only 16% similar to the reference. This caused a lower metric score for this metric in the final analysis of the metrics than the reference's score for QSI (taxa). The percent contribution of dominant taxa, however, was lower for OUA137A than the reference and this metric scored higher for OUA137A in the final evaluation (Tables M-2 and M-3). All of the other metric scores were equal between the two sites. Taxa richness was greater at OUA137A than the reference but the equal scores are explained since all sites are compared with the reference. If another site has more taxa, it will automatically receive a score equal to the reference. Each site contained one EPT taxa although they were from different families and had different HBI values. However, the scoring criterion is determined by the number of EPT taxa and is sensitive only at the order level. The community at OUA137A was most organic pollution tolerant but the final assessment scores were equal among all of the sites.

The lower percentage of predators at OUA137A shows a more balanced community than at the reference (Figure M-1). The community at the reference was dominated by organisms from the taxonomic order Odonata, probably due to the watershed size. This site drains less than 5 mi^2 and is near the headwater of the unnamed tributary while OUA137A was supported by more than 12 mi^2 of watershed. Besides the larger watershed, OUA137A also had the outflow from ELCC that may simulate a larger watershed due to the greater flow. Stream flow was almost two times greater at OUA137A than at OUA137E. In other surveys in the Gulf Coastal Plain, sites with the low stream flow (<3.0 cfs) were dominated by predator species, usually members of the order Odonata (ADPCE, 1997).

Collector feeding group percentages increased at each downstream site except OUA137C. This is in relation to the associated watershed size increases and is expected (Figure M-2). The percent

Figure M-1

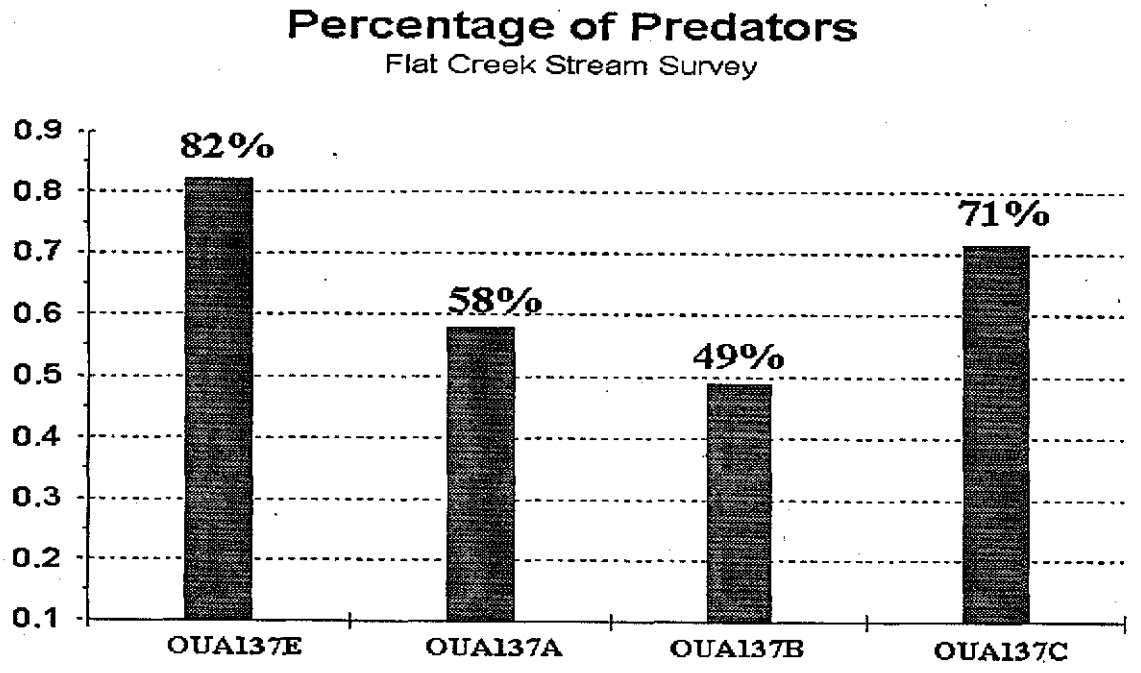
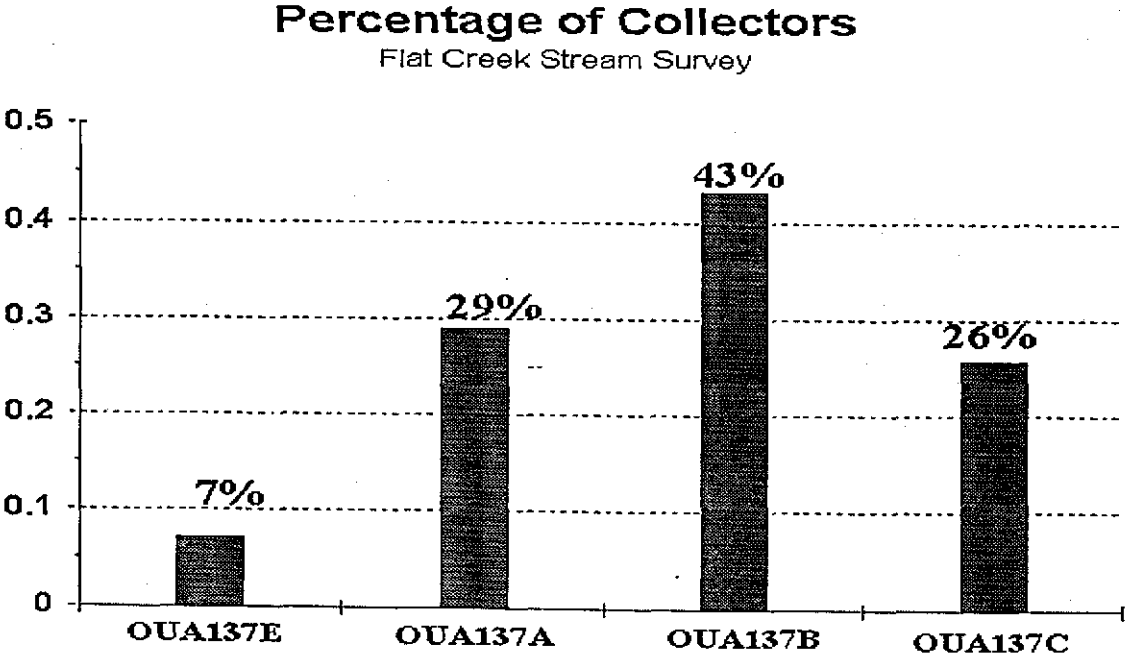


Figure M-2



of shredders were low considering the riparian area and canopy cover of the stream. One would expect many shredders where large quantities of allocthonous material are available. An explanation may be that water quality is too poor for this portion of the community to exist. Another factor may be the time of the year the sample was collected. This portion of the community may have already left the water to become terrestrial adults.

