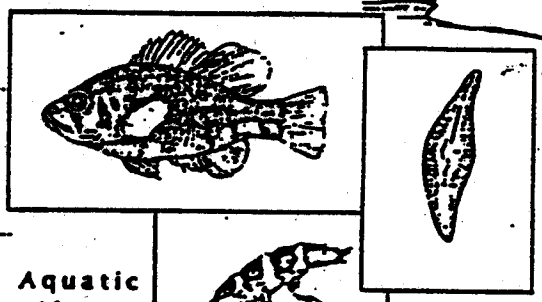
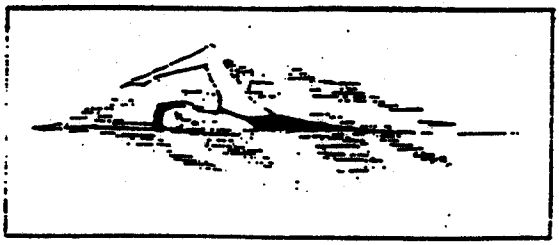
A Biological and Water Quality Investigation of the North Elkhorn Creek Drainage (Kentucky River System)

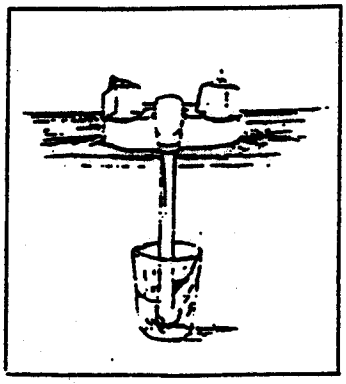
Outstanding Resource Waters



Aquatic Life

Recreation





Domestic Use

Natural Resources and Environmental Protection Cabinet

Ecological Support Section
Division of Water
Technical Report No. 42

A BIOLOGICAL AND WATER QUALITY INVESTIGATION OF THE NORTH ELKHORN CREEK DRAINAGE (KENTUCKY RIVER SYSTEM)

Kentucky Department for Environmental Protection

Division of Water

Water Quality Branch

Ecological Support Section

Frankfort, Kentucky

Technical Report, No. 42

November, 1992

This report has been approved for release:

Jack A. Wilson, Director

Division of Water

Nov. 27, 1992

Date

List of Contributors

Michael R. Mills
Project Leader

Gary Beck
Bacteriologist

John Brumley
Phycologist

Samuel M. Call
Aquatic Invertebrate Zoologist

Ron Houp
Aquatic Invertebrate Zoologist

Lythia Metzmeier
Phycologist

Allen Robison
Ichthyologist

Charles Roth
Toxicologist

Clifford C. Schneider
Aquatic Invertebrate Zoologist

Karen Smathers
Aquatic Invertebrate Zoologist

Don Walker
Botanist

Summary

1) North Elkhorn Creek comprises two Kentucky River 303e segments designated as 04016 and 04018. It also embodies Kentucky River waterbodies signified as KY5100205-019, 020, 021, 022, 023, 024, and 025.

2) North Elkhorn has 15 permitted dischargers which discharge treated waste to the drainage.

3) The North Elkhorn basin is underlain by Ordovician aged, soft, phosphoric limestones which have been highly eroded both above and below the surface resulting in a karst topography.

4) The seven-day, ten-year low flow (7Q10) for North Elkhorn Creek is 0.0 cubic feet per second (ft^3/sec) near Georgetown and 0.6 ft^3/sec at Switzer.

5) Physicochemical samples were taken on four occasions: the summer (20 stations) of 1986, the winter (20 stations) and fall (9 stations) of 1987, and the summer (5 stations) of 1988. (A) During the summer of 1986, 24 parameters exceeded respective STORET 75th percentiles at one or more stations and nutrients were elevated throughout the drainage. Mercury (Hg) exceeded Kentucky Surface Water Standards (KSWS) at 13 stations (65%) while (Cd) and copper (Cu) were above KSWS at station 16-28. (B) In the winter of 1987, 18 parameters exceeded the STORET 75th percentiles, and nutrients were again elevated throughout the sampling area.

Only lead (Pb) exceeded KSWS at stations 16-9, 16-14, and 16-26. (C) Samples from the fall of 1987 revealed that 20 parameters exceeded respective STORET 75th percentiles at one or more stations, with the nutrients continuing to be elevated throughout the sampling area. Ammonia exceeded the STORET 75th percentile at 8 stations and unionized ammonia also violated the KSWS at station 16-7. Mercury violated the KSWS at all sampling locations and Pb exceeded standards at stations 16-5 and 16-14. (D) During the last sampling period, summer of 1988, 18 parameters were elevated above respective STORET 75th percentiles at one or more stations. Two nutrients, total phosphorus (P) and ammonia (NH_3-N), were elevated at each sampling site. Mercury exceeded KSWS at all sites.

6) Nutrient enrichment is the most serious water quality problem facing the North Elkhorn Creek drainage. The presence of Hg and Pb are also of concern.

7) Sediment samples were collected in the spring (2 stations) and summer (16 stations) of 1986, and the fall (8 stations) of 1987. A) The spring and summer 1986 samples show that the sediments were contaminated to some degree throughout the drainage, when comparing the data to U.S.

Environmental Protection Agency harbor sediment guidelines. The areas with the worst contamination were on Cane Run below Lexington, North Elkhorn below Georgetown and an unnamed tributary (UT) to North Elkhorn that flows from the Bluegrass Army Depot. B) Sediment data from 1987 showed that the area below Georgetown continued to have the worst sediment quality of the stations sampled. The sediment quality at the lower end of Lanes Run had also deteriorated from the 1986 data.

8) Bacteriological data show that the mainstem of North Elkhorn Creek meets the criteria for Primary Contact Recreation (KSWS) whereas the tributary streams experience bacteriological problems.

9) Biological samples, consisting of algae, macroinvertebrate and fish, were collected at six stations on the mainstem, two stations on Lanes Run and one station on Dry Run. The biological data were utilized to produce a Biotic Assessment Index (BAI). The BAI showed that North Elkhorn Creek was partially supporting the warmwater aquatic habitat use classification.

10) The algal community found throughout most of North Elkhorn Creek was characteristic of the nutrient-enriched Bluegrass Region streams (i.e., slightly to moderately impaired). The algal data indicated that the area below Georgetown has been severely degraded by wastewater treatment plant (WWTP)

effluent. A total of 174 algal taxa, representing five divisions, were observed in the North Elkhorn Creek System. This included 35 taxa of Chlorophyta (green algae); 14 taxa of Cyanophyta (blue-green algae); five taxa of Euglenophyta; two taxa of Rhodophyta (red algae); and 118 taxa of Chrysophyta (Vaucheria sp. and 117 Bacillariaceae or diatoms).

11) A total of 129 taxa of macroinvertebrates were collected from the North Elkhorn Creek system. This included one Turbellaria (flat worm), four Annellida (leeches and segmented worms), five Crustacea (sow bugs, sideswimmers, and crayfish), nine Mollusca (clams, mussels, and snails), and 110 Insecta (aquatic insects). The macroinvertebrate bioassessment data indicate that the sampled streams in the basin are either slightly or moderately impaired.

12) During this study, 34 species of fish were observed from the drainage. This included three Catostomatidae (suckers), 10 Cyprinidae (minnows), one Atherinidae (silverside), two Ictaluridae (catfishes), one Poeciliidae (livebearers), one Cyprinodontidae (killifishes), one Cottidae (sculpins), 10 Centrarchidae (basses and sunfishes), and five Percidae (perches and darters). The Index of Biotic Integrity showed that the fish communities at the mainstem North Elkhorn stations ranged from unimpaired to slightly

impaired, while the tributary streams were ranked as severely impaired.

13) Fish tissue analysis results for fillets and whole-body samples indicated that chlordane, though only exceeding United States Food and Drug Administration (FDA) action levels in fillets once, is a primary contaminant of concern throughout the drainage. Lead and Hg are also contaminants of concern.

14) Toxicity tests conducted in April, 1986, showed that the final chlorinated effluent of the Georgetown #1 Wastewater Treatment Plant (WWTP) had an estimated acute LC_{50} value of 21% effluent (4.76 TU_a) for fathead minnows and 6% (16.67 TU_a) for Ceriodaphnia dubia. Chronic toxicity testing with fathead minnows indicated an LC_{50} value of 7% effluent.

15) Instream toxicity tests were conducted in April of 1986 at 13 locations using both fathead minnows and Ceriodaphnia dubia. Fathead minnow tests on the two Royal Springs stations, 16-22 and 16-23, indicated acute toxicity with 0% and 75% survival, respectively. Ceriodaphnia tests also indicated acute toxicity at station 16-22 (0% survival) and at station 16-7 on North Elkhorn Creek (50% survival).

Table of Contents

List of Figures and Tables

Page

Page

Recommendations

1) Based on the diversity of the aquatic biota and aquatic habitat, it is recommended that North Elkhorn Creek and its tributaries be designated for Aquatic Life/Warmwater Aquatic Habitat, per 401 KAR 5:031 Section 4(1) and the criteria of that section be applied throughout the North Elkhorn Creek drainage system without modification.

2) Based on fecal coliform bacterial and pH data, it is recommended that North Elkhorn Creek and its tributaries be designated for Primary and Secondary Contact Recreation, per 401 KAR 5:031 Section 6, and the criteria of that section be applied throughout the North Elkhorn Creek drainage system without modification.

3) It is recommended that Royal Springs and North Elkhorn Creek be designated for Domestic Water Supply at the points of withdrawal per 401 KAR 5:031 Section 5, and the criteria of that section be applied without modification.

4) In an attempt to control nutrient inputs into the North Elkhorn Creek system, it is recommended that all sources of nutrients be evaluated for future implementation of effective point and/or nonpoint source controls. Forested 100 foot buffer zones should be established on each side of the channel for North Elkhorn and its tributaries.

5) It is recommended that additional fish tissue samples be collected to monitor the accumulation of chlordane, Hg and Pb. Concurrent sampling of the water column and sediments should also be conducted.

INTRODUCTION

The North Elkhorn Creek subbasin lies in central Kentucky in portions of Franklin, Scott, and Fayette counties. This drainage, from the headwaters to the confluence with the mainstem of Elkhorn Creek (Elkhorn Creek MP 17.8) in Frankfort, is a portion of a 303(e) segment, which is designated as 04 (Kentucky River Basin), 016 (North Elkhorn Creek segment) in the River Basin Water Quality Management Plan for Kentucky (Miller, Wihry, and Lee 1975). Cane Run Creek (Segment 04018) is also located in this watershed. There are seven water bodies designated within North Elkhorn Creek drainage, they are KY5100205-019, -020, -021, -022, -023, -024, and -025.

A survey of the North Elkhorn Creek subbasin was conducted by the Kentucky Department for Environmental Protection (KDEP), Kentucky Division of Water (KDOW) in spring 1986. Twenty-eight stations were established in the North Elkhorn Creek subbasin, 16 stations on North Elkhorn Creek and 12 on tributaries (Figure 1). All stations were sampled once in spring/summer 1986, while selected sites were resampled in the winter and summer/fall, 1987 and again in summer, 1988. The location of these stations, dates sampled, and parametric coverage are given in Appendix A.

The purposes of this investigation were to determine the legitimate stream uses of the North Elkhorn, to compile background water quality and biological data for the subbasin, to determine the number of miles presently attaining proposed designated uses, and to determine the suitability for listing North Elkhorn Creek as outstanding resource water.

North Elkhorn Creek is presently designated for warmwater aquatic habitat, (WAH), public water supply (PWS) at points of withdrawal, and primary and secondary contact recreation (PCR and SCR). Data from this report indicate that these uses should continue. However, this same data also shows that, except for Cane Run and two miles of North Elkhorn below Georgetown WWTP #1, waters of the North Elkhorn Creek system

Figure 1: Map of the North Elkhorn Creek Drainage Depicting Sampling Locations

are only partially supporting designated uses. Therefore, North Elkhorn Creek does not qualify for an outstanding resource water classification at this time.

Literature Review

The recreational and aesthetic value of North Elkhorn Creek have been discussed by Sehlinger (1978) and Sehlinger and Underwood (1980). The Kentucky Nature Preserves Commission has recommended that North Elkhorn Creek, from the headwaters to the mouth, be listed as an outstanding resource water (Hannan et al. 1982). According to Jones (1973), North Elkhorn has historically been known as an excellent smallmouth bass stream. Miller, Wihry and Lee (1975) provide a variety of physical and sociological data for the basin.

Physicochemical and biological data for the North Elkhorn drainage are available from a variety of sources. Physicochemical data are presented by Jones (1968), Laflin (1970),and Foree (1974). Biological data, primarily fish data are presented by Lachner and Jenkins (1967), Jones (1968), Laflin (1970), Westerman (1980), and Elkin (1984). Macroinvertebrate data are presented by Laflin (1970), Heer (1974), and Taylor (1984). Bradfield and Porter (1990) provide a summary of biological investigations that have occurred in the Kentucky River basin, including North Elkhorn Creek.