The sample at site OUA137B contained too few numbers of organisms to accurately describe the macroinvertebrate community. These low numbers may be a result of environmental stress caused by poor water quality. The low numbers found at OUA137C may also be a result of the poor water quality runoff from several oil fields and associated facilities. However, this phenomenon could also be a normal attribute of the macroinvertebrate communities in Gulf Coastal Plains ecoregion. Other Gulf Coastal Plains surveys have exhibited similar numbers of organisms in five minute RBA samples (ADPCE 1997).

Macroinvertebrate Conclusions

The aquatic macroinvertebrate community below the ELCC discharge is different from the community above the discharge; however, the RBA metrics indicate "no impairment" to "slight impairment" at sites below the discharge. These differences may be caused by habitat differences, different flow regimes or the substantial difference in water quality.

FISH COMMUNITY

In June 1997, fish community surveys were conducted at the stations listed below:

Station Description

OUA137E Unnamed tributary above El Dorado Chemical, at 19th Street bridge, approx. 1.5 mi. W. of US 167 BR. (Sec 18, T17S, R15W).

OUA137A Effluent tributary at Ar. Hwy. 7S bridge, approx. ½ mi. N. of Ar. Hwy. 7S and US 167 jnct. (Sec 9, T17S, R15W).

OUA137B Effluent tributary at O'Rear Road bridge, approx. 3.5 mi. W. of US 167. (Sec 4, T17S, R15W).

Flat creek Flat Creek at county road bridge just east off US 167, 1 mi. N. of US 167 and Ar. Hwy. 7 intersection. (Sec 10, T17S, R15W).

Methodology

A Smith-Root model 15-B backpack electrofishing device with pulsed DC current was used to collect fish from these sites. The device was used in the shallow pools and along the pool edges while wading upstream and dipping the stunned fishes from the water with dip nets. The riffles were collected by posting a twenty foot seine near the toe of the riffle and while working the electrofisher in a downstream direction through the riffle, the bottom substrate was disturbed and the fish were herded into the seine or washed in by the current.

Fish species of all types were collected from all available habitat within the sample area until a fully representative sample of the species in the area was thought to be obtained. Larger specimens were field identified and released. The smaller specimens and those unidentifiable in the field were preserved in a ten percent (10%) formalin solution and returned to the lab for identification.

Habitat Evaluation

Habitat evaluations were performed at all sites and were comprised of five parameters consisting of three to seven variables. These parameters included: 1) habitat type; 2) habitat quantity; 3) quantity of substrate type based on fish use; 4) quantity of in stream cover; and 5) sediment on substrate. Each parameter for substrate type and in stream cover was given a score depending on its abundance. The scores given to the substrate parameters were multiplied by a factor to adjust these scores based on how they relate to fish habitat quality. Length, depth and width measurements were estimated for each habitat type and recorded in feet. The sediment on substrate parameter was scored according to the amount of sedimentation of the substrate.

A total score for each habitat type was calculated by summing the scores for the substrate type, in stream cover and sediment on substrate. The scores from like habitat types were averaged for

each sampling station. The lengths of each habitat type were also summed giving a total length of habitat type sampled per sampling station. The total habitat type lengths were then divided by 100 and multiplied by the average habitat type score. This score is the Ichthyofauna Habitat Index (IHI). Table F-1 summarizes the fish habitat evaluations and includes the IHI for all stations sampled. Appendix F-1, Habitat Evaluation Summarization , displays the data for all habitat types sampled from each sampling location.

The Flat Creek sample site generally scored lowest for habitat quality and habitat quantity. The habitat quality of OUA137E, OUA137A, and OUA137B were similar except for the low value for run habitat at OUA137A. However, the IHI for run habitat at this site was comparable to the OUA137E site due to the greater amount of run habitat at OUA137A. A similar condition existed with the riffle habitat at these same stations, although there was less difference than in run habitat quality, and the IHI for OUA137A was substantially greater for riffle habitat type.

Table F-1

Fish Habitat Evaluation

SITE	Riffle				Run				Pool			
	Number Sampled	Total Length	Average Habitat Score	IHI *	Number Sampled	Total Length	Average Habitat Score	IHI	Number Sampled	Total Length	Average Habitat Score	IHI
OUA137E	3	50	44.4	22.2	3	400	42.3	169.3	4	475	43.0	204.3
OUA137B	3	140	41.6	58.3	5	560	42.1	235.8	4	620	39.3	243.5
OUA137A	2	100	34.9	34.9	5	600	24.9	149.4	1	350	44.0	154.0
Flat Creek	3	215	34.2	73.5	4	550	33.7	185.4	4	430	31.0	133.3

*- Ichthyofauna Habitat Index - Total Length of habitat in hundredths multiplied by the Average Habitat Score.

Fish Community Evaluation

The fish communities were evaluated by comparing the community structures of the sites affected by the discharge to the fish community of Whitewater Creek, a least-disturbed, typical Gulf Coastal ecoregion reference stream of approximately the same size watershed and to a like-size reference stream with similar in-stream habitat located upstream from the discharge.

Results

Fish community samples were collected at all stations on June 2 and 3, 1997. Original plans were to use the samples collected at OUA137E and possibly from Flat Creek as reference sites for comparison to the sites located below the effluent discharge, OUA137A and OUA137B. In addition, the fish community from Whitewater Creek, a Gulf Coastal Plains Ecoregion reference stream, was to be used to determine the likeness of the fish community in the reference streams to a typical Gulf Coastal Plains Ecoregion stream.

Appendix F-2 is a list of species collected from each site, the number of specimens per species collected, and the percent community composition of each species. Table F-3 depicts the family comparisons between sampling stations, percent and total sensitive, key and primary trophic level species and the diversity index of each sample. Sixteen different parameters were compared between each of the communities (see Tables F-3 and F-4). A fish community index was calculated using eight of these parameters using ecoregion reference streams data to generate the scoring criteria. These criteria are listed below in Table F-2.

TABLE F-2

Fish Community Biocriteria
Typical Gulf Coastal Ecoregion Reference Streams

Metric (as % community)	SCORE		
	4	2	0
Cyprinidae	4 - 35	<4 or 35 - 45	>45
Ictaluridae	1 - 8	0.5 - 1 or 8 - 12, and < 7% bullheads	>12 or >7% bullheads
Centrarchidae	28 - 47	18 - 28 or 47 - 57	<18 or >47
Percidae	>10	6-10	<6
Sensitive Individuals	>1	0.5 - 1	<0.5
Primary TFL	<15	15 - 22	>22
Key Individuals	>19	13 - 19	<13
Diversity Index	>3.89	3.65 - 3.89	<3.65

In addition, comparisons were made among the samples using a similarity index to compare the percentage of common species. Also, the similarity index was modified to use the relative abundance of the species to compare similarity of the total communities. These results are in Table F-5. A comparison of the Ecoregion Community Structure Index (ECSI) of the fish community sample sites (Table F-4) indicate that the OUA137E sample site is not equivalent to an ecoregion fish community such as Whitewater Creek. The primary reason may be the very small watershed size of this site, which is less than 5 mi^2 compared to 23 mi^2 watershed of Whitewater Creek. The OUA137E site, however, does have numerous Gulf Coastal Ecoregion fish community

characteristics. For this reason, the site was used as a reference to compare with the OUA137A site which has a watershed size of 12 mi^2. The OUA137B site was compared to Whitewater Creek and the OUA137E site. It is apparent that the Flat Creek site is impaired and can not be used as a reference site. Only eleven species were collected from this stream and over 55% of the community was composed of pollution tolerant yellow bullheads and green sunfish.