Basin Impacts and Stream Uses

The North Elkhorn subbasin has 15 permitted dischargers (Table 1) and receives runoff from urban (Georgetown and Lexington) and agricultural activities. Miller, Wilhry and Lee (1975) listed North Elkhorn as water quality limited because of a lack of stream flow during dry weather. At that time, bacteriological criteria were not met 50% of the time, mostly because of the lack of proper wastewater treatment in Stamping Ground. Since that time, a new Stamping Ground wastewater treatment plant (WWTP) plant has been constructed. The Division of Water (1990) reported 2 miles of North Elkhorn Creek as not supporting classified uses because of organic

Table 1: A Listing of Kentucky Pollutant Discharge Elimination System (KPDES) Dischargers Located in the North Elkhorn Creek Drainage

Facility Number	Facility Name	Receiving Stream	River Mile	Flow MGD	County
4016055	Stamping Ground WWTP	N. Elkhorn Ck.	23.4	0.1	Scott
4016049	Georgetown #1 WWTP	N. Elkhorn Ck.	8.8	3.0	Scott
4016050	Nally and Gibson Rock Quarry	N. Elkhorn Ck.	36.7	0.0	Scott
4016060	MGM Concrete Products Inc.	None	NA	4.67	Scott
4016060	MGM Concrete Products Inc.	None	NA	0.93	Scott
4016051	US Army Depot	UT to N. Elkhorn Ck.	6.2	0.1	Fayette
4016059	Georgetown #2 WWTP	Lanes Run	0.6	2.2	Scott
4016062	Toyota MMV 001	Dry Run	3.1	0.0	Scott
4018055	IBM Lexington	Cane Run	16.0 16.1	1.2	Fayette
4017056	General Electric Co. Glass PLT	Cane Run	16.6	0.0	Fayette
4018053	Vulcan Materials Co. Lexington	None	NA	0.0	Fayette
4018051	Ky. Horse Park WWTP	Cave Run	8.7	0.15	Fayette
04018058	Maple Grove MHP	UT to Cane Run	3.2	.03	Fayette
04018050	Ponderosa MHP	UT to Cane Run	0.90	.04	Fayette
04018049	Spindletop MHP	UT to Cane Run	0.60	.04	Fayette

NA - Not Applicable WWTP - Wastewater Treatment Plan MHP - Mobile Home Park

enrichment, high nutrients, and chlorine discharges from municipal facilities. Cane Run (17.4 miles) did not support classified uses because of toxicity from unknown sources (DOW 1990).

The city of Georgetown currently has two permitted water withdrawal points from the North Elkhorn Creek basin. The primary supply is permitted to withdraw 2 million gallons per day (mgd) from Royal Springs, a tributary to North Elkhorn in Georgetown. The auxiliary supply, located on North Elkhorn at milepoint 50.9, is permitted to withdraw 1.1 mgd. The Royal Springs supply has historically had a problem with fecal bacterial contamination during wet weather. In 1990, benzene was detected in the waters discharging from Royal Springs. This resulted in the City of Georgetown temporarily interrupting water withdrawals at this location. The source of the benzene was never determined.

North Elkhorn Creek is used for fishing and recreational boating activities. Primary and secondary contact recreation occurs throughout the subbasin.

Hunting for waterfowl, small mammals, and deer occur throughout the drainage in rural areas. Both game and non-game species utilize the various streams and adjacent buffer zones for breeding, rearing young, feeding and water supply. Trapping for small mammals such as muskrats, mink, etc., is also expected to occur in the drainage.

According to Miller, Wihry and Lee (1975) land use within the North Elkhorn Creek watershed is primarily agricultural. Urban development, the second land use, occurs mainly in the Lexington and Georgetown vicinities.

Methods

Water and sediment samples were collected in accordance with KDOW's Standard Operating Procedures Manual (KDOW 1987a). All samples were iced and transported to the Division of Environmental Services laboratory for analysis.

Biological samples (bacteriological, algae, macroinvertebrates, and fish) were also collected in accordance with the KDOW (1987a) manual. These samples were

delivered to the Water Quality Branch laboratory and identified to the lowest possible taxonomic level. Laboratory procedures, data analysis, and interpretation methods are described in the KDOW (1987a) manual; quality assurance procedures are outlined in KDOW (1986). Toxicity tests were conducted in accordance with KDOW (1987b). Physicochemical data were analyzed using the STORET median values, STORET 75th percentile values, and/or Kentucky Surface Water Standards (KSWS).

The Biotic Assessment Index (BAI) was used to analyze biological (algae, macroinvertebrate and fish) data to assess the ecological health of a waterbody. Each data set is analyzed and ranked independently, then the individual scores are summed and averaged. The resulting score is compared to the values listed in Table 2 for the appropriate use support designation.

The diatom data were analyzed in detail to assess the biological integrity of each station, using a multi-metric Periphyton Bioassessment Index (PBI). Total number of diatom taxa (TNDT), diversity (d), a diatom taxonomic index (DTI), relative abundance of sensitive species (RA_s), and percent community similarity (PS_c) to the reference site(s) are used in the assessment method. For each metric, a site is assigned a score from one through five, based on expected ranges of values for that metric (Table 3). Scoring criteria have been developed by analyses of previous DOW biological monitoring and intensive survey data. These are values expected for diatom assemblages from mid-sized (third through fifth order)

Table 2: Biotic Assessment Index Interpretations		
Score	**Assessment Category**	**Use Support Category**
4 - 5	Excellent	Support WAH Uses
3 - 4	Good	Partially Supports WAH Uses
2 - 3	Fair	Partially Supports WAH Uses
1 - 2	Poor	Does Not Support WAH Uses

WAH = Warmwater Aquatic Habitat

Table 3: Ranges of Metric Values Used to Assign Scores for the Periphyton Bioassessment Index (PBI)					
Metric	**Expected Values for Scoring**				
	1	2	3	4	5
TNDT	<20	20-30	30-50	50-70	>70
Diversity	<1.5	1.5-2.5	2.5-3.5	3.5-4.5	≥4.5
DTI	<1.0-1.5	1.5-2.0	2.0-2.5	2.5-3.0	≥3.0
RA_s (%)	0.1	0.1-1.0	1.0-5.0	5.0-20	20-100
PS_c (%)	≤10%	10-30	30-50	50-75	≥75

streams in the Bluegrass Region. For each site, the mean of the five metric scores results in a final PBI score ranging from one to five. Reference sites are scored slightly differently; the PS_c metric is omitted, and the mean is derived from the four remaining metric scores. Each PBI score is given a descriptive classification (excellent, good, fair or poor) as outlined in Table 2.

The PBI has been modeled after other multiple-metric bioassessment methods such as: Karr's Index of Biotic Integrity (IBI) (1981); the Rapid Bioassessment Protocols developed by the U.S. EPA (Plakfin et al. 1989); and the "Rapid Bioassessments of Lotic Macroinvertebrate Communities: Biocriteria Development" manual used by the state of Arkansas (Shackleford 1988). Methods for calculating metrics in the PBI will be described in the revised Water Quality Standard Operating Procedures Manual (KDOW in draft). Pollution tolerances of diatoms were derived from published literature including Patrick and Reimer (1966 and 1975); Patrick (1977); Lowe (1974); Lange-Bertalot (1979), Descy (1979) and previous DOW biological monitoring and intensive survey data.

In the North Elkhorn Creek study, the macroinvertebrate data were analyzed using a multimetric approach similar to Plafkin et al. (1989). The selected metrics were used to develop a Macroinvertebrate Bioassessment Index (MBI), which in turn was used to calculate the BAI. The MBI was accomplished using total number of macroinvertebrate taxa (Taxa Richness, TR), total number of individuals (TNI), Ephemeroptera-Plecoptera-Trichoptera (EPT) index, and percent community dominance (PS_c). Each metric was separately scored according to criteria listed in Table 4. All four metrics were then added together and averaged. The average score was then used in the BAI.

The fish community biological asssessment was accomplished using the Index of Biotic Integrity (IBI) (Table 5). The IBI was calculated in accordance with the methods

Table 4: Ranges of Metrics for Macroinvertebrate Bioassessment Index Used to Assign Numerical Scoring Criteria for Blue Grass Streams				
Metric	**Scoring Criteria**			
TNT	≥50	37-48	20-35	≤18
TNI*	≥85% or ≤115%	70-80% or 120-130%	55-65% or 135-145%	≤50% or ≥150%
EPT	≥17	12-15	7-10	≤5
CD** (%)	<60	61-68	70-75	>77
4 Score Range	4.2 - 5 Excellent	3.2-3.8 Good	2.2-2.8 Fair	1-1.8 Poor

* This metric is calculated as a percentage of the control.
** This metric is derived by adding the taxa with the top five relative abundances.

Table 5: Ranges of Index of Biotic Intregrity (IBI) used to Assign Scoring Criteria				
	Excellent	**Good**	**Fair**	**Poor**
IBI Score	≥54	46-52	38-44	≤36
Score Range	4-5	3-4	2-3	1-2

discussed by Karr (1981) and Karr et. al (1984, 1986). The IBI scores were then converted to a value that can be used in the BAI (Table 5).

PHYSICAL EVALUATION

North Elkhorn Creek is a fourth order tributary to Elkhorn Creek. It rises in central Fayette County, flows northwesterly for approximately 122 km (76 mi) and joins the South Fork Elkhorn Creek at the Forks of the Elkhorn in Franklin County. North Elkhorn drains an area of 715 km^2 (276 mi^2) (Bower and Jackson 1981) and has an average gradient of 0.87 m/km (4.6 ft/mi).

North Elkhorn Creek basin lies almost entirely in the Inner Blue Grass Subsection of the Blue Grass Section of the Interior Low Plateau Physiographic Province (Quarterman and Powell 1978). This region is underlain by Ordovician aged, soft, phosphoric limestones, which have been subjected to considerable erosion both on and below the surface. As a result, karst topography is well developed throughout most of the drainage (Miller, Wihry, and Lee 1975). Consequently, groundwater discharges to streams in the North Elkhorn system via springs and seeps are common throughout the drainage.

According to Miller, Wihry and Lee (1975), the major soil associations drained by North Elkhorn are Lowell, Mercer, Faywood, Maury, and McAfee. These soils developed from phosphoric, Ordovician limestones, and are well suited to agriculture. With the exception of Maury soils, which has a low potential for sediment runoff, all soils have a moderate potential for sediment runoff. Maury soils also have a moderate water infiltration rate when they are fully wetted, while the remaining soils have a slow infiltration rate.

A review of the geological and soil data indicates that the streams of the North Elkhorn Creek basin are normally alkaline, hardwater streams that carry a moderate to high dissolved solids load. During moderate to severe storm events, the streams can have rapid increases in discharge and carry moderate to high suspended sediment concentrations.

United States Geological Survey (USGS) flow data presented by Ruhl and Martin (1991) show that the 7-day, 10 year low flow (7Q10) for North Elkhorn Creek near Georgetown

is 0.0ft^3/sec, while at Switzer the 7Q10 is 0.039m^3/sec (0.6 ft^3/sec). For the Georgetown location for the period of record (1950-1982), the average discharge is 4.64m^3/sec (167 ft^3/sec) and the average runoff is 47.55 cm/yr (19.06 in/yr). The mean monthly discharges during the period of record range from a low of 0.88 m^3/sec (31ft^3/sec) in October to a high of 11.13m^3/sec (393 ft^3/sec) in March (Melcher and Ruhl, 1984). The lowest flows occur July through October, while the highest flows occur December through April.

Flow data, taken from selected sites during this study, are presented in Table 6. Although flows were moderate in the mainstem of North Elkhorn Creek during the 1986 sampling, tributary stream flows approached low flow conditions.

All streams sites where biological samples were collected had similar habitats. The riffles generally had a moderate slope with cobble, pebble, gravel substrates. Expanses of bedrock were common in the pools, as were moderate sediment deposits. Undercut banks, brush piles, and leaf packs were common throughout the drainage. Water willow (Justicia) beds were also common throughout the drainage.

Table 6: Discharge Data From Selected Sites in the North Elkhorn Creek Draninage			
Date	**Stn. No.**	**Stream**	**($ft.^3/sec$)**
June 3, 1986	16-1	N.Elkhorn Ck.	35.28
	16-2	N.Elkhorn Ck.	31.80
	16-3	N.Elkhorn Ck	35.62
June 5, 1986	16-17	Lecomptes Run	1.08
June 3, 1986	16-18	McConnells Run	0.75
June 5, 1986	16-24	Dry Run	0.0 (Pooled)
Oct. 2, 1987	16-1	N.Elkhorn Ck.	1.75
	16-5	N.Elkhorn Ck.	2.86
Sept. 30, 1986	16-6	N.Elkhorn Ck.	3.27
	16-12	N.Elkhorn Ck.	1.86
	16-13	N.Elkhorn Ck.	0.05
	16-14	N.Elkhorn Ck.	1.46
April 22, 1986	16-25	Lanes Run	0.92
	16-26	Lanes Run	1.17

PHYSICOCHEMICAL EVALUATION

Physicochemical samples were taken on four separate occasions, the summer of 1986 (20 stations), the winter (20 stations) and fall of 1987 (9 stations), and the summer of 1988 (5 stations). During 1986, a total of 119 parameter were analyzed. In the winter of 1987, 111 parameters were analyzed, while in the fall of 1987, 135 constituents were sampled. During the summer of 1988, 108 parameters were analyzed. The chemical values which were above detection limits at each sampling site during each sampling period are given in Appendices B, C, D and E. The parameters with values below detection limits are listed in Appendix F.

Parameter values for the four sampling periods were compared to the 1990 Kentucky Surface Water Standards (KSWS) (401 KAR 5:031) where applicable (Table 7). Selected parameters were also compared to Kentucky STORET data (1983-1989) (Table 7). Any parameter with a value above the 75th percentile (Table 7) was considered to be elevated. STORET is a national computerized management information system operated by the U.S. Environmental Protection Agency (U.S. EPA). It is designed for the storage and retrieval of water quality data. In Kentucky, STORET water quality data is derived from a statewide network of 52 monitoring stations, 45 of which are currently active. The active stations have been sampled on a monthly basis since 1979.

Water quality data from North Elkhorn has been presented in three previous studies. Jones (1968) presented data on temperature, dissolved oxygen (DO), ABS detergents, ammonia-nitrogen (NH_3-N), total Phosphorus (TP), total alkalinity (Alk), and pH from 1963 through 1965. His data indicated that North Elkhorn in the Switzer area was an alkaline, nutrient rich stream. Laflin (1970) collected physicochemical data in 1968 and 1969 below Georgetown at Elkview Road (equal to KDOW station 16-5) and above Georgetown at Huffman Mill Road. He sampled monthly for DO, five day biochemical oxygen demand (BOD_5), pH, water temperature, NH_3-N, Alk, and carbon dioxide

Table 7: A List of STORET (1983-1989) Medians, STORET 75th Percentile Values, and Kentucky Surface Water Standards (KSWS)

Parameters[a]	STORET Median	STORET 75th PERCENTILE	KSWS
Alkalinity	78.3	124	[b]
Chloride	8.6	16.3	600
Cond. (umhos\cm)	300	200	[b]
Hardness	130	178	[b]
pH (SU)	7.3	7.0	6.0-9.0
Sulfate	33.3	74.6	[b]
TOC	2.96	4.6	[b]
Turbidity (NTU)	19	40	[b]
Ammonia-N	0.05	0.075	Calculate
TKN	0.38	0.63	[b]
Nitrate-N	0.5	1.1	[b]
Phosphorus (total)	0.046	0.11	[b]
Calcium	36.5	52.6	Calculate
Magnesium	8.2	13.1	[b]
Potassium	2.4	3.4	[b]
Sodium	7.2	17.8	[b]
Aluminum	0.239	0.575	[b]
Arsenic	0.001	0.002	0.05
Barium	0.039	0.06	[b]
Cadmium	0.001	0.001	Calculate
Chromium	0.002	0.003	Calculate
Copper	0.003	0.006	Calcalate
Iron	0.5	1.02	1.0
Lead	0.002	0.004	Calculate
Manganese	0.11	0.2	[b]
Mercury	0.0001	0.0002	0.000012
Nickel			Calculate
Silver			Calculate
Zinc	0.016	0.03	Calculate

[a]Units are mg/l unless otherwise stated.

(CO_2). His data showed that North Elkhorn at both stations was an alkaline stream with elevated NH_3-N values and good DO concentrations throughout the year. Foree (1974) conducted 13 physicochemical tests at each of six locations in the North Elkhorn Creek drainage from June through October, 1974. He measured temperature, DO, BOD_5, chemical oxygen demand (COD) pH, Alk, turbidity (Turb.), total suspended solids (TSS), TP, ortho-phosphorus (Ortho-P), NH_3-N, nitrate-nitrogen (NO_3-N), and conductivity (Cond.). The only water quality problem that Foree's (1974) data consistently showed was elevated nutrients throughout the North Elkhorn sampling area.

During this study, Alk, cond., hardness, and chloride were consistently above the STORET 75th percentile. However, these parameters were not thought to be degrading water quality or adversely affecting aquatic life.

Twenty-four parameters exceeded respective STORET 75th percentiles at one or more stations during the summer, 1986 sampling period (Table 8). The number of elevated parameters per station varied from eight at stations 16-16, 16-18, and 16-27 to 14 at station 16-28 on North Elkhorn in the headwaters. Nutrients, primarily TP, NO_3-N, total Kjeldahl nitrogen (TKN), and to a lesser extent NH_3-N, were elevated throughout the drainage (Table 8).

Mercury (Hg) exceeded KSWS criteria at 13 stations (65%). Cadmium (Cd) exceeded the KSWS chronic criterion at station 16-28 and copper (Cu) exceeded the acute criterion at the station 16-28.

During the winter, 1987 sampling period, 18 parameters were above their STORET 75th percentiles (Table 9). The number of elevated parameters per station ranged from ten at station 16-13 to 16 at station 16-19. Again, two nutrients, TP and NO_3-N were consistently elevated throughout the drainage. It should be noted that NO_3-N concentrations were extremely high during this sampling period. Only lead (Pb) exceeded KSWS (Table 9); violations of the chronic criterion occurred at stations 16-1, 16-9, 16-14, and 16-26.

Table 8: Parameters that Exceeded STORET (1983-1989) 75th Percentile and Kentucky Surface Water Standards (KSWS) for the North Elkhorn Creek Drainage During the Summer, 1986					
	STATIONS				
Parameter[a]	16-1	16-2	16-3	16-5	16-6
Alkalinity	154	142	150	211	140
Chloride	21.8	20.4	21.5	24.6	29.1
Cond. (umhos)		427	420	554	628
Hardness	206	191	203	195	221
pH (SU)	8.4	8.0	8.0		
Sulfate					
TOC					
Turbidity					
Ammonia Nitrogen		0.159			
TKN			0.701	0.695	0.796
Nitrate	1.23	1.27	1.64	1.92	2.21
Phosphorus, total	0.315	0.335	0.365	0.33	0.47
Calcium	64.9	65.3	66.9	64.6	75.0
Magnesium					
Potassium					
Sodium					18.9
Barium				0.064	
Cadmium					
Chromium	0.25			0.007	0.005
Copper					
Lead	0.005				
Manganese					
Mercury	.0001*				.0001*
Zinc					
Total STORET Exceedences	9	9	9	10	10
Total KSWS Violations	1	0	0	0	1

*Exceeded KSWS Chronic Criteria
**Exceeded KSWS Acute Criteria [a]In mg/l unless otherwise stated

Table 8. (Continued)					
	STATIONS				
Parameter[a]	16-9	16-12	16-13	16-14	16-15
Alkalinity	157	153	161	161	145
Chloride	18	18.8	18.8	20.3	18.8
Cond. (umhos)	538	420	557	463	424
Hardness	205	197	211	220	204
pH (SU)	7.79		7.9	7.93	7.9
Sulfate					
TOC					
Turbidity (NTU)					
Ammonia Nitrogen	0.143	0.118			0.094
TKN		0.739	0.741		0.753
Nitrate	1.34			1.24	1.62
Phosphorus, total	0.154	0.188	0.174	0.23	0.24
Calcium	65.8	59.2	68.4	73.7	56.9
Magnesium					
Potassium					
Sodium					
Barium	0.074	0.067			
Cadmium					
Chromium	.004	.005	.008	.008	.004
Copper	0.008				
Lead		0.006			
Manganese		0.23			
Mercury	* .0001	* .0001		* .0001	* .0001
Zinc			0.01		
Total STORET Exceedences	12	12	10	9	11
Total KSWS Violations	1	1	0	1	1

*Exceeded KSWS Chronic Criteria
**Exceeded KSWS Acute Criteria
[a]In mg/l unless otherwise stated

Table 8. (Continued)					
	STATIONS				
Parameter[a]	**16-16**	**16-17**	**16-18**	**16-19**	**16-20**
Alkalinity	131	166	138	155	181
Chloride	24.7			26.9	34.9
Cond. (umhos)		429	418	619	797
Hardness	180	204		223	262
pH (SU)	7.8	8.5	8.2	6.2	8.11
Sulfate		210			63.1
TOC	6.3	5.5	6.2		
Turbidity (NTU)					
Ammonia Nitrogen				0.103	0.387
TKN	0.723	0.845	1.04	0.685	1.05
Nitrate					2.4
Phosphorus, total	0.265	0.274	.136	0.272	0.840
Calcium	53.6	68.8	53.4	77.0	87.4
Magnesium					
Potassium					
Sodium					21.0
Barium				0.062	
Cadmium					
Chromium					0.006
Copper				0.022	
Lead					
Manganese		0.23	.22		
Mercury	* .0001		*.0001		
Zinc					
Total STORET Exceedences	8	10	8	11	13
Total KSWS Violations	1	0	1	0	0

*Exceeded KSWS Chronic Criteria
**Exceeded KSWS Acute Criteria
[a]In mg/l unless otherwise stated

Table 8. (Continued)

STATIONS					
Parameter[A]	**16-21**	**16-22**	**16-24**	**16-27**	**16-28**
Alkalinity	143	179	129	156	149
Chloride	53.9	48.6	18.8		
Conductivity	737	729	447		421
Hardness	269	296		185	191
pH	8.0	6.9	8.0	7.9	
Sulfate	114				
TOC			8.5		7.6
Turbidity					80.0
Ammonia Nitrogen				0.162	0.129
TKN			1.13	0.946	1.46
Nitrate	1.25	3.72			1.60
Phosphorus, total	0.260	0.248	0.126	0.182	0.488
Calcium	77.2	102.3		56.1	53.1
Magnesium	16.7				
Potassium	3.69				
Sodium	45.3	24.1			
Barium	0.098	0.063	0.069		0.072
Cadmium					0.006*
Chromium	0.008		0.005	0.004	
Copper	0.014				2.03*
Lead					
Manganese					0.30
Mercury	*.0002	*.0001	*.0001	0.0001*	0.0002*
Zinc	0.042				
Total STORET Exceedences	17	10	9	8	14
Total KSWS Violations	1	1	1	1	3

*Exceeded KSWS Chronic Criteria
**Exceeded KSWS Acute Criteria
[A]In mg/l unless otherwise stated

Table 9: Parameters that Exceeded STORET (1983-1989) 75th Percentile and Kentucky Surface Water Standards (KSWS) for the North Elkhorn Creek Drainage During the Winter, 1987

	STATIONS				
Parameter[a]	16-1	16-5	16-6	16-9	16-13
Alkalinity	176	175	174	170	171
Chloride	17.7	17.5	14.0	16.5	10.0
Cond. (umhos)	478	488	510	150	453
Hardness, total	238	239	243	240	226
pH (SU)	8.2	7.9	8.0	8.1	36.6
Sulfate	42.4	45.7	46.6	49.2	
TKN	0.39				
Nitrate	5.12	6.00	5.80	5.50	5.10
Phosphorus, total	0.249	0.330	0.801	0.19	0.174
Calcium	88.4	88.6	84.6	83.8	81.4
Magnesium					
Potassium					
Sodium	7.6	8.3	10.0	10.6	
Barium	0.050	0.047		0.039	0.059
Copper	0.018	0.011	0.15		
Iron			.6		
Lead	0.072*	0.003	0.003	0.097*	
Zinc	0.051	0.081	0.093	0.021	0.022
Total STORET Exceedences	15	14	14	13	10
Total KSWS Violations	1	0	0	1	0

*Exceeds KSWS Chronic Criteria
**Exceeds KSWS Acute Criteria
[a]In mg/l unless otherwise stated

Table 9. (Continued)					
	STATIONS				
Parameter[a]	16-14	16-16	16-19	16-25	16-26
Alkalinity	172	167	179	173	157
Chloride	11.5	13.2	13.0	6.0	11.5
Cond. (umhos)	453	446	510	512	406
Hardness, total	174	183	247	264	179
pH (SU)	8.1	8.1	8.0	8.2	8.0
Sulfate	37.1	36.2	44.5	62.5	37.8
Ammonia Nitrogen			0.071	0.054	
TKN		0.45	0.41		
Nitrate	4.10	2.95	7.70	7.20	3.30
Phosphorus, total	0.116	0.052	0.365	0.230	0.069
Calcium	77.9	73.7	97.4	107	73.9
Magnesium		8.69			
Sodium			7.5		
Barium	0.047		0.046	0.077	
Copper		0.005	0.006	0.010	
Iron					
Lead	0.007*		0.009	0.009	0.009*
Zinc		0.025	0.026	0.060	0.018
Total STORET Exceedences	11	13	16	14	11
Total KSWS Violations	1	0	0	0	1

*Exceeds KSWS Chronic Criteria
**Exceeds KSWS Acute Criteria
[a]In mg/l unless otherwise stated

Physicochemical samples taken from selected sites in the fall of 1987 revealed that 20 parameters were elevated above their STORET 75th percentiles at one or more stations (Table 10). The maximum number of elevated parameters was 19 at station 16-7, while the least was 11 at station 16-16. The nutrients were again degrading water quality. Total phosphorus was elevated at all stations, NO_3-N was elevated at about half the sites, and TKN and NH_3-N were elevated at all but one location. In fact, un-ionized NH_3-N was sufficiently elevated at station 16-7 to exceed KSWS (0.05 mg/l) (Table 10). Metals data showed that Hg violated KSWS at all sampling sites, while Pb violated KSWS chronic criteria at stations 16-5 and 16-14.

The final set of samples were collected in summer of 1988. Five stations were collected. A total of 18 parameters were elevated above the STORET 75th percentile at one or more stations (Table 11). The number of elevated parameters ranged from seven at site 16-1 to 15 at station 16-6. As previously, nutrients were consistently elevated at all sites. Total phosphorus and NH_3-N were elevated at each site. Although ammonia-nitrogen was elevated at all sampling locations, the criteria for un-ionized ammonia was not exceeded (Table 11). Three of the five locations had elevated TKN values. The nitrate-nitrogen concentration was extremely high (7.8 mg/l) at station 16-6 downstream of the Georgetown #1 WWTP. Mercury violated KSWS at all locations (Table 11).