TABLE F-3

COMMUNITY STRUCTURE (as percent total community)					
Family	OUA137E	OUA137A	OUA137B	Flat Creek	Whitewater
Cyprinidae	12.03	3.86	11.50	2.53	2.10
Catostomidae	0.00	0.00	0.00	0.00	4.80
Ictaluridae	0.00	0.00	0.00	26.58	0.20
Centrarchidae	56.82	21.24	37.17	56.96	53.20
Percidae	0.00	0.00	0.88	0.00	12.90
Total Species Collected	16	16	16	11	24
No. Sensitive Species	0	0	1	1	0
No. Sensitive Individuals	0	0	1	0	0
% Sensitive Individuals	0	0	0.88	0	0
No. Primary TFL	3	5	4	0	0
% Primary TFL	2.26	1.93	3.54	0	0
No. Key Individuals	14	12	32	24	112
% Key Individuals	10.52	4.63	28.32	30.38	26.70
Diversity Index	3.20	1.84	3.22	2.74	3.94

TABLE F-4

ECOREGION COMMUNITY STRUCTURE INDEX					
Family	OUA137E	OUA137A	OUA137B	Flat Creek	Whitewater
Cyprinidae	4	2	4	2	2
Ictaluridae	0	0	0	0	0
Centrarchidae	2	2	4	2	2
Percidae	0	0	0	0	4
Sensitive Individuals	0	0	2	0	0
Primary TFL	4	4	4	4	4
Key Individuals	0	0	4	4	4
Diversity Index	0	0	0	0	4
Total Score	10	8	18	12	20

Fish Community of ELCC Tributary Below the Plant Discharge

The fish community at OUA137A was comprised of 16 species. Nine centrarchid species comprised only 21% of the community; the green sunfish was the dominant Centrarchidae comprising 33% of the sunfish family. The mosquitofish was the dominant species comprising over 70% of the overall community. As a result, the diversity index at this site was only 1.8, compared to the reference site (OUA137E) of 3.20. The similarity index of this site compared to the reference was 69% for the species collected and 37% for the relative abundance of the species. This indicates some commonality among the species at both sites but very little similarity in the relative abundance of the species. This site also had the lowest ECSI of all communities.

The habitat quality of the OUA137A site was slightly lower for riffles, substantially lower for runs and essentially the same for the pool habitats compared to the reference site (Table F-1). This lower quality habitat may have influenced the fish community somewhat at this site; however, as shown above, the species comparisons among the sites is somewhat similar, but the relative abundance similarity is very low among the sites. The primary reason is that the extremely tolerant mosquitofish made up over 70% of the total community. This indicates other causes of impairments. It is also possible that this community is still recovering for the fish kill that occurred in May of 1997.

The fish community approximately 4.5 miles below the discharge (OUA137B) was comprised of 16 species. Seven species made up the sunfish family which comprised 37% of the community; the longear sunfish, bluegill sunfish and green sunfish were all co-dominant species each comprising 19% to 24% of the sunfish community. The mosquitofish was again the dominant species accounting for almost 31% of the overall community. By comparing the ECSI of this site with the other sample sites, it appears that the fish community is showing some recovery from the upstream station. This index is highest at OUA137B than any other station, except for Whitewater Creek. Also, the similarity index with the OUA137E site indicates a greater similarity among the species (75%) and an increase in similarity of species abundance (53%) over the same comparisons with OUA137A. The species diversity index had increased to 3.22, which is almost identical to that of the upstream reference community. The community, however, remains dominated by the mosquitofish. The measured habitat quality at this site was very similar to the reference site for all three primary habitat types. Therefore, the fish community difference among these sites is not habitat related.

Discussion

On May 5, 1997, one month prior to this investigation, a fish kill was reported in the ELCC tributary. Approximately 2000 gallons of sodium hydroxide leaked into the storm drain which emptied into the effluent ditch. The spill traveled downstream as a slug without much neutralization or mixing. It was reported that on the night of May 6, 1997, much of the spill was neutralized at the Highway 335 bridge, approximately seven miles downstream from the plant in Haynes Creek. An undetermined number of fish were reported killed, but it was estimated that on May 7, 1997, in a ½ mile stretch of the tributary at O'Rear Road, (OUA137B), approximately 100 fish were seen floating on the top of the water.

Although the fish kill likely had a significant impact on the fish community of the affected streams, it is believed that long-term, chronic impacts is the major cause of these impaired fish communities.

TABLE F-5

FISH COMMUNITY SIMILARITY INDICES									
Species					Relative Abundance				
	19th Street	OUA137 A	OUA137 B	Flat Creek		19th Street	OUA137 A	OUA137 B	Flat Creek
OUA137A	0.69				OUA137A	0.37			
OUA137B	0.75	0.81			OUA137B	0.53	0.68		
Flat Creek	0.44	0.67	0.59		Flat Creek	0.44	0.53	0.54	
Whitewater	0.40	0.40	0.25	0.29	Whitewater	0.37	0.31	0.28	0.29

SUMMARY AND CONCLUSIONS

1. Investigations of water quality impairments of the ELCC tributary to Flat Creek, Flat Creek and Salt Creek were conducted in three phases from January 1995 through December 1997. These investigations involved 1) monthly water quality sampling at four stations from January 1995 through July 1996; (2) quarterly sampling of water quality and in-stream toxicity testing at four stations from March 1997 through December 1997, and (3) an intensive water quality, physical habitat and biological investigation at nine stations on June 2-3, 1997.

2. Water quality data demonstrates problem areas of minerals, heavy metals, ammonia and nitrates.

3. The ELCC tributary exhibits substantially elevated sulfate and total dissolved solids; ammonia levels were as high as 360 mg/L immediately below the discharge to almost 50 mg/L about 4.25 miles downstream; toxic levels of copper and zinc were found as far as 4.25 miles below the discharge; consistent, in-stream toxic affects to test organisms existed; and impairment of the indigenous biota of the stream was identified.

4. Flat Creek receives elevated levels of sulfates and TDS from the ELCC tributary and very high levels of chlorides from its upstream watershed; Salt Creek has chloride values as high as 3000 mg/L contributed from its upstream watershed.

5. Storm water runoff from the north side of the ELCC plant results in toxic levels of copper, zinc and ammonia in the tributary stream approximately one mile below the facility.

6. The elevated hardness of the ELCC effluent resulted in the measured levels of copper and zinc in the effluent to be below the calculated acute toxicity level but considerably above the toxicity values using typical ecoregion hardness in the calculations. However, at stations 1.5 miles and 4.25 miles downstream, where hardness values have returned to near typical ecoregion levels, acute toxicity was indicated.

7. In-stream toxic effects existed for fathead minnows below the ELCC discharge on three of the four sample events; two of these events also produced significant lethality to Ceriodaphnia. At the next station downstream, minnow toxicity existed in one of the four tests. Toxicity was strongly correlated with in-stream pH and was much more severe on the minnow than the Ceriodaphnia, thus indicating ammonia as the primary toxic compound.

8. The RBA protocol for analyses of macroinvertebrate communities did not indicate significant impairments below the ELCC discharge when compared to the site above the discharge. The communities, however , were quite different.

9. The fish community below the ELCC discharge ranked very low in comparison to typical Gulf Coastal Ecoregion communities. While somewhat similar to the upstream (control) community in species composition, this site was very dissimilar to the control in the relative abundances of the fish species. The mosquitofish comprised over 70% of the community below the discharge.

10. Discharge of process water from ELCC outfall 001 (Lake Killdeer) and stormwater runoff from both the north and south drainage from the plant have severely impaired the designated uses of over five miles of the ELCC tributary.

RECOMMENDED REMEDIATION PROGRAM

The impairments to ELCC tributary, most likely, can be remediated through the NPDES permit process. This will require development of water-quality based discharge permit limits and treatment facilities to reduce discharges of minerals (sulfates and total dissolved solids) and to prevent the discharge of toxic levels of copper, zinc and ammonia. This will also require reduction of nitrate-nitrogen discharge levels to prevent elevation of in-stream values above the drinking water secondary maximum contaminant level of 10 mg/L. Additionally, since this area is generally located in a ground water aquifer recharge zone, facility plans must be developed to prevent ground water intrusion from the plant area as well as the plant's treatment facilities.

APPENDICES

El Dorado Chemical Water Chemistry																			
Water Quality					Water														
STATION	FLOW	DO	pH	pH	Temp	NH3-N	NH3-N	CL	NO3-N	O-PHOS	T-PHOS	SO4	TOC	BOD	Turbidity	TSS	TDS	TOXICITY	TOXICITY
DATE			(PC&E)	(EPA)		(PC&E)	(EPA)											*C. dubia*	*P. promelas*
	cfs	mg/L			C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	mg/L	% Mort.	% Affected *
OUA0137E																			
3\10\97		6.7	6.7	6.5	16.6	0.3	1.1	19.0	0.1	0.1	N/A	16.2	12.7	N/A	N/A	12.0	110.0	0	0
5\27\97		5.4	6.8	6.9	23.4	0.4	1.0	35.1	0.2	0.0	0.2	13.1	9.2	3.4	32.0	23.0	144.0	0	0
6\03\97	2.27	5.4	6.7		20.9	0.2		26.1	0.1	0.1	0.1	11.1	10.4	1.3	25.0	12.5	104.0		
9\22\97		2.2	6.8	7.2	23.1	0.3	9.6	46.7	0.2	0.0	0.3	4.0	6.4	2.6	45.0	16.5	174.0	10**	0
12\01\97		5.3	6.7	6.9	12.4	0.4	1.3	39.1	0.1	0.0	0.2	12.7	12.5	3.4	19.0	8.5	153.0	0	0
OUA0137H																			
3\10\97		9.0	8.4	8.0	15.2	39.8	57.6	<12.0	80.5	<0.20	N/A	223.0	7.2	N/A	N/A	8.5	734.0	90	100
5\27\97		7.4	7.0	7.5	23.8	25.1	52.8	41.8	65.0	<0.03	0.1	243.0	7.9	7.8	2.1	3.0	735.0	0	7**
9\22\97		7.5	7.9	8.0	27.8	12.7	40.8	77.9	157.0	0.0	0.2	553.0	7.6	6.2	4.2	9.0	1769.0	0	100
12\01\97		8.2	8.2	8.0	14.5	246.0	360.0	63.4	380.0	0.0	0.2	183.6	10.7	12.6	6.5	20.5	1741.0	100	100
OUA0137F																			
3\10\97		7.6	9.3	8.9	15.9	11.8	20.4	23.8	22.2	0.4	N/A	53.7	12.1	N/A	N/A	33.5	310.0	0	100
5\27\97		5.8	6.6	7.1	23.0	56.9	72.0	33.8	73.4	<0.03	0.1	49.8	11.2	5.8	33.0	33.5	307.0	0	7**
9\22\97		3.9	6.9	7.2	23.4	6.8	32.4	70.1	105.0	0.0	0.1	412.0	9.0	4.3	6.2	4.5	1373.0	0	3**
12\01\97		5.6	6.7	6.8	12.3	34.0	46.0	32.7	55.5	0.0	0.1	100.5	16.7	2.2	8.5	5.0	399.0	0	10**
OUA0137I																			
6\03\97	0.5	8.2	7.8		25.7	<0.05		16.5	0.6	0.1	0.1	12.0	9.5	1.6	17.0	12.0	131.0		
OUA0137A																			
6\03\97	5.22	6.3	7.0		21.0	11.0		25.5	20.9	0.1	0.1	73.6	11.1	6.7	26.0	23.0	303.0		
OUA0137G																			
3\10\97		8.8	6.3	6.4	15.6	4.6	10.8	31.4	7.9	0.4	N/A	40.5	13.7	N/A	N/A	20.5	163.0	0	10**
5\27\97		6.6	6.9	7.2	22.5	6.6	15.6	19.0	13.6	<0.03	0.3	38.6	11.4	4.9	70.0	86.0	216.0	0	10**
6\03\97	0.24	7.0	7.3		20.7	0.5		22.9	2.7	0.2	0.2	17.0	9.3	2.2	33.0	9.0	214.0		
9\22\97		6.6	7.8	8.1	21.8	0.0	0.4	28.1	4.3	0.1	0.2	12.5	4.5	1.4	28.0	8.0	284.0	0	0
12\01\97		6.2	5.6	5.8	12.3	114.0	34.0	18.3	40.8	0.0	0.1	74.2	8.4	1.1	12.0	3.5	275.0	0	3**
OUA0137B																			
6\03\97	6.43	5.7	6.3		20.9	5.6		27.9	16.5	0.1	0.1	50.8	12.7	5.0	29.0	23.0	229.0		
OUA0137C																			
6\03\97	8.95	6.1	6.9		22.1	0.2		254.4	2.141	<0.03	0.1	70.9	7.3	0.8	20.0	13.0	675.0		
OUA0137D																			
6\03\97	5.95	4.9	5.2		21.7	0.2		771.0	<0.02	<0.03	<0.03	1.7	6.0	0.3	7.5	5.0	1562.0		

* Toxicity- % affected includes the combined number of dead embryos (unhatched) and larvae, also, organisms exhibiting terata and abnormal swimming behavior.