The most serious water quality problem observed in the North Elkhorn Creek drainage was the elevated nutrient concentrations. Data from this report, as well as historical data indicated that nutrients are entering the North Elkhorn system from both point and nonpoint sources. Phosphorus was consistently elevated throughout the drainage. Phosphorus is typically the limiting nutrient in aquatic ecosystems, and thus determines the extent of primary productivity (Cole 1975). However, this does not appear to be the case in the North Elkhorn Creek drainage. Nitrate-nitrogen concentrations

Table 10: Parameters that Exceeded STORET (1983-1989) 75th Percentile and Kentucky Surface Water Standards (KSWS) for the North Elkhorn Creek Drainage During the Fall, 1987

	STATIONS			
Parameter[a]	16-1	16-5	16-6	16-7
Alkalinity	165	196	174	179
Chloride	37.5	75.6	89.9	111.2
Cond. (umhos)	573	781	939	1080
Hardness, total	200	233	278	250
pH (SU)	9.0	8.2	7.8	7.8
Sulfate	44.2	75.6	115	138
TOC	5.81	8.60	13.7	20.7
Ammonia Nitrogen		0.104	0.187	2.40+
TKN	0.789	0.994	1.67	6.50
Nitrate			8.30	12.0
Phosphorus, total	0.39	0.920	4.75	8.40
Calcium	61.9	82.0	91.1	89.4
Potassium	3.75	7.73	10.6	16.6
Sodium	26.5	61.3	76.4	110
Chromium, total		0.008	0.008	0.030
Copper, total				0.010
Lead, total		0.01*		
Manganese, total				0.03
Mercury, total	0.0002+	0.0001+	0.0003+	0.0002+
Zinc, total	0.059	0.704*		0.166
Total STORET Exceedences	14	16	16	19
Total KSWS Violations	1	2	1	2

*Exceeds KSWS Chronic Criteria
+Exceeds KSWS Criteria
[a]In mg/l unless otherwise stated

Table 10. (Continued)			
	STATIONS		
Parameter[a]	16-9	16-13	16-14
Alkalinity	180	182	256
Chloride	23.5		26.8
Cond. (umhos)	532	457	688
Hardness, total	217	202	303
pH (SU)	8.0	8.0	8.1
Sulfate		30.5	41.4
TOC	5.63	5.33	13.7
Ammonia Nitrogen	0.357	0.084	0.114
TKN	1.19	0.886	
Nitrate			2.80
Phosphorus, total	0.310	0.124	0.235
Calcium	66.3	57.2	102
Magnesium			
Potassium	4.97		
Sodium			18.6
Lead, total			0.088*
Manganese, total	0.40	0.24	
Mercury, total	0.0002+	0.0001+	0.0001+
Zinc, total	0.075		0.040
Total STORET Exceedences	14	11	14
Total KSWS Violations	1	2	3

*Exceeds KSWS Chronic Criteria
+Exceeds KSWS Criteria
[a]In mg/l unless otherwise stated

Table 10. (Continued)		
	STATIONS	
Parameter[a]	16-16	16-25
Alkalinity	135	293
Chloride		
Cond. (umhos)		843
Hardness, total		418
pH (SU)	8.0	7.8
Sulfate	26.2	152
TOC	13.7	12.1
Ammonia Nitrogen	0.197	0.757
TKN	1.23	1.55
Nitrate		1.5
Phosphorus, total	0.136	
Calcium	49.3	114
Magnesium		24.0
Potassium	3.80	6.81
Sodium		
Lead, total		
Manganese, total		0.69
Mercury, total	0.0002+	0.0001+
Zinc, total	0.046	
Total STORET Exceedences	11	13
Total KSWS Violations	2	2

*Exceeds KSWS Chronic Criteria
+Exceeds KSWS Criteria
[a]In mg/l unless otherwise stated

Table 11: Parameters that Exceeded STORET (1983-1989) 75th Percentile and Kentucky Surface Water Standards (KSWS) for the North Elkhorn Creek Drainage During the Summer, 1988

	STATIONS				
Parameter[a]	**16-1**	**16-5**	**16-6**	**16-9**	**16-13**
Alkalinity		143	165	151	166
Chloride	17.2	51.3	95.4	48.4	19.6
Cond. (umhos)		573	860	548	443
Hardness, total		201	266	199	191
pH (SU)	9.0	8.4	8.0	7.9	7.9
Sulfate			78.1		
TOC	6.7	6.6	8.4	4.9	4.8
Ammonia Nitrogen	0.068	0.119	0.214	0.077	0.057
TKN	1.0	1.04	1.42		
Nitrate			7.80		
Phosphorus, total	0.237	0.411	3.30	0.456	0.267
Calcium		72.4	98.0	69.7	66.2
Potassium		3.62	10.1		
Sodium		34.9	71.7	32.1	
Arsenic				0.005	
Chromium					0.004
Manganese		0.40			0.28
Mercury	0.0002+	0.0004+	0.0003+	0.0002+	0.0002+
Lead	0.004				
Total STORET Exceedences	7	14	15	12	12
Total KSWS Violations	1	1	1	1	1

+Exceeds KSWS Criteria

[a]In mg/l unless otherwise stated

were also high, though the concentrations fluctuated seasonally. In general, NO_3-N concentrations were higher in the winter throughout the drainage, although concentrations in the reach from Georgetown downstream were consistently elevated. The decrease in nitrogen concentrations during the summer may indicate that nitrates were being utilized in primary production, since extensive filamentous algal growths were observed during that time. The elevated concentrations of NO_3-N in the Georgetown area were apparently the result of WWTP discharges.

In-stream concentrations of total NH_3-N were consistently elevated above the STORET 75th percentile. Concentrations tended to be higher during the summer and fall months when flow was decreased, and water temperature and pH were increased. However, the only violation of the KSWS criteria, which is 0.05 mg/l as un-ionized ammonia, was observed at station 16-7 during the fall of 1987. The un-ionized ammonia level for this sample was 0.09 mg/l. The amount of un-ionized ammonia present is determined by the level of total ammonia-nitrogen, water temperature, and pH (refer to 401 KAR 5:031).

Two metals, Hg and Pb, violated KSWS on several occasions. Mercury appears to be a problem throughout the drainage; it violated KSWS at most or all stations in the summer of 1986, fall of 1987, and summer of 1988. The source of the Hg contamination is currently unknown. During the winter and fall of 1987, Pb sporadically violated the KSWS chronic toxicity criterion. The source of the Pb contamination is also unknown. Concentrations of Hg and Pb that exceed KSWS can be toxic to aquatic life, especially for the more sensitive species.

On two occasions (fall, 1987 and summer, 1988), pH values at station 16-1, located near the mouth on North Elkhorn, approached the upper KSWS (9.0 su), but did not exceed it. These high pH values were probably caused by algae blooms. This station had shallow water and large expanses of bedrock covered by profuse filamentous algal growths. It is likely

that pH values such as these periodically occur under these conditions.

Based on the results of this investigation, the existing water quality of the North Elkhorn drainage is considered to be moderately impaired overall. The consistently elevated nutrient concentrations and violations of KSWS for Hg contribute to this impairment. Violation of KSWS for NH_3, Cd, Cu, Pb and Zn are other factors which contribute to this impairment rating. Consequently, North Elkhorn Creek does not qualify for outstanding resource water (ORW) status at this time.

SEDIMENT EVALUATION

Sediment samples were collected from the North Elkhorn Creek system in the spring (Stations 16-25 and 16-26) and summer (16 stations) of 1986 (Appendix G), and the fall of 1987 (eight stations, Appendix H). A total of 50 constituents were sampled in 1986, while 63 parameters were sampled in 1987. All constituents which were below detection levels at all stations for both sampling period are given in Appendix I.

Data from both sampling periods were compared to U.S. EPA (1977) guidelines. These guidelines separate parameter concentrations into: non-polluted, moderately polluted and heavily polluted categories (Table 12). Only those constituents falling into the moderately or heavily polluted categories are considered in this report.

Analyses of sediment samples taken in the spring and summer of 1986 showed that the North Elkhorn Creek basin sediments are contaminated to at least some degree throughout the system. The stream reaches with the greatest contamination (i.e., highest number of parameters in the moderately polluted or heavily polluted categories) were Cane Run in Lexington at Newtown Pike (station 16-21) with 11; North Elkhorn Creek (stations 16-6 and 16-5) below Georgetown with 11 and 8, respectively; and an unnamed tributary to North Elkhorn (station 16-28), which flows from the Bluegrass Army Depot and joins North Elkhorn Creek on the C.V. Whitney Farm, with nine elevated parameters (Table 13). The areas of least contamination (four elevated parameters) were North Elkhorn Creek north of Lexington on the Elmendorf Farm (station 16-15), Lecomptes Run below Stamping Ground (station 16-17) and the Lanes Run stations (16-25 and 16-26) (Table 13). The remaining 10 stations had five to seven elevated parameters (Table 13).

All reaches with the greatest contamination were located downstream of either large metropolitan areas or industrial operations. The Cane Run station (16-19) was located a few hundred yards downstream of a major Lexington sanitary sewer pump station. This pump station occasionally overflows during

Table 12: Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments Established by the U.S. Environmental Protection Agency, Region V (1977)

Parameter (mg/kg dry weight)[a]	Nonpolluted	Moderately Polluted	Heavily Polluted
Volatile Solids (%)	<5	5-8	>8
COD	<40,000	40,000-80,000	>80,000
TKN	<1,000	1,000-2,000	>2,000
Oil and Grease (Hexane Solubles)	<1,000	1,000-2,000	>2,000
Lead	<40	40-60	>60
Zinc	<90	90-200	>200
Ammonia	<75	75-200	>200
Cyanide	<0.10	0.10-0.25	>0.25
Phosphorus	<420	420-650	>650
Iron	<17,000	17,000-25,000	>25,000
Nickel	<20	20-50	>50
Manganese	<300	300-500	>500
Arsenic	<3	3-8	>8
Cadmium	*	*	>6
Chromium	<25	25-75	>75
Barium	<20	20-60	>60
Copper	<25	25-50	>50
Mercury	*	1.0	>1.0
Total PCBs	*	10.0	>10.0

*Lower limits not established
[a]In mg/kg dry weight unless otherwise stated

Table 13. Comparison of Summer, 1986 North Elkhorn Creek Drainage Sediment Data With U.S. EPA (1977) Sediment Criteria

	STATIONS								
Pollution Category	**16-1**	**16-2**	**16-3**	**16-5**	**16-6**	**16-9**	**16-12**	**16-14**	**16-15**
Moderately Polluted	COD	COD	COD	COD	COD	COD	COD	NH_3-N	NH_3-N
	Fe	O&G	TVS	TVS	TVS	TKN	TKN	Pb	Fe
	Ni	TVS	TKN	NH_3-N	NH_3-N	As			
		TKN	Ni	Cr	As				
		Ni		Fe	Cr				
				Ni	Fe				
					Pb				
					Zn				
Total	3	5	4	6	8	3	2	2	2
	STATIONS								
	16-1	**16-2**	**16-3**	**16-5**	**16-6**	**16-9**	**16-12**	**16-14**	**16-15**
Heavily Polluted	TKN	Fe	Fe	TKN	TKN	Fe	Fe	TKN	TKN
	Mn	Mn	Mn	Mn	Mn	Mn	Mn	Fe	Mn
					Ni	Zn	Zn	Mn	
								Zn	
Total	2	2	2	2	3	3	3	4	2

Table 13. (Continued)

STATIONS									
Pollution Category	**16-16**	**16-17**	**16-18**	**16-19**	**16-21**	**16-24**	**16-25**	**16-26**	**16-28**
Moderately Polluted	COD	TKN	COD	NH_3-N	COD	Fe	COD	COD	COD
	TVS	Ni	NH_3-N	TKN	TVS	Ni	NH_3-N		NH_4
	TKN		Ni	As	NH_4				TKN
	Fe			Fe	Cr				As
				Ni	Fe				Cr
									Pb
									Ni
Total	4	2	3	5	5	2	2	1	7

STATIONS									
	16-16	**16-17**	**16-18**	**16-19**	**16-21**	**16-24**	**16-25**	**16-26**	**16-28**
Heavily Polluted	Mn	Fe	TKN	Mn	O&G	TKN	TKN	TKN	Fe
	Zn	Mn	Fe		TKN	Mn	Mn	Fe	Mn
			Mn		Cu	Zn		Mn	
					Pb				
					Mn				
					Zn				
Total	2	2	3	1	6	3	2	3	2

periods of heavy rainfall and discharges untreated municipal waste to Cane Run. The Cane Run basin upstream of this site also receives urban runoff from a large area of north Lexington. The combination of these two pollution sources are considered to be the principal sources of sediment contamination in the upper reaches of Cane Run (station 16-21).

The two most contaminated North Elkhorn Creek sites (16-6 and 16-5) were located directly downstream of the city of Georgetown (Figure 1). These sites receive treated municipal waste and urban runoff from Georgetown, and sediment contamination in this stream reach is attributed to these two pollution sources.

The site on the UT to North Elkhorn (16-28) received treated industrial waste and runoff from industrial operations occurring on the Bluegrass Army Depot. These inputs are considered to be the principal sources of sediment contamination for this stream reach.

In 1986, manganese (Mn) was in the heavily polluted category at all 18 stations, while total kjeldahl nitrogen (TKN) was in either the moderately or heavily polluted categories at all stations (Table 13). Iron (Fe) was also in the moderately on heavily polluted categories at all stations except 16-25 on Lanes Run (Table 13). Chemical oxygen demand (COD) and nickel (Ni) were elevated at 10 stations while the remaining parameters were elevated at seven or less stations.

The elevated levels of Mn and Fe are probably a reflection of the basin geology. The elevated concentrations of TKN are probably the result of the agricultural activities occurring in the watershed. TKN is the measurement of ammonia and organic nitrogen (APHA 1989). These compounds are normally encountered in agricultural areas and below WWTPs. The highest TKN value (Appendix G) was observed at Station 16-5 located immediately downstream of the city of Georgetown. Also, TKN values were listed as heavily polluted at stations 16-5 and 16-6, the two stations directly below the Georgetown WWTP.

Stream reaches in which high levels of Ni occurred in the sediments appear to be impacted by urbanization (North Elkhorn below Georgetown, Cane Run, and the UT to North Elkhorn) through stormwater runoff or WWTP effluent. No patterns emerged to explain the elevated COD data. An extremely high concentration of Pb, 312 mg/kg, was observed in the Cane Run sediments at Newtown Pike in Lexington (Station 16-21). While the origin of this contamination was not determined, concentrations of this magnitude could be expected to result from some industrial processes.