** denotes those percentages that are not statistically significant

Water Quality Data Collected 1995 &1996															
Station ID	Date	DO	pH	Water Temp	NH3-N	CL	NO3-N	O-PHOS	T-PHOS	SO4	TOC	BOD	Turbidity	TSS	TDS
		mg/L		C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	mg/L
OUA0137A	950124		6.6	6.1	20.0	21.0	24.6	<0.02	0.1	68.8	8.3	1.1	14.0	5.5	276
	950321	7.5	6.8	17.7	7.0	31.6	16.2	0.3	1	92.4	9.5	5.2	15.0	22.5	303
	950404	7.5	6.8	16.6	20.4	30.4	37.8	0.1	1	59.1	11.2	7.7	18.0	44.5	288
	950905	5.7	6.6	25.6	20.4	71.9	80.2	0.1	<0.03	700.0	7.3	2.3	4.5	4.0	1589
	960108	12.1	6.2	1.3	51.4	59.1	78.7	0.1	0.2	351.0	9.7	5.4	11.0	8.0	873
	960206	11.3	6.7	3.3	30.8	43.7	40.8	0.1	0.1	155.0	8.8	2.9	12.0	7.5	440
	960326	12.4	5.9	11.0	5.6	20.1	13.7	0.1		47.6	15.4	2.4	37.0	27.5	206
	960430	7.2	5.9	18.0	9.8	22.0	16.9	0.1		69.1	18.4	3.5	24.0	22.0	258
	960528	5.6	6.4	29.0	54.1	55.7	117.0	<0.02	0.2	>400	8.1	7.5	6.5	9.0	1335
	960618		6.8	27.0	45.8	46.6	99.2	1.2	0.0	396.0	10.1		13.0	12.0	1186
	960716	5.2	6.1	30.0	18.3	34.1	52.7	0.1	0.1	283.0	13.9	1.2	12.0	9.5	681
OUA0137B	950124		6.5	6.4	11.3	15.8	13.4	<0.02	0.1	50.0	8.7	1.3	16.0	4.5	202
	950321	7.0	7.0	18.4	4.8	24.6	13.9	<0.03	0.1	76.4	10.4	5.2	17.0	6.5	253
	950404	7.0	6.6	16.8	2.3	25.5	11.3	0.1	0.1	70.4	11.0	8.0	20.0	23.5	264
	950905	5.5	6.1	24.8	12.7	63.6	71.8	0.1	<0.03	652.0	7.2	1.6	3.4	3.0	1447
	960108	12.2	6.7	1.5	48.3	49.9	69.3	<0.02	0.1	305.0	8.7	1.8	19.0	6.0	732
	960206	11.1	6.8	2.8	29.5	43.4	44.2	<0.02	0.1	182.0	10.0	3.2	17.0	8.0	521
	960326	10.1	5.6	12.0	2.7	15.3	7.3	0.1		34.4	15.2	2.9	45.0	52.5	159
	960430	7.6	5.8	17.0	3.6	15.0	8.3	0.1		33.4	17.9	4.8	33.0	32.5	165
	960528	3.2	5.7	27.0	31.3	52.7	96.0	<0.03	0.1	>400	9.6	4.2	11.0	9.0	1191
	960618		6.1	28.0	34.0	40.4	80.9	0.5	0.0	361.0	11.6	5.1	11.0	8.5	947
	960716	5.4	5.7	29.0	8.2	21.8	26.1	0.0	0.1	117.0	14.6	1.0	18.0	10.0	366
OUA0137C	950124		6.6	6.3	0.2	261.3	2.2	<0.02	0.1	43.6	6.3	0.7	12.0	5.0	610
	950321	7.6	7.0	18.8	<0.05	287.0	1.9	<0.03	0.1	48.3	6.1	1.1	8.9	6.5	628
	950404	8.3	7.0	17.2	0.1	247.0	1.2	<0.03	0.1	39.7	9.5	4.1	18.0	23.5	592
	960108	12.2	6.6	1.9	1.5	850.0	2.0	<0.3	0.0	30.5	5.4	0.6	8.2	7.0	1485
	960206	12.2	6.9	2.2	4.7	347.0	1.8	<0.03	0.0	51.6	5.9	1.6	11.0	9.0	710
	960326	10.2	6.6	12.0	0.7	227.0	1.6	0.1		30.1	10.6	2.4	25.0	18.0	496
	960430	7.3	5.6	17.0	0.2	758.0	0.3	<0.03		9.3	11.7	1.2	17.0	12.0	1448
	960528	2.5	6.7	27.0	0.1	298.0	0.4	<0.03	0.1	73.5	11.0	1.8	8.4	5.0	690
	960618		6.3	27.0	0.3	16.6	2.1	<0.03	<0.03	125.0	7.1	2.0	7.5	6.0	518
	960716	6.2	5.2	29.0	0.2	1160.0	1.1	<0.03	0.0	27.4	7.2	0.3	11.0	9.5	2000
OUA0137D	950124		6.2	6.1	<0.05	170.1	0.1	<0.02	<0.03	10.6	6.9	0.4	5.0	<1	780
	950321	6.7	6.7	16.3	<0.05	594.0	<0.02	<0.03	<0.03	7.4	7.4	0.6	2.6	2.0	1136
	950404	5.3	5.7	16.2	<0.05	876.0	<0.02	<0.03	<0.03	<1.0	6.2	0.7	1.9	<1	1724
	950905	5.1	4.1	24.2	0.7	2970.0	<0.02	<0.03	<0.03	2.3	6.9	0.5	13.0	5.5	5231
	960108	12.2	6.7	2.1	0.4	1020.0	0.4	<0.03	<0.03	11.6	5.4	0.4	2.4	2.0	1704
	960206	11.6	5.5	3.7	0.1	1040.0	<0.02	<0.03	<0.03	7.6	4.1	0.5	16.0	2.0	1681
	960326	10.4	5.3	13.0	0.1	650.0	0.1	<0.03		5.4	9.6	1.0	3.1	2.0	1114
	960430	5.1	5.5	19.0	0.1	642.0	0.1	<0.03		8.0	17.1	1.4	11.0	3.0	871
	960528	0.9	3.8	27.0	0.3	1160.0	0.2	<0.03	0.1	3.4	8.1	1.1	13.0	3.0	2242
	960618		3.7	28.0	<0.05	1340.0	0.2	<0.03	<0.03	7.5	6.4	2.8	8.6	3.0	2714
	960716	4.2	5.1	30.0	<0.05	1130.0	0.2	<0.03	<0.03	5.9	8.8	0.4	7.0	3.5	1961

APPENDIX W-3 DISSOLVED METALS

El Dorado Chemical Water Chemistry																								
Dissolved Metals				Water																				
STATION	DO	pH	pH	Temp	Hardness	Hardness	Cd	Cr	Pb	Al	Cu	Ca	Fe	K	Mg	Mn	Na	Zn	Ni	B	Be	Ba	Co	V
DATE		(PC&E)	(EPA)		(PC&E)	(EPA)																		
	mg/L			C	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	ug/L	mg/L	mg/L	ug/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
OUA0137E																								
3\10\97	6.7	6.7	6.5	16.6	21.0	35.0	0.2	1.2	3.0	115.0	2.8	5.6	1070.0	1.6	1.7	391.0	9.9	13.7	<5	21.1	<2	90.2	5.6	<5
5\27\97	5.4	6.8	6.9	23.4	39.0	48.0	<0.04	0.5	<0.4	51.4	<2.0	10.4	808.0	4.5	3.1	390.0	17.0	19.4	<5	27.7	<2	142.2	<3	<5
6\03\97	5.4	6.7		20.9	22.0					41.2	<2.0	5.7	872	2	1.8	232	10.7	7.6	<5	12.1	<2	101.6	<3	<5
9\22\97	2.2	6.8	7.2	23.1	27.0	44.0	<0.04	0.5	<0.4	<16	<2.0	6.6	356.0	3.4	2.6	554.0	27.9	3.8	<5	40.9	<2	106.1	6.3	<5
12\1\97	5.3	6.7	6.9	12.4	33.0	40.0	0.1	<.4	0.5	68.4	<2.0	8.3	730.0	7.0	2.9	338.0	23.2	19.4	<5	40.1	<2	117.9	3.3	<5
OUA0137H																								
3\10\97	9.0	8.4	8.0	15.2	100.0	113.0	<.04	2.7	<0.4	209.8	8.6	21.8	91.0	2.1	11.0	3.8	175.2	33.7	14.9	88.0	<2	46.3	<3	6.7
5\27\97	7.4	7.0	7.5	23.8	115.0	130.0	<.04	2.4	<0.4	85.8	8.0	16.4	65.0	5.1	17.9	59.0	170.9	85.1	18.2	114.1	<2	54.1	<3	6.5
9\22\97	7.5	7.9	8.0	27.8	158.0	172.0	<.04	6.1	<0.4	273.2	13.6	31.0	172.0	5.5	19.5	74.1	496.1	60.1	23.3	232.5	<2	33.2	8.7	21.6
12\1\97	8.2	8.2	8.0	14.5	169.0	172.0	<.04	2.1	<0.4	127.5	14.7	27.7	79.1	7.5	24.2	90.2	475.5	50.3	21.3	237.2	<2	42.4	<3	6.6
OUA0137F																								
3\10\97	7.6	9.3	8.9	15.9	28.0	43.0	0.0	1.2	<0.4	273.9	7.8	7.2	723.0	1.8	2.4	275.0	68.8	8.1	<5	43.4	<2	52.4	3.4	<5
5\27\97	5.8	6.6	7.1	23.0	77.0	95.0	0.1	0.9	<0.4	60.7	2.7	16.4	628.0	4.3	8.7	1270.0	38.2	41.2	12.3	39.4	<2	154.8	9.6	<5
9\22\97	3.9	6.9	7.2	23.4	124.0	132.0	0.1	2.0	<0.4	<16.0	10.5	25.9	151.0	5.3	14.3	839.0	370.5	37.6	15.7	184.4	<2	88.8	9.0	6.1
12\1\97	5.6	6.7	6.8	12.3	56.0	,60.0	0.1	0.5	<.4	132.8	10.2	11.7	478.0	7.2	6.6	539.0	77.3	37.8	7.5	54.6	<2	91.8	5.5	<5
OUA0137I																								
6\03\97	8.2	7.8		25.7	26.0					42.7	2.5	7.9	889.0	2.4	1.6	248.0	25.8	9.8	<5	30.4	<2	70.1	<3	<5
OUA0137A																								
4\04\95	7.5	6.8		16.6	54.0		<0.5	<1	<2	290.6	5.1	12.9	1200.0	2.2	5.5	1050.0	50.2	25.3	8.4	235.4	<2	114.7	7.8	<5
6\03\97	6.3	7.0		21.0	52.0					57.3	4.4	9.7	772.0	1.9	6.7	775.0	56.3	21.9	7.5	42.6	<2	92.8	<3	<5
OUA0137G																								
3\10\97	8.8	6.3	6.4	15.6	36.0	43.0	0.2	2.5	0.7	324.3	9.7	10.0	660.0	2.0	2.7	302.0	13.3	44.1	8.6	15.7	<2	66.7	9.0	<5
5\27\97	6.6	6.9	7.2	22.5	30.0	39.0	0.1	2.4	0.5	166.8	7.8	8.0	399.0	6.3	2.3	120.0	37.6	8.9	<5	44.1	<2	63.7	<3	<5
6\03\97	7.0	7.3		20.7	8.0					109.2	4.7	2.3	474.0	1.6	0.5	53.1	57.2	6.9	<5	67.2	<2	21.8	<3	<5
9\22\97	6.6	7.8	8.1	21.8	5.0	12.0	<0.04	1.4	<0.4	67.7	3.6	1.7	185.0	1.9	0.3	2.3	86.3	<2.0	<5	103.5	<2	11.4	3.2	<5
12\1\97	6.2	5.6	5.8	12.3	67.0	80.0	0.4	1.7	0.4	365.2	7.2	18.8	193.0	7.4	4.9	297.0	40.0	108.0	18.9	40.8	<2	90.9	11.6	<5
OUA0137B																								
4\04\95	7.0	6.6		16.8	39.0		1.3	1.8	5.2	385.7	10.0	9.8	1170.0	2.0	3.7	730.0	55.6	25.8	8.1	353.8	<2	81.7	5.2	<5
6\03\97	5.7	6.3		20.9	38.0					92.2	11.1	7.9	690.0	1.9	4.5	737.0	38.3	21.7	5.5	32.8	<2	99.9	3.5	<5
OUA0137C																								
4\04\95	8.3	7.0		17.2	121.0		<0.5	<1	<2	198.5	<2	33.2	408.0	5.0	9.8	444.0	173.3	9.3	6.0	507.5	<2	353.1	11.9	<5
6\03\97	6.1	6.9		22.1	120.0					<16	<2	32.7	117.0	6.6	9.4	289.0	202.2	5.8	6.3	249.8	<2	336.9	5.2	<5
OUA0137D																								
4\04\95	5.3	5.7		18.2	312.0		<0.5	<1	<2	140.6	<2	91.4	292.0	5.0	21.8	403.0	566.2	19.5	6.6	774.5	<2	851.4	9.2	<5
6\03\97	4.9	5.2		21.7	262.0					28.1	<2	74.4	390.0	2.6	18.4	1600.0	407.0	15.8	9.7	376.7	<2	759.9	50.5	<5