Sediment samples were collected from eight selected North Elkhorn sites again in the fall of 1987 (Appendix H). Station 16-6 had ten parameters with concentrations in the moderate or heavily polluted categories (Table 14); this was only one fewer than in 1986. Station 16-16 located on the Whitney Farm had the fewest number (3) of elevated sediment parameters (Table 14) in 1987 as compared to six in 1986 (Table 13). Stations 16-5 and 16-13 each had nine elevated sediment values while station 16-14 had eight. The other four stations each had seven or eight elevated constituents in the sediments (Table 14). Overall, this represented an increase in the number of elevated sediment parameters for five (63%) of the stations (16-1, 16-5, 16-9, 16-14, 16-25) as compared to the 1986 results (Tables 13 and 14).

Ammonia-nitrogen (NH_3-N) was in either the moderately or heavily polluted categories at all eight stations sampled in the fall of 1987 (Table 14). Manganese was in the heavily polluted category at the eight stations sampled in 1987. This was consistent with the Mn results obtained in 1986 for seven of the same stations; station 16-13 was not sampled in 1987. As with TKN in 1986, the NH_3-N values are probably a reflection of the agricultural activities occurring within the watershed. Arsenic (As), Ni, total volatile solids (TVS) and COD were elevated at seven (88%) sites. These same parameters

TABLE 14. Comparison of Fall, 1987 North Elkhorn Creek Drainage Sediment Data with U.S. EPA (1977) Sediment Criteria

	STATIONS							
Pollution Category	**16-1**	**16-5**	**16-6**	**16-9**	**16-13**	**16-14**	**16-16**	**16-25**
Moderately Polluted	O&G	As	COD	COD	As	O&G	NH_3-N	As
	TVS	Fe	TVS	As	Pb	Pb	As	Ni
	Fe	Zn	NH_3-N	Ni	Ni	As		Zn
	Ni		As		Zn	Ni		
			Cr					
			Fe					
			Ni					
			Zn					
Total	4	3	8	3	4	4	2	3
	STATIONS							
	16-1	**16-5**	**16-6**	**16-9**	**16-13**	**16-14**	**16-16**	**16-25**
Heavily Polluted	COD	COD	Pb	TVS	COD	COD	Mn	COD
	NH_3-N	CN	Mn	NH_3-N	TVS	TVS		TVS
	Mn	TVS		Fe	NH_3-N	NH_3-N		NH_3-N
		NH_3-N		Mn	Fe	Mn		Mn
		Mn			Mn			
		Ni						
Total	3	6	2	4	5	4	1	4

were also high in the 1986 samples. The elevated As concentrations may be a further reflection of agricultural activities occurring in the drainage, since As is a constituent in some agricultural pesticides.

BIOLOGICAL EVALUATION

Biological samples (algae, macroinvertebrates, and fish) were collected from nine locations in the North Eklhorn drainage during the spring and summer of 1986. Bacteriological analyses were conducted in the summer and fall of 1986 on samples from 29 stations. Fish-tissue samples were collected at 6 sites in 1986 and 1987. Acute toxicity tests were performed on samples from 13 stations in North Elkhorn drainage and the Georgetown #1 WWTP (Royal Springs discharge) during April, 1986.

Biological data (algae, macroinvertebrates, and fish) have been integrated to produce a Biotic Assessment Index (BAI). The purpose of the BAI is to evaluate the overall health of the biotic community. Table 15 gives individual component and composite scores for the North Elkhorn Creek drainage during 1986. Table 2 (Methods Section) gives an interpretation of those ratings. The final BAI score is the mean value of equally weighted scores from all components. This average value is then compared to the values shown in Table 2 to determine if the stream reach supports designated uses.

A review of the BAI for the North Elkhorn Creek drainage shows that the mainstem rates as good except just below Georgetown where it is fair (Table 15). Both tributaries sampled (Dry run and Lanes Run) were fair except the upper portion of Lanes Run which rated as poor. With regard to use designation (Tables 2 and 15), the entire drainage rates as

Table 15: Biotic Assessment Index Scores and Assessments for Sampling Locations in the North Elkhorn Creek Drainage					
Stations	**Algae**	**Macro-invert**	**Fish**	**Score**	**Assessment**
16-1	3.2	3.1	5.0	3.8	Good
16-5	2.8	4.1	5.0	3.9	Good
16-6	2.0	3.2	4.0	2.7	Fair
16-9	2.4	3.6	4.0	3.3	Good
16-13	3.0	4.2	4.0	3.7	Good
16-14	3.2	2.9	4.0	3.4	Good
16-24	3.5	2.1	1.0	2.6	Fair
16-25	2.4	2.1	2.0	2.2	Fair
16-26	2.2	2.2	1.0	1.8	Poor

partially supporting warmwater aquatic habitat uses except for the upper portion of Lanes Run which does not support designated uses.

Bacteria

Bacteriological data can be found in Table 16. Bacteriological indicators used to assess the North Elkhorn Creek drainage were fecal coliform (FC), fecal streptococci (FS), Escherichia coli, and Enterococci. In general, all these indicators showed acceptable bacteriological quality in the North Elkhorn Creek mainstem, with most of the degraded water quality occurring in tributary streams. Possible ways to improve unacceptable water quality in these tributaries are by proper land management, limiting stream access from livestock and animal waste, use of properly operating septic tank/lateral field drains, and proper waste treatment operations.

A total of 29 stations were sampled in June of 1986 (Table 16), including 16 located on North Elkhorn Creek, 11 located on tributaries to North Elkhorn Creek, one raw water supply (Georgetown at Royal Springs), and the Georgetown WWTP #1 at Royal Spring. These same stations were also sampled in October of 1986, with the exception of station 16-24 (Dry Run), 16-26 (Lanes Run) and 16-29 (Georgetown WWTP #1).

In June, only one of the 16 mainstem stations (16-13) slightly exceeded the FC criterion for primary contact recreational uses (401 KAR 5:031, Section 6). Of the 13 tributary stations, six (46 percent) had unacceptable FC

Table 16: North Elkhorn Creek Drainage Bacteriological Data for Summer and Fall, 1986

				Bacteria per 100 ml	
Station No.	Source Receiving Stream	Milepoint	Bacterio-logical Test	June 1986	October 1986
04016001	North Elkhorn Creek	17.9	FC: FS: FC/FS Ratio: E.coli: Entoc:	140 150 0.9	16 32 NA 20 100
04016002	North Elkhorn Creek	25.1	FC: FS: FC/FS Ratio: E.coli: Entoc:	160 120 1.3	32 48 NA 70 40
04016003	North Elkorn Creek	34.8	FC: FS: FC/FS Ratio: E.coli: Entoc:	240 200 1.2	100/88 48/48 NA 130 20
04016004	North Elkhorn Creek	39.0	FC: FS: FC/FS Ratio: E.coli: Entoc:	150 130 1.2	96 96 NA 80 720
04016005	North Elkhorn Creek	44.2	FC: FS: FC/FS Ratio: E.coli: Entoc:	78/ 70 66/ 88 NA	8 16 NA 20 10
04016006	North Elkhorn Creek	49.7	FC: FS: FC/FS Ratio: E.coli: Entoc:	130 310 0.4 0 0	24 56 NA 10 10

Table 16: Continued					
				Bacteria per 100 ml	
Station No.	Source Receiving Stream	Milepoint	Bacterio-logical Test	June 1986	October 1986
04016007	North Elkhorn Creek	50.8	FC: FS: FC/FS Ratio: E.coli: Entoc:	88 78 NA	24 <8 NA 40 <8
04016008	North Elkhorn Creek	50.9	FC: FS: FC/FS Ratio: E.coli: Entoc:	120 130 0.9	<8 <8 NA <8
04016009	North Elkhorn Creek	53.0	FC: FS: FC/FS Ratio: E.coli: Entoc:	72 100 0.7	32/8 8/32 NA 40 20
04016010	North Elkhorn Creek	55.5	FC: FS: FC/FS Ratio: E.coli: Entoc:	180 170 1.1	<8 24 NA 80 720
04016011	North Elkhorn Creek	55.7	FC: FS: FC/FS Ratio: E.coli: Entoc:	350 140 2.5	24 16 NA 20 20
04016012	North Elkhorn Creek	58.3	FC: FS: FC/FS Ratio: E.coli: Entoc:	20 56 NA	120 220 0.5 170 90
04016013	North Elkhorn Creek	66.8	FC: FS: FC/FS Ratio: E.coli: Entoc:	420 120 3.5	<8 <8 NA <10 30

Table 16: Continued					
				Bacteria per 100 ml	
Station No.	Source Receiving Stream	Milepoint	Bacterio-logical Test	June 1986	October 1986
04016014	North Elkhorn Creek	78.3	FC: FS: FC/FS Ratio: E.coli: Entoc:	160 300 0.5	120 220 0.5 170 190
04016015	North Elkhorn Creek	82.0	FC: FS: FC/FS Ratio: E.coli: Entoc:	140/ 150 290/ 270 0.5/ 0.6	210 160 1.3 140 90
04016016	North Elkhorn Creek	86.0	FC: FS: FC/FS Ratio: E.coli: Entoc:	200 300 0.7	32 250 0.1 24 180
04016017	Lecomptes Run	1.5	FC: FS: FC/FS Ratio: E.coli: Entoc:	430 130 3.3	80 8 NA 120 8
04016018	McConnell Run	0.5	FC: FS: FC/FS Ratio: E.coli: Entoc:	150 290 0.5	220 490 0.4 280 400
04016019	Cane Run	0.2	FC: FS: FC/FS Ratio: E.coli: Entoc:	600 200 3.0	96 16 NA 160 50

Table 16: Continued					
04016020	Cane Run	5.8	FC: FS: FC/FS Ratio: E.coli: Entoc:	440 870 0.5	420/390 320/280 1.3/1.4 440/460 200/200
04016021	Cane Run	12.0	FC: FS: FC/FS Ratio: E.coli: Entoc:	250 380 0.7	>16,000 >16,000 NA >16,000 >16,000
04016022	Royal Springs	0.1	FC: FS: FC/FS Ratio: E.coli: Entoc:	4 2 NA	1,100 100 11 1,800 50
04016023	Royal Springs	0.7	FC: FS: FC/FS Ratio: E.coli: Entoc:	420/ 140 770/ 140 0.5/ 1.0	2,900 16 NA 3,100 10
04016024	Dry Run	1.2	FC: FS: FC/FS Ratio: E.coli: Entoc:	1600 670 2.4	
04016025	Lane Run	1.7	FC: FS: FC/FS Ratio: E.coli: Entoc:	140/ 310 120/ 430 1.2/ 0.7	130 24 NA 120 30

Table 16: Continued					
04016026	Lane Run	5.5	FC: FS: FC/FS Ratio: E.coli: Entoc:	330/ 300 98/ 110 NA/ 2.7	
04016027	Goose Creek	0.1	FC: FS: FC/FS Ratio: E.coli: Entoc:	>16, 000 >16, 000 NA	64 1,500 NA 20 750
04016028	UT to North Elkhorn Creek	0.4	FC: FS: FC/FS Ratio: E.coli: Entoc:	1000 220 4.5	40 56 NA 80 70
04016029	Georgetown WWTP	0.6	FC: FS: FC/FS Ratio: E.coli: Entoc:	<2 <2 NA	

NA= No Assessment
UT = Unnamed Tributary
WWTP = Wastewater Treatment Plant

levels (16-17 on LeComptes Run; 16-19 and 16-20 on Cane Run; 16-23 on Royal Springs; 16-24 on Dry Run; and 16-28, an unnamed tributary to North Elkhorn Creek).

The Georgetown raw water supply (16-22, Royal Springs) FC level was acceptable (4/100 ml) in June and well within the KSWS for domestic raw water supplies(no greater than 2,000/100 ml as a geometric mean). During sampling, the Georgetown WWTP #1 effluent did not exceed the daily maximum effluent limits stated in their KPDES permit for FC bacteria (no greater than 400/100 ml).

In October, there were no mainstem stations with unacceptable FC levels (Table 16). Only three (19 percent) of the tributary stations had unacceptable levels (16-20 and 16-21 in Cane Run, and 16-23 in Royal Springs). However, the Georgetown raw water supply at Royal Springs had an unacceptable level of fecal coliforms (2,900/100 ml).

In June, FC/FS ratios, which indicate if the source of the fecal pollution is either human or animal, generally indicated animal origin (Table 16). The levels of bacteria recovered in October were too low to use the ratio at most locations. Stations indicating human fecal pollution on either of the two sampling dates were 16-13, North Elkhorn Creek (milepoint 66.8); 16-17, LeComptes Run (milepoint 1.5); and 16-28, an unnamed tributary to North Elkhorn Creek (milepoint 0.4). The FC/FS ratio found in Georgetown's raw water supply at Royal Springs indicated human origin in October.

The E. coli level for June indicated over 80 percent of the mainstem stations had acceptable water quality when compared to the most stringent limit for single sample maximum allowable density (MAD) for E. coli established by USEPA in 1986 (Table 17). Using the level of protection meant for waters used for infrequent full body contact recreation, all samples were acceptable. The E. coli data from mainstem stations in October showed all samples to be acceptable at any level of recreational use.

The E. coli level from the tributary stations were not as good as those from the mainstem stations on either sampling occasion (Table 17). In June, over 90 percent of the tributary stations failed to meet the most stringent MAD limit. However, two thirds (66.6 percent) were within the least stringent MAD limit. In October, the range of samples meeting the most stringent to least stringent MAD levels were 60 percent and 70 percent, respectively.

Enterococci data were collected only in October. Using the same data provided by USEPA in 1986 for single sample MAD (Table 18), 53 percent of the mainstem samples were less than the most stringent MAD limit, and approximately 73 percent were less than the least stringent MAD limit. Enterococci data from the tributary stations showed 58 percent of the samples less than the most stringent MAD limit, and 67 percent being less than the least stringent MAD limit.

In summary, the bacteriological data shows that the mainstem of North Elkhorn Creek meets the PCR and SCR KSWS.