APPENDIX W-4 TOTAL METALS

El Dorado Chemical Water Chemistry																							
Total Metals																							
STATION	DO	pH	pH	Temp	Hardness	Hardness	Cd	Cr	Pb	Al	Cu	Ca	Fe	K	Mg	Mn	Na	Zn	Ni	B	Be	Ba	Co	V
DATE		(PC&E)	(EPA)		(PC&E)	(EPA)																		
	mg/L			C	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	ug/L	mg/L	mg/L	ug/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
OUA0137E																								
3\10\97	6.7	6.7	6.5	16.6	18.0	35.0	<.5	1.3	3.5	301.2	11.3	6.0	2520.0	1.8	0.7	406.0	10.3	80.7	<6.0	18.6	<3.0	102.4	7.0	<5.3
5\27\97	5.4	6.8	6.9	23.4	34.0	48.0	<.5	1.1	2.8	285.0	3.6	10.6	2870.0	4.6	1.9	416.0	17.0	17.0	<6.0	29.7	<3.0	158.6	4.5	<5.3
6\03\97	5.4	6.7		20.9	18.0		<.5	1.4	<2	207.4	<2.0	5.9	2780.0	2.1	0.7	260.0	12.1	9.1	<6.0	10.9	<3.0	119.1	<3.0	<5.3
9\22\97	2.2	6.8	7.2	23.1	22.0	44.0	<.5	<1	<2	206.7	<2.0	7.4	2960.0	1.8	0.8	638.0	29.6	6.4	<6.0	32.0	<3.0	130.7	5.0	<5.3
12\1\97	5.3	6.7	6.9	12.4	31.0	40.0				339.5	2.4	8.7	1800.0	6.6	2.3	369.0	23.8	26.7	<6.0	39.8	<3.0	130.7	4.4	<5.3
OUA0137H																								
3\10\97	9.0	8.4	8.0	15.2	102.0	113.0	<.5	4.5	2.9	317.1	9.9	22.2	204.0	2.3	11.2	25.9	181.5	44.9	15.1	88.2	<3.0	50.0	<3.0	7.6
5\27\97	7.4	7.0	7.5	23.8	117.0	130.0	<.5	3.4	<2	174.0	11.1	16.5	163.0	4.9	18.3	106.0	173.9	106.0	18.7	115.6	<3.0	56.8	<3.0	7.2
9\22\97	7.5	7.9	8.0	27.8	158.0	172.0	<.5	5.4	<2	392.9	16.4	32.1	293.0	2.9	18.9	96.4	512.9	111.0	25.2	229.2	<3.0	35.8	5.7	23.2
12\1\97	8.2	8.2	8.0	14.5	169.0	172.0				489.7	20.2	27.9	603.0	6.6	24.2	110.0	483.3	101.0	24.2	238.9	<3.0	45.2	<3.0	10.0
OUA0137F																								
3\10\97	7.6	9.3	8.9	15.9	28.0	43.0	<.5	1.9	2.4	535.0	8.3	7.8	1760.0	1.9	2.0	424.0	69.9	24.4	<6.0	43.2	<3.0	71.1	5.6	<5.3
5\27\97	5.8	6.6	7.1	23.0	69.0	95.0	<.5	1.5	3.2	462.0	6.6	15.4	2200.0	4.2	7.5	1290.0	39.4	50.1	10.1	41.9	<3.0	160.8	11.0	<5.3
9\22\97	3.9	6.9	7.2	23.4	122.0	132.0	<.5	<1	<2	162.5	12.6	26.3	538.0	3.0	13.8	880.0	386.6	42.2	13.7	180.9	<3.0	92.4	6.4	6.3
12\1\97	5.6	6.7	6.8	12.3	56.0	60.0				464.5	11.8	12.2	1180.0	8.3	6.3	558.0	78.9	43.5	9.5	55.8	<3.0	96.7	5.5	<5.3
OUA0137I																								
6\03\97	8.2	7.8		25.7	23.0		<.5	<1	2.6	167.7	2.7	8.2	2500.0	2.4	0.6	287.0	26.8	12.3	<6.0	28.2	<3.0	84.2	<3.0	<5.3
OUA0137A																								
6\03\97	6.3	7.0		21.0	50.0		<.5	1.9	<2	299.9	7.3	9.8	2200.0	2.1	6.3	820.0	61.9	29.1	11.5	42.3	<3.0	109.2	3.1	<5.3
OUA0137G																								
3\10\97	8.8	6.3	6.4	15.6	36.0	43.0	<.5	3.3	2.9	818.3	12.8	10.5	1330.0	2.3	2.4	309.0	13.1	53.6	9.7	15.4	<3.0	78.6	10.4	<5.3
5\27\97	6.6	6.9	7.2	22.5	21.0	39.0	<.5	5.3	6.9	1568.0	15.9	7.2	2290.0	6.1	0.8	114.0	38.1	25.1	<6.0	46.3	<3.0	75.5	3.3	<5.3
6\03\97	7.0	7.3		20.7	5.0		<.5	4.2	3.2	603.1	10.7	2.5	1630.0	1.7	<0.006	63.2	65.1	11.1	7.4	72.3	<3.0	34.6	<3.0	<5.3
9\22\97	6.6	7.8	8.1	21.8	5.0	12.0	<.5	<1	<2	380.1	3.7	1.9	668.0	0.6	<0.006	6.3	90.4	8.1	<6.0	98.2	<3.0	18.9	<3.0	<5.3
12\1\97	6.2	5.6	5.8	12.3	67.0	80.0				845.0	8.9	18.9	477.0	6.7	4.7	300.0	39.8	110.0	19.8	40.5	<3.0	92.1	11.3	<5.3
OUA0137B																								
6\03\97	5.7	6.3		20.9	36.0		<.5	2.5	2.3	357.9	15.4	8.1	1980.0	1.9	3.9	785.0	40.8	25.8	11.4	32.4	<3.0	115.1	3.2	<5.3
OUA0137C																								
6\03\97	6.1	6.9		22.1	119.0		<.5	<1	<2	211.6	2.5	32.9	958.0	6.8	9.0	298.0	208.6	14.0	6.6	250.7	<3.0	348.4	5.9	<5.3
OUA0137D																								
6\03\97	4.9	5.2		21.7	265.0		<.5	2.4	<2	82.5	<2.0	75.2	1440.0	2.7	18.8	1640.0	436.9	17.2	14.3	387.7	<3.0	600.4	51.6	<5.3