Table 17: *Escherichia coli* Data Comparisons to Single Sample Maximum Allowable Density (MAD)				
	Designated Beach Area	**Moderate Full Body Contact Recreation**	**Lightly Used Full Body Contact Recreation**	**Infrequent Full Body Contact Recreation**
Mainstem Stations, June, 1986				
E. coli MAD	235	298	406	576
Values >MAD	3	2	1	0
Total Values	16	16	16	16
%Values >MAD	19	12	6	0
Mainstem Stations, October, 1986				
E. coli MAD	235	298	406	576
Values >MAD	0	0	0	0
Total Values	16	16	16	16
%Values >MAD	0	0	0	0
Tributary Stations, June, 1986				
E. coli MAD	235	298	406	576
Values >MAD	1	9	7	4
Total Values	12	12	12	12
%Values >MAD	92	75	58	33
Tributary Station, October, 1986				
E. coli MAD	235	298	406	576
Values >MAD	4	4	4	3
Total Values	10	10	10	10
%Values >MAD	40	40	40	30

Table 18: Enterococci Data Comparisons to Single Sample Maximum Allowable Density (MAD)				
	Designated Beach Area	**Moderate Full Body Contact Recreation**	**Lightly Used Full Body Contact Recreation**	**Infrequent Full Body Contact Recreation**
Mainstem Staions, October, 1986				
Enterococci MAD	61	89	108	151
Values >MAD	3	3	2	2
Total Values	15	15	15	15
%Values >MAD	20	20	13	13
Tributary Stations, October, 1986				
Enterococci MAD	61	89	108	151
Values >MAD	4	3	2	2
Total Values	10	10	10	10
%Values >MAD	20	20	13	13

The tributary streams, however, are subject to bacteriological pollution resulting in noncompliance with PCR KSWS.

Algae

One hundred seventy-four algal taxa, representing five algal divisions, were collected from the North Elkhorn drainage during the study period (Appendix J and K). Total numbers of taxa per individual station ranged from 43 at station 16-6 (North Elkhorn Creek below the WWTP discharge) to 83 at station 16-24 (Dry Run). The filamentous green alga, Cladophora glomerata, was present at all sites, and abundant at most. This species, which can form long, ropey bundles of filaments over a meter long, is typical of Bluegrass Region streams. The limestone bedrock substrate, high nutrient inputs from surrounding agricultural and urban areas, warm water temperatures, and moderate to fast current conditions favor the growth of Cladophora during late spring, continuing throughout the summer.

We identified 35 taxa of Chlorophyta (green algae); 14 taxa of Cyanophyta (blue-green algae); five taxa of Euglenophyta; two species of Rhodophyta (red algae); and 118 taxa of Chrysophyta, one from the family Vaucheriaceae (Vaucheria sp.) and the remaining 117 from the family Bacillariophyceae (diatoms). Of the 57 non-diatom taxa, 32 are periphytic (growing attached to a substrate) or tychoplanktonic (entangled among other filaments), while 25 are euplanktonic (floating). The high percentage of euplanktonic taxa is attributable to the series of small

impoundments on Elkhorn Creek, as well as transport of some species from neighboring farm ponds. Several euplanktonic diatom species were abundant both during this sampling period and in summer plankton samples collected in 1985 (Metzmeier 1987).

The periphyton bioassessment index (PBI), including values for the metrics used in the bioassessment, is summarized in Table 19. The metrics used in the PBI are: total number of diatom taxa (TNDT), diatom diversity (d), diatom taxonomic index (DTI), relative abundance of sensitive species (RA_s), and percent community similarity (PS_c). Scores for the values for each metric were derived from Table 3 (Methods Section).

The diatom communities of North Elkhorn Creek sites 16-1, 16-13 and 16-14, and Dry Run (16-24) received PBI ratings of 3.2, 3.0, 3.2, and 3.5, respectively, and are classified as "good". The slight impairment in those North Elkhorn sites, indicated by these PBI scores (Table 2), results from a predominance of species that are either tolerant of or prefer high nutrient concentrations. In addition, the impoundments built along the length of North Elkhorn Creek slow water flow to the point where planktonic diatoms flourish, and the input of nutrients, especially phosphorus, causes periodic algal blooms, particularly in the summer. The planktonic diatoms settle to the substrate or become entangled in algae filaments causing them to be collected along with the periphyton. As a result taxa richness and diatom diversity were high at those

Table 19: North Elkhorn Creek Drainage Diatom Date Summary: Metric Values and Periphyton Bioassessment Index (PBI) Scores by Station

Station	TNDT	d	DTI	RA_s	PS_c	PBI	WAH Use Impairment
16-1	52	4.0	1.7	5.9	30.8	3.2	Partially
*	4	4	2	3	3	Good	Supporting
16-5	41	3.5	2.0	1.3	31.2	2.8	Partially
*	3	3	2	3	3	Fair	Supporting
16-6	32	2.2	1.1	0.4	13.7	2.0	Not
*	3	2	1	1	2	Poor	Supporting
16-9	39	3.0	1.7	0	47.8	2.4	Partially
*	3	3	2	1	3	Fair	Supporting
16-13	57	4.2	2.0	0.5	-	3.0	Partially
*	4	4	2	2	NA	Good	Supporting
16-14	63	4.2	1.6	2.3	33.3	3.2	Partially
*	4	4	2	2	3	Good	Supporting
16-24	49	4.7	2.3	2.3	-	3.5	Partially
*	3	5	3	3	NA	Good	Supporting
16-25	29	2.9	2.0	0.4	30.2	2.4	Partially
*	2	3	3	2	3	Fair	Supporting
16-26	38	1.7	2.1	0	20.2	2.2	Partially
*	3	2	3	1	2	Fair	Supporting

*DBI score for each metric
NA - Reference/control sites - not given PS_c scores
WAH - Warmwater Aquatic Habitat

three sites (Table 19), but the DTI and RA_s values were lower than expected in an unimpaired stream.

North Elkhorn sites 16-5 and 16-9, and both Lanes Run sites (16-25 and 16-26) received PBI ratings of 2.8, 2.4, 2.4, and 2.2, respectively, earning them each a rating of "fair", which indicates moderate water quality impairment. Species composition at these sites was obviously affected by both nutrient enrichment and the presence of impoundments, as species tolerant of either or both these conditions dominated. In addition, taxa richness and diversity values were lower than at those locations that rated as "good". The low values for those two metrics at Station 16-9 may be related to toxic effects of urban runoff from the city of Georgetown. Moderate impairment of the diatom communities of the Lanes Run sites is indicated by low taxa richness and diversity (compared to Dry Run), low community similarity to Dry Run, (PS_c = 30.2 and 20.2), and low numbers of sensitive species (Table 19). The Lanes Run diatom assemblage was dominated by epiphytes attached to the filamentous green alga, Cladophora glomerata, which almost completely covered the substrate at both sites. The profuse Cladophora growths and the dominance of diatoms that prefer nutrient enriched streams (eg. Gomphonema angustatum, Nitzschia paleacea, Navicula minima) are a result of the high nutrient (phosphorus and nitrogen) inputs from surrounding agricultural areas. The lack of any shade-providing canopy over these segments of Lanes Run also contributed to the extremely high biomass of Cladophora

observed at these sites, especially 16-26.

The North Elkhorn site below the Georgetown WWTP (16-6), received an PBI score of 2.0 and was classified "poor". This site had the lowest number of algal taxa (43) of all sites. The diatom community was impaired by municipal waste from Georgetown WWTP #1. Total number of diatom taxa (TNDT) was low and pollution-tolerant taxa were predominant. Navicula minima, which can tolerate oxygen-poor water (Lowe 1974) and large amounts of sulphides (Patrick 1977), and Nitzschia amphibia, a facultative nitrogen heterotroph (Patrick 1977), made up 46% and 36% of the diatom community, respectively. Less than 1% of the diatoms counted were species that are considered to be pollution intolerant (RA_s = 0.4).

In summary, the algal communities of the North Elkhorn drainage, with the exception of Station 16-6, are characteristic of productive nutrient-enriched Bluegrass Region streams. Nonpoint source runoff from agricultural land in the drainage is the primary nutrient source and main reason for the slight to moderate impairment at all stations. Station 16-6, downstream of Georgetown WWTP #1, was the only site classified as poor (severely impaired) by analysis of algal data.

Macroinvertebrates

Macroinvertebrate data have been previously collected from North Eklhorn by Laflin (1970), Heer (1974) and Taylor (1984). Laflin (1970) collected three surber samples on a monthly basis from each of two locations on North Elkhorn

during 1968 and 1969. One location was below Georgetown on Elkview Road (equivalent to KDOW 16-5), while the other site was above Georgetown on Huffman Mill road. Since his data were presented at the Order level of taxonomic identification, comparisons between his study and KDOW data are difficult. He observed that most major groups of aquatic insects, mollusks, and crustaceans were present at both locations. His data also indicated that ephemeropterans and trichopterans were important constituents of the community at both sites.

Heer (1974) studied the life history of the isopod Lirceus fontinalis from limestone dominated streams of North Elkhorn. This isopod is often a numerically dominant constituent of small to mid-sized limestone streams in the Bluegrass.

Taylor's (1984) preliminary survey of the freshwater mussels of the Elkhorn Creek system included two sites from North Elkhorn; one site 8 km west of Switzer and the other at the White Oak Pike bridge in Scott County. He found a total of 13 species at the two locations. According to KNPC (1991), the mussel Villosa fabula, which is listed by the Kentucky Academy of Science/Kentucky Nature Preserves Commission (KAS/KNPC) (Warren et al. 1986) as endangered, has been reported from the North Elkhorn Creek drainage.

A total of 129 taxa of macroinvertebrates were identified during this study (Appendix L). This included one Turbellaria, four Annellida, five Crustacea, nine mollusca, and 110 Insecta. The Insecta were most diverse group, being composed of seven Ephemeroptera (Mayflies), three Plecoptera

(stoneflies), 21 Odonata (Dragonflies and Damselflies), 12 Hemiptera (true bugs), 19 Coleoptera (beetles), two Megaloptera (Hellgrammites and fishflies), 11 Trichoptera (caddisflies), and 35 Diptera (flies) taxa.

The macroinvertebrate collection from station 16-16, located on the Whitney Farm, was inadequately preserved and therefore lost. A portion of the lower station on Lanes Run (16-25) had, prior to sampling, been subjected to instream bulldozer work resulting in the construction of an earthen dam across the creek. The upper station on Lanes run (16-26) was a small headwater stream that had apparently been channelized through a portion of the sampling area. This site was also apparently subjected to nutrient impacts, resulting in extensive Cladophora growths. The site on Dry Run (16-24) was sampled at near zero flow, so small pools were the major stream habitat. As a result of the above, these sites are subject to reduced total number of taxa (TNT) and Ephemeroptera-Plecoptera-Trichoptera (EPT) index values.

Total number of taxa values ranged from a high of 55 at station 16-13 on Johnson Mill Road to a low of 19 at station 16-24 on Dry Run (Table 20). The mainstem stations had values ranging from 36 to 55 while the tributaries varied from 19 to 37. Generally speaking, stations that exceed 50 taxa are considered to have diverse macroinvertebrate communities. Stations 16-6, located off US 460 at the Scott County Dog Pound had a reduced TNT (38). This site received treated municipal waste from Georgetown WWTP #1, which is 2 km (1.3 mi) upstream. Station 16-14 on Russell Cave Rd. also had a

Table 20: Macroinvertebrate Metric Data for the North Elkhorn Creek Drainage									
	Stations								
Metric	16-1	16-5	16-6	16-9	16-13	16-14	16-24	16-25	16-26
Total Number Taxa (TNT)	54	52	38	45	55	36	19	31	37
Total Number Individuals (TNI)	3862	355	218	338	438	191	82	846	745
(% of control)	881%	81%	50%	77%	*	44%	19%	193%	170%
EPT	12	10	9	8	9	5	1	5	7
% Community Dominance (%CD)	74	50	52	36	50	45	62	87	81

reduced TNT (36). This site had excellent habitat, good flow regimes, and suitable substrate. The physicochemical parameters were in line with the rest of the drainage; therefore, the reduction of TNT is not readily explained.

Ephemeroptera-Plecoptera-Trichoptera values ranged from a high of 12 at 16-1 to a low of 1 at 16-24 (Table 20). Most of the mainstem stations (16-5, 16-6, 16-9 and 16-13) had values ranging from 7 to 9. The two Lanes Run stations (16-25 and 16-26) had values generally less than the mainstem stations (Table 20). High quality streams in the Bluegrass would be expected to have EPT values approaching 15 taxa.

The total number of individuals (TNI) ranged from a high of 3,862 at station 16-1 to a low of 82 at station 16-24 (Table 20). The tributary streams ranged from a high of 846 at 16-25 to a low of 82 at 16-24. The two Lanes Run stations (16-25 and 16-26) had TNI values of 846 and 745 respectively, which is considerably higher than all mainstem sites except 16-1. Both 16-25 and 16-26 had large populations of the isopod Lirceus fontinalis.

The reduced TNT and EPT values observed at stations 16-6, 16-14, 16-24, 16-25, and 16-26 indicate that these sites are under stress. Station 16-6 is 2 km (1.3 mi) below the Georgetown WWTP #1. The chlorinated effluent from the WWTP is believed to be impacting this stream reach. Stations 16-14 and 16-24 were sampled during a low flow period, consequently the stream was pooled with little or no observable flow between pools. Small, intermittent headwater streams in the Bluegrass typically do not have as diverse a macroinvertebrate

fauna as do larger, permanent streams. Also, this stream appears to be subjected to an elevated nutrient load. At the time of sampling, dense filamentous algal growth, primarily associated Zygnematales and Cladophora, were abundant throughout the site. The combination of elevated nutrients and small stream size have apparently resulted in a reduced macroinvertebrate fauna in Dry Run. The Lanes Run stations (16-25 and 16-26) had similar TNTs, EPTs, and TNIs (Table 20). These stations also had similar percent community dominance (% CD) values, which indicate that one or a few organisms are numerically dominating the macroinvertebrate community. The isopod Lirceus fontinalis composed 98% of the community at station 16-25 and 47% at station 16-25. Liceus fontinalis is common and often the numerically dominant macroinvertebrate in small, shallow, limestone streams of the Bluegrass. It also thrives in nutrient enriched waters, such as those found in Lanes Run.

Three stations had high TNI values, 16-1, 16-25, and 16-26. The latter two were discussed above. Station 16-1, located near the mouth of North Elkhorn, has broad expanses of limestone bedrock with moderate flows and shallow runs and riffles. This site has elevated nutrients as evidenced by the dense growth of periphyton, especially Cladophora and Zygnematales, that was present during sampling. A large percentage (43%) of the community was composed of the riffle beetle, Stenelmis. These beetles, present both in larval and adult forms, are considered scrapers (Merrit and Cummins 1984) feeding primarily on algae (Brown 1972). These beetles

require well-aerated lotic habitat and cannot tolerate pollution by wetting agents such as soaps and detergents (Brown 1972). This site is located far enough downstream from Georgetown to be free of wetting agents, is well aerated, and has an ample food supply; hence, a suitable habitat exists in which Stenelmis flourishes.

Four macroinvertebrate metrics (TNT, EPT, TNI, and %CD) were used to arrive at the macroinvertebrate bioassessment index (MBI) ranking (Table 21). Each metric is given a score ranging from one through five, with one being the lowest possible score and five being the highest. Scores of 4 to 5 indicate an excellent site, scores of 3 to 4 are considered good, scores ranging from 2-3 are deemed fair, and sites with scores of 1 to 2 are considered poor. Ranges for the metrics and associated scores are given in Table 4.

A review of the macroinvertebrate bioassessment ranking listed in Table 21 shows that the mainstem macroinvertebrate communities are either good or fair. Station 16-13 had an excellent ranking, but this station has a reduced EPT score. This is unexpected since this station has excellent stream habitats. Because of the reduced EPT value (8), the macroinvertebrate community at station 16-13 is considered as good. Two mainstem stations (16-6 and 16-14) were moderately impaired. Station 16-6 is located downstream of Georgetown WWTP #1; this plant's effluent has stressed the macroinvertebrate community in this stream reach. With the exception of elevated nutrients, impacts to station 16-14 located on North Elkhorn at Russel Cave Pike, are not

Table 21: Macroinvertebrate Bioassessment Index (MBI) Scores and Ranking for the North Elkhorn Creek Drainage						
Station	TNT	TNI	EPT Index	%CD	Average Score	Ranking
16-1	4.8	2	3.2	2.6	3.1	Good
16-5	4.7	3.9	2.8	5	4.1	Good
16-6	3.3	1.8	2.5	5	3.2	Fair
16-9	3.6	3.5	2.4	5	3.6	Good
16-13	5	**	2.5	5	4.2	Excellent
16-14	3.1	1.5	1.8	5	2.9	Fair
16-24*	3	1	1	3.3	2.1	Fair
16-25*	4	1.2	2	1	2.1	Fair
16-26*	4	1.3	2	1.5	2.2	Fair

* Parameters weighted for small intermittent streams.
** This station was considered the control, so the metric was not included in the scoring.

apparent. Excellent habitat exists throughout this stream reach. The tributary streams (Dry Run, 16-24, and Lanes Run, 16-25 and 16-26) were ranked as moderately impaired. This is probably a function of intermittent stream flow, anthropgenic impacts, and elevated nutrients.

Fish

A total of 1788 fish representing 34 species were collected from nine sampling stations in the North Elkhorn Creek basin (Appendix M). Branson and Batch (1983) reported 40 species from North Elkhorn Creek, twenty-nine (73%) of which were also collected in this study.

Stations 16-1, 16-5, 16-6, 16-9, 16-13 and 16-14 were located along the mainstem of North Elkhorn Creek, and contained diverse, well-balanced fish communities. Index of Biotic Integrity (IBI) scores ranged from 48-58, and each of these communities was rated as either good or excellent based on these scores (Table 22). Station 16-6 was located approximately 1.5 mi. below the confluence with Royal Springs, the location where effluent from Georgetown WWTP #1 enters North Elkhorn Creek. Although eight intolerant species were collected, the community contained a higher number of omnivores than expected. Other components of the community were balanced; therefore, the North Elkhorn Creek fish community did not appear to be impacted (IBI 50/good) by the WWTP plant or by the elevated sediment pollutants during this sampling period (Tables 13 and 14).

Table 22: Index of Biotic Integrity for the North Elkhorn Creek Drainage[a]							
Station Name/Number	**Stream Size**	**Total Species**	**Total Individs**	**Darter Species**	**Sunfish Species**	**Sucker Species**	**Intol. Species**
North Elkhorn Ck. 16-1	V	+/19	+/302	+/4	+/4	+/2	+/8
North Elkhorn Ck. 16-5	V	+/21	+/258	+/4	+/5	0/1	+/8
North Elkhorn Ck. 16-6	IV	+/18	+/215	+/4	+/3	0/1	+/8
North Elkhorn Ck. 16-9	III	+/14	+194	0/2	+/3	-/0	0/4
North Elkhorn Ck. 16-13	III	+/19	+/270	0/2	+/5	-/3	+/7
North Elkhorn Ck. 16-14	III	+/16	+224	0/3	0/2	0/1	+/6
Dry Run 16-24	II	0/9	+/95	0/2	-/1	-/0	-/1
Lanes Run 16-25	II	+/11	+/126	0/2	+/3	-/0	-/1
Lanes Run 16-26	II	0/4	+/104	-/0	+/2	-/0	-/0

Table 22: (Continued)								
Station Name/Number	Omni-vores	Insecti-vorous Cyprinids	Green Sunfish	Top Carni-vores	Hybrids	Diseased etc.	IBI[b] Index	Bio-assess-ment Score (C)
North Elkhorn Ck. 16-1	+/6.3	+/76.5	+/<1	0/3	+/0	+/0	58(E)	5
North Elkhorn Ck. 16-5	+/15.5	0/37.2	+/1.2	+/6.2	+/0	+/0	56(E)	5
North Elkhorn Ck. 16-6	-/52.6	0/36.7	+/0	0/1.9	+/0	+/0	50(G)	4
North Elkhorn Ck. 16-9	+/7.2	0/36.1	+/1.0	0/4.1	+/0	+/0	48(G)	4
North Elkhorn Ck. 16-13	0/39.3	-/12.2	+/1.1	0/4.4	+/0	+/0	48(G)	4
North Elkhorn Ck. 16-14	+/16.5	-/11.2	+/<1	0/1.3	+/0	+/0	48(G)	4
Dry Run 16-24	-/57.9	-/2.1	+/0	-/0	+/0	+/0	32(P)	1
Lanes Run 16-25	+/19.1	-/0	0/7.1	-/0	+/0	+/0	40(F)	2
Lanes Run 16-26	-/52.9	-/0	-/21.2	0/1.9	+/0	+/0	32(P)	1

[a]Scores are assigned as 1 for (-); 3 for (0) and 5 for (+)
[b]E = Excellent F = Fair
G = Good P = Poor
[c]For conversion values, see Table 5

Fish communities at the Lanes Run stations (16-25 and 16-26) were rated as fair (40) and poor (32), respectively. Only four species were collected upstream of the proposed Georgetown WWTP #2 (Lanes Run discharge) at Station 16-26. The small stream size, increased algal growth, and intermittent flows in summer months probably accounted for the poor fish community observed at this station. Most of the species observed here are tolerant to low levels of oxygen, turbidity, and silt (Karr et al., 1986). Also, darters, suckers, and other intolerant species were not found at this site. At 16-25, the lower Lanes Run station, eleven species were collected. Although a portion of the station had been impacted by instream bulldozer activity and large numbers of cattle, the fish community was rated as fair (IBI 40).

The fish community at Station 16-24 (Dry Run) was considered to be of poor quality based on the IBI score of 32. Although nine species were collected, only one intolerant species was found and the community was numerically dominated by omnivores (Table 22). Branson and Batch (1983) have previously reported four species from Dry Run. Based on our findings, the fish community in Dry Run is limited by the frequent occurrence of low to no flow conditions.

Overall, North Elkhorn Creek supported a diverse fish fauna, with well-balanced communities found at most sampling stations. Exceptions were the fish communities found in small tributaries with low oxygen levels, intermittent flows and reduced habitat.

The IBI scores are converted to scores between 1 and 5

(Table 5) to rate the fish communities as either excellent, good, fair, or poor, and for use in the BAI. The data presented in Table 22 shows that the fish communities in the mainstem of North Elkhorn are either excellent or good. The two tributaries sampled (Dry Run and Lanes Run) are either good or fair, however this impairment is probably related to conditions other than poor water quality, i.e., low flow conditions.

Fish Tissue

Twelve whole-body and eight fillet samples were analyzed as part of this study. These samples were collected during 1986 and 1987 from six North Elkhorn Creek stations, and represented eight species. Most samples were analyzed for metals, pesticides and pesticide metabolites, PCB Aroclors, and percent lipids. Analytical results for 1986 and 1987 samples are shown in Appendix N, and discussed below.

The FDA action level for chlordane (0.3 ppm) was exceeded in the carp fillet sample from Station 16-3 (0.331 ppm). While no other FDA action levels were exceeded in the fillet samples, two of these had chlordane levels which approached the FDA action levels: catfish (0.208 ppm) at Station 16-3 and carp (0.248 ppm) at Station 16-16. Catfish and carp fillet samples from Station 16-9 also had somewhat elevated total chlordane values (0.133 and 0.127 ppm, respectively), but were below the FDA action level. These results indicate that exposures to chlordane are occurring throughout the North Elkhorn system.

Sediment concentrations of chlordane isomers were all

below analytical detection levels of 0.01 mg/kg (Appendix I), and chlordane isomers were not analyzed in the water samples (Appendices B-F). For these reasons, a source of the chlordane could not be determined. Follow-up sampling and analysis of fish samples is recommended along with concurrent sediment and water sampling.

PCBs and DDT concentrations in fillet samples were well below their respective FDA action levels (2.0 ppm and 5.0 ppm), and were frequently below analytical detection levels. Likewise, mercury (Hg) values in the fillet samples did not exceed the FDA action level of 1.0 ppm. Comparison of residue concentrations in whole-body samples to FDA action levels is not discussed, as these regulatory levels do not apply to whole-body samples.

Overall, residues of organochlorine compounds in the North Elkhorn fish whole-body samples were predominantly below analytical detection limits. Total DDT, PCBs and total chlordane values were usually below geometric mean values reported by the National Contaminant Biomonitoring program (NCBP). Several exceptions noted include: Aroclor 1248 in the rockbass sample from Station 16-2; total chlordane residues in bass, catfish, and carp samples from Station 16-9; and total chlordane in carp at Station 16-13. Although six isomers of chlordane are included in the NCBP organochlorine data, nine isomers are routinely used in the DOW monitoring program.

Arsenic, Cd, Hg and Pb concentrations in the whole-body samples were generally at or below mean values determined in

the NCBP. The few exceptions noted were Hg (0.267 ppm) in the redhorse sample from Station 16-1 and Pb (1.03 ppm) in the rockbass sample from Station 16-1. Zinc (Zn) concentrations were comparable to the NCBP mean and 85th percentile values except for carp whole-body samples at Stations 16-9 and 16-13. Copper (Cu) residues in whole-body samples were consistently higher than NCBP results.

At station 16-1, Hg concentrations exceeded the KSWS chronic criterion (0.012 ug/l) in water samples collected during the fall of 1986 (Table 8) and 1987 (Table 10). Mercury levels in the sediment samples collected at station 16-1 were not in the moderately or heavily polluted categories (Tables 12, 13, 14) used by U.S. EPA (1977). Although no lower limit for Hg has been established by U.S. EPA for sediment, only 3 of 18 (17%) Hg values in 1986, and 2 of 8 (25%) in 1987, exceeded the 0.1 ppm no effect level proposed by the Ontario Ministry of the Environment (Persaud et al. 1989). Since Hg levels in water samples collected in 1987 and 1988 consistently exceeded the water quality criterion to protect human health for fish consumption (0.146 ug/l), additional sampling and analysis of fish is recommended.

Although KSWS were not exceeded, Pb was considered to be slightly elevated in water samples from stations 16-1 and likewise for Zn at station 16-9. Since no sediment samples were collected at station 16-13, no evaluation can be made regarding potential contaminant exposures at that site. Station 16-13 should be included in any follow-up sampling.

Although the reason is not clear, hexachlorobenzene was

detected at substantially higher levels in the 1987 samples.

The fillet and whole-body sample results identify chlordane as a contaminant of concern. While the FDA action level was exceeded only once in this data set, chlordane was prevalent throughout the North Elkhorn Creek system and follow-up analysis is recommended. Lead and mercury are also contaminants of concern and should continue to be monitored.

Toxicity

Instream acute toxicity tests were performed at 13 locations in the North Elkhorn Creek drainage on the fathead minnow (Pimephales promelas) and the waterflea (Ceriodaphnia dubia) from April 2 to April 11, 1986 (Tables 23 and 24). During this same time period, acute and chronic toxicity tests were conducted on the Georgetown WWTP #1 (Tables 25 and 26).

Instream acute test data (Table 23 and 24) show that acute toxicity occurred at station 16-7, which is located on North Elkhorn Creek directly below Royal Springs. Toxicity at this location is attributed at least in part to chlorine, which was transported to this location in the Georgetown WWTP #1 effluent.