APPENDIX M-1

HBI	FEEDING GROUP	EPT TAXA	TAXA	OUA137E	OUA137A	OUA137B	OUA137C
4	COL	N	*Lirceus*		1	1	5
4	COL	N	*Hyalella*	3	6		
4	COL	N	*Crangonyx*				3
2	COL	N	*Gammarus*			1	
3	COL	N	Cambaridae (F)				1
3.5	COL	Y	*Caenis*	1			
3.5	COL	Y	Siphlonuriidae		1		
3	PRE	N	*Argia*	1		1	
4	PRE	N	*Enallagma*		13	10	4
4.5	PRE	N	*Ischnura*	6	3	2	1
3.2	PRE	N	*Aeschna*			1	
2	PRE	N	*Boyeria*		2	2	3
4.5	PRE	N	*Somatochlora*		1		
4.7	PRE	N	*Erythemis*	1			
5	PRE	N	*Ranatra*	1		1	
5	PRE	N	*Belastoma*	1			
2.5	PRE	N	*Trichocorixa*		8	1	
4	PRE	N	*Sialis*	1	1		2
4.55	PRE	N	Glossiphonidae				
3	PRE	N	*Dineutus (A)*		1		
2	PRE	N	*Gyrinus (A)*		1	3	7
2	PRE	N	*Gyrinus (L)*		5	1	
2.5	SHR	N	*Peltodytes (A)*			1	
3.3	SHR	N	*Hydrochus (A)*		1	1	
4.45	PRE	N	*Agabus*	2			
3	PRE	N	*Hoperius*			1	
3	PRE	N	*Thermonectus (A)*			1	
3.6	PIE	N	*Laccobius (A)*		1		
4.8	COL	N	*Tropisternus*		1		
2.5	COL	N	*Ancyronyx (A)*			5	
2.5	SCR	N	*Ordobrevia (L)*		11		
3	SCR	N	*Stenelmis (A)*	3		1	
3	SCR	N	*Stenelmis (L)*			1	
3.8	PRE	N	*Chelifera*		1	1	
2.7	SHR	N	*Leptotarsus*				1
4.7	PRE	N	Chaoboridae (P)	1			
4.7	PRE	N	*Chaoborus*				
3	COL	N	*Simulium*		1	3	
3	PRE	N	*Tabanus*		2		
3	PRE	N	Tanypodinae	4			3
4.5	PRE	N	*Procladius*	4	15		3
3	PRE	N	Chironomidae	54			2
3	PRE	N	Chironomidae (P)	6	2		
3	PRE	N	Chironomini		1		
4.8	COL	N	*Chironomus*	3	18	12	
3.8	FIL	N	*Sphaerium*	8			
			TOTAL	100	97	51	35

APPENDIX F-1 - Habitat Data Summarization

Habitat Type - Unnamed Trib at 19th street (OUA137E)						
No.	Riffle		Run		Pool	
	Score	Length	Score	Length	Score	Length
1	48	10	47.1	100	49.8	100
2	48	20	32.9	150	38.8	200
3	37.1	20	47	150	52.2	100
4					31.2	75
Avg/Tot	44.37	50	42.33	400	43.00	475

Habitat Type - OUA137A						
No.	Riffle		Run		Pool	
	Score	Length	Score	Length	Score	Length
1	34	30	42.8	100	44	350
2	35.8	70	13.5	50		
3			16.7	70		
4			20.8	250		
5			30.7	130		
Avg/Tot	34.90	100	24.90	600	44.00	350

APPENDIX F-1 (cont.)

Habitat Type - OUA137B						
No.	Riffle		Run		Pool	
	Score	Length	Score	Length	Score	Length
1	44.7	30	51.8	60	36.7	100
2	38.5	30	29.8	200	42.8	250
3	41.7	80	47.6	100	39.8	70
4			43.7	100	37.8	200
5			37.6	100		
Avg/Tot	41.63	140	42.10	560	39.28	620

Habitat Type - Flat Creek at Hwy 67						
No.	Riffle		Run		Pool	
	Score	Length	Score	Length	Score	Length
1	18.5	60	41.5	100	32.6	125
2	42.6	125	24.7	150	25	125
3	41.5	30	39.6	100	28.8	100
4			29	200	37.6	80
Avg/Tot	34.20	215	33.70	550	31.00	430

APPENDIX F-2 - FISH COMMUNITY

FAMILY & SPECIES	COMMON NAME	SEN	TFL	KEY	19th Street		OUA137A		OUA137B		Flat Creek	
					Num	% Com	Num	% Com	Num	% Com	Num	% Com
Amiidae	Bowfins											
Amia calva	Bowfin				1	0.76			1	0.88		
Esoxidae	Pickerels											
Esox americanus	Grass pickerel			K	1	0.76	10	3.86	19	16.81	4	5.06
Cyprinidae	Minnows											
Notemigonus crysoleacus	Golden shiner		P		3	2.27	5	1.93	4	3.54		
Cyprinella venustus	Blackspot shiner						3	1.16	3	2.65	1	1.27
Lythrurus umbratilis	Redfin shiner			K	13	9.85	1	0.34	6	5.31		
Semotilus atromaculatus	Creek chub						1	0.34			1	1.27
Ictaluridae	Freshwater catfishes											
Ameiurus melas	Black bullhead										1	1.27
Ameiurus natalis	Yellow bullhead			K							20	25.32
Aphredoderidae	Pirate perches											
Aphredoderus sayanus	Pirate perch				3	2.27	1	0.39	1	0.88	1	1.27
Cprinodontidae	Killifishes											
Fundulus chrysotus	Golden topminnow				2	1.51			1	0.88		
Fundulus olivaceus	Blackspotted Topminnow				34	25.76						
Poeciliidae	Livebearers											
Gambusia affinis	Mosquitofish						183	70.66	35	30.97	6	7.59
Centrarchidae	Sunfishes											
Centrarchus macropterus	Flier			K			1	0.39	7	6.19		
Elassoma zonatum	Banded pigmy sunfish						9	3.47				
Lepomis cyanellus	Green sunfish				9	6.82	18	6.95	8	7.08	24	30.38
Lepomis gulosus	Warmouth sunfish				8	6.06	2	0.77	3	2.65	8	10.17
Lepomis macrochirus	Bluegill sunfish				13	9.85	12	0.39	9	7.96	3	3.80
Lepomis marginatus	Dollar sunfish				2	1.51						
Lepomis megalotis	Longear sunfish				26	19.70	7	2.70	10	8.85	10	12.66
Lepomis punctatus	Spotted sunfish				13	9.85	1	0.39	4	3.54		
Lepomis symmetricus	Bantam sunfish				1	0.76	3	1.16				
Micropterus salmoides	Largemouth bass				2	1.51	2	0.77	1	0.88		
Pomoxis nigromaculatus	Black crappie				1	0.76						
Percidae	Perches											
Etheostoma parvipinne	Goldstripe darter	S							1	0.88		
	TOTAL SPECIES				16		16		16		11	
	TOTAL NUMBERS				132		259		113		79	
	Effort (sec)				2061		2447		3071		3374	
	Catch/Minute				4.05		6.35		2.21		1.40	