Acute toxicity tests on the Georgetown WWTP #1 effluent consisted of a 96 hr static renewal using Pimephales promelas and a 48 hr static test using Ceriodaphnia dubia; the chronic test consisted of a daily renewal, 9-day embryo-larval test on the fathead minnow. Both prechlorinated and chlorinated final effluent samples were tested. The results of the acute test on the prechlorinated effluent showed it was toxic (Table 25),

Table 23: Acute Toxicity Tests (Pimephales promelas) for Selected Stations in the North Elkhorn Creek Drainage			
	Pimephales promelas % survival		
Site No.	Stream	MP	Mean % Survival
16-1	N. Elkhorn Creek	17.9	90
16-5	N. Elkhorn Creek	44.2	100
16-6B	N. Elkhorn Creek	45.9	90
16-7	N. Elkhorn Creek	50.8	90
16-8	N. Elkhorn Creek (above dam)	50.9	95
16-10	N. Elkhorn Creek	55.5	100
16-11	N. Elkhorn Creek	55.7	100
16-19	Cane Run	0.2	100
16-25A	Lane's Run	0.5	90
16-25B	Lane's Run	1.7	100
16-26	Lane's Run	5.5	85
16-22	Royal Springs	0.1	0
16-23	Royal Springs	0.7	75
Control	control		100
(Dechlorinated Tap)	control		100

Table 24: Acute Toxicity Tests (Ceriodaphnia dubia) for Selected Stations in the North Elkhorn Creek Drainage			
	Ceriodaphnia dubia % survival		
Site No.	Stream	MP	Mean % Survival
16-1	N. Elkhorn Creek	17.9	95
16-5	N. Elkhorn Creek	44.2	100
16-6B	N. Elkhorn Creek	45.9	100
16-7	N. Elkhorn Creek	50.8	50
16-8	N. Elkhorn Creek (above dam)	50.9	100
16-10	N. Elkhorn Creek	55.5	95
16-11	N. Elkhorn Creek	55.7	100
16-19	Cane Run	0.2	85
16-25A	Lane's Run	0.5	100
16-25B	Lane's Run	1.7	ND
16-26	Lane's Run	5.5	100
16-22	Royal Springs	0.1	0
16-23	Royal Springs	0.7	90
Control	control		
(Dechlorinated Tap)	control		95

ND - Not Determined

Table 25: Acute Toxicity Test for the Georgetown Wastewater Treatment Plant No. 1 In April, 1986

	Prechlorinated Effluent		Final Effluent	
% Effluent	% Survival of Fathead Minnow, 96 hr. Static Renewal	% Survival of Fathead Minnow, 48 hr. Static	% Survival of Fathead Minnow, 96 hr. Static Renewal	% Survival of Ceriodaphnia 48 hr. Static
100	75	0	0	0
71	100	0	0	0
50	100	45	0	0
35	100	55	0	0
18	100	85	60	0
5	-	70	70	55
1	-	-	80	95
Royal Spring stream above	75	90	75	90
stream below	0	0	0	0
control	100	90	100	90

Table 26: Chronic Fathead Minnow 9-Day Embryo-Larval Test (Daily Renewal) for the Georgetown Wastewater Treatment Plant No. 1 in April, 1986

% Effluent	% Survival
71	0
50	0
35	0
18	0
5	60
1	83
stream above	86
stream below	0
control	98

with an estimated LC_{50} of 100% for fathead minnows and an estimated LC_{50} of 43% for Ceriodaphnia. The chlorinated effluent was highly toxic to both species (Table 25), with a LC_{50} of 21% for fatheads and 6% for Ceriodaphnia. The chronic test conducted on prechlorinated effluent yielded toxicity (Table 26) with an estimated LC_{50} for the fathead minnow of 7%.

The above data indicate that the Georgetown WWTP #1 effluent, whether chlorinated or not, is acutely toxic to both fish and aquatic invertebrates. The data show that chronic toxicity from the effluent also occurs, and at very low concentrations. This may explain the reduced aquatic macroinvertebrate fauna observed at Station 16-6, which is located 2km (1.3 mi) downstream of the Georgetown WWTP #1. Chlorine appeared to be the principal component of toxicity in the effluent; however, other constituents of the effluent are also causing toxicity.

Literature Cited

American Public Health Association. (APHA) 1989. Standards Methods for the Examination of Water and Wastewater. 17th Edition. Am. Publ. Heal. Assoc., Am. Water Works Assoc., Water Poll. Contr. Fed., Washington, D. C.

Bower, D. E. and W. H. Jackson. 1981. Drainage areas of streams at selected locations in Kentucky. U.S. Dept. Int., Geol. Surv., Louisville, Ky. Open File Rept. 81-61.

Bradfield, A.D. and S.D. Porter. 1990. Summary of Geological Investigation Relating to Surface Water Quality in the Kentucky River Basin, Kentucky. U.S. Geol. Survey., Water Res. Invest. Rpt. 90-4051.

Brown, H. P. 1972. Biota of freshwater ecosystems identification manual No. 6. Aquatic dryopoid beetles (Coleoptera) of the United States. U.S. EPA, Water Poll. Confr. Res. Ser. 18050ELD04/72.

Cole, G.A., 1975. Textbook of Limnology. C.V. Mosby Co. Saint Louis, MO.

Descy, J.P. 1979. A new approach to water quality estimation using diatoms. Nova Hedwigia. 64: 305-323.

Elkin, R. L. 1984. Life history of Etheostoma spectible in central Kentucky. M.S. Thesis, Univ. of KY, Lexington, KY.

Foree, E. G. 1974. Assessment of surface water quality in the Lexington, Kentucky metropolitan region. Off. Res. Eng. Serv., Coll. Eng. Univ. KY. UKY TR92-74-CE23.

Hannan, R. R., M. L. Warren, Jr., K. E. Camburn, and R. R. Cicerello. 1982. Recommendations for Kentucky outstanding resource water classifications with water quality criteria for protection. KY Nat. Pres. Comm. Frankfort, KY Tech: Rept.

Heer, L. M. 1974. Comparative life history of Lirceus fontinalis, Rafinesque (Isopoda, Asellota), in two limestone creeks near Lexington, Kentucky. M.S. Thesis. Univ. of KY, Lexington, KY.

Jones, A. R. 1968. Changes in the bass population of Elkhorn Creek following the establishment of a size limit. Dept. Fish. Wildl. Res., KY Fish Bull. No. 45.

Jones, A. R. 1973. Inventory and classification of streams in the Kentucky River drainage. KY Dept. Fish & Wildl. Res., Bull. No. 56.

Kentucky Nature Preserves Commission (KNPC). 1991. Natural heritage database. KNPC, Frankfort, KY.

Kentucky Division of Water. 1986. Quality assurance guidelines. Biol. Analy. Sect., Div. Water, Dept. Environ. Prot., KY Nat. Res. Environ. Prot. Cab., Frankfort, KY.

_____. 1987a. Standard operating opocedures manual. KY Dept. Envir. Prot., Div. Water, Water Qual. Branch. Biol. Analy. Sect., Frankfort, KY.

_____. 1987(b). Methods for Culturing and Conducting Toxicity Test with Pimephales promelas, Daphnia pulex and Ceriodaphnia sp. (Second Edition). KY Dept. Environ. Prot., Div. Water, Biol. Analy. Sect.,

Frankfort, KY.

_____ (in draft). Standard Operating Procedures. Revision 1. Water Quality Branch. Division of Water, Frankfort, KY.

_____. 1990 Kentucky Report to Congress on Water Quality. DOW, Frankfort, KY 187 pp. Lachner, E. A. and R. E. Jenkins. 1967. Systematics, distribution, and evolution of the chub genus Nacomis (Cyprinidae) in the southwestern Ohio River basin, with the description of a new species. Copeia, 1967: 557-580.

Laflin, B. D. 1970. Some effects of municipal sewage pollution upon the biota and water quality of Elkhorn creek. KY Dept. Fish & Wildl. Res., Bull. No. 55.

Lange-Bertalot, H., 1979. Pollution tolerance of diatoms as a criterion for water quality estimation. Nova Hedwigia. 64: 295-304.

Melcher, N. B. and K. J. Ruhl. 1984. Streamflow and basin characteristics at selected sites in Kentucky. USGS, Open-File Dept. 84-704.

Merritt, R. W. and K. W. Cummins. Editors. 1984. An Introduction to the Aquatic Insects of North America, Second Edition. Kendall/Hunt Publishing Company. Dubuque, IA.

Metzmeier, L.A. 1987. Longitudinal distribution and abundance of diatoms in summer plankton samples from the Kentucky River basin. Masters Thesis. Univ. of Louisville, Louisville, KY.

Miller, Wihry and Lee, 1975. The River Basin water quality management plan for Kentucky - Kentucky River. KY. Dept. Nat. Res. and Environ. Prot.

Patrick, R. and C.W. Reimer. 1975. The Diatoms of the United States. Vol. 2, Part 1. Monogr. Acad. Sci. of Phila. No. 13. Philadelphia, PA.

Persaud, D., R. Jaagumagi, and A. Hayton. 1989. Development of Provincial sediment quality guideines. Ont. Min. Environ., Water Res. Br., Aquatic Biol. Sec. Toronto, Ontario, Canada.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, R.M. Hughes. 1989. Rapid Bioassessment protocols for use in streams and rivers: benthic macroinvertebrates and fish. U.S. EPA, Office of Water, EPA/444/4-89-001, Washington, DC.

Quarterman, E. and R. L. Powell. 1978. Potential ecological/geological natural landmarks of the Interior Low Plateaus. U.S. Dept. Int., Nat. Park Serv., Washington, D.C.

Ruhl, K.J. and G.R. Martin. 1991. Low-flow characteristics of Kentucky Streams. U.S. Geol. Surv., Water Res. Invest. Rept. 91-4097.

Sehlinger, B. 1978. A canoeing and kayaking guide to the streams of Kentucky. Thomas Press, Ann Arbor, MI.

Sehlinger, B. and W. Underwood. 1980. A fishing guide to the streams of Kentucky. Thomas Press. Ann Arbor, MI.

Shackleford, Bruce. 1988. Rapid bioassessments of lotic macroinvertebrate communities: biocriteria development.

AK Dept. Poll. Contr. and Ecol. Little Rock, AK.

STORET. 1983-1989. United States Environmental Protection Agency water quality file. U.S. EPA, Office of Reg. and Stds., Washington, D.C., U.S. Environmental Protection Agency, 1977.

Taylor, R. W. 1984. Preliminary survey of the mussels of Elkhorn Creek, north central Kentucky. Trans. KY Acad. Sci., 45:73.

Warren, M. L., Jr., W. H. Davis, R. R. Hannan, M. Evans, D. L. Batch, B. D. Anderson, B. Palmer-Ball, Jr. J. R. MacGregor, R. R. Cicerello, R. Athey, B. A. Branson, G. I. Fallo, B. M. Burr, M. E. Medley, and J. M. Baskin. 1986. Endangered, threatened, and rare plants and animals of Kentucky. Trans. KY Acad. Sci., 47:83-98.

Westerman, D. T. C. 1980. Biology of the rosefin shiner, Notropis ardens lythrurus (Jordan). M. S. Thesis. Univ. of KY, Lexington, KY.

APPENDIX A
Site Information

Site No: 04016001 (16-1) Type Sampling: Physicochemical
Waterbody No: KY 5100205-019 Segment
Stream: North Fork Elkhorn Creek Bacteriological
County: Franklin Biological
Location: Off U.S. 460 upstream of KY 1689 bridge Fish Tissue
Latitude:38 - 13 - 17 Toxicity
Longitude: 84 - 47 - 40
Stream Order: V
USGS Topo Quad: Frankfort East
DOW Map No.: 14 - 42
MP: 18.2
Sampling Dates: 2 & 3 June 86, 2 April 86, 5 August 86, 31 Oct. 86, 6 January 87, 28 September 87, 7 July 88

Site No: 04016002 (16-2) Type Sampling: Physicochemical
Waterbody No: KY 5100205-019 Sediment
Stream: North Elkhorn Creek Bacteriological
County: Franklin
Location: At Switzer Covered Bridge
Latitude: 38 - 15 - 15
Longitude: 84 - 45 - 07
Stream Order: V
USGS Topo Quad: Switzer, KY
DOW Map No.: 15 - 42
MP: 25.1
Sampling Dates: 2 & 3 June 86, 31 October 86

Site No: 04016003 (16-3) Type Sampling: Physicochemical
Waterbody No: KY 5100205-019 Sediment
Stream: North Elkhorn Creek Bacteriological
County: Scott
Location: Off White Oak Pke, downstream of McConnel Run
Latitude: 38 - 14 - 37
Longitude: 84 - 41 - 40
Stream Order: V
USGS Topo Quad: Midway, KY
DOW Map No.: 14 - 43
MP: 34.8
Sampling Dates: 2 & 3 June 86, 31 October 86

Site No: 04016004 (16-4) Type Sampling: Physicochemical
Waterbody No: KY 5100205-019 Bacteriological
Stream: North Elkhorn Creek
County: Scott
Location: Off Galloway Road
Latitude: 38 - 13 - 58
Longitude: 84 - 39 - 14
Stream Order: V
USGS Topo Quad: Midway, KY
DOW Map No.: 14 -43
MP: 39.0
Sampling Dates: 2 & 4 June 86, 31 October 86

Site No: 04016005 (16-5) Type Sampling: Physicochemical
Waterbody No: KY 5100205-019 Sediment
Stream: North Elkhorn Creek Bacteriological
County: Scott Biological
Location: At dam of Elkview Road Fish Tissue
Latitude: 38 - 12 - 47 Toxicity
Longitude: 84 - 37 - 37
Stream Order: V
USGS Topo Quad: Midway, KY
DOW Map No.: 14 - 43
MP: 44.2
Sampling Dates: 2 & 4 June 86, 2 April 86, 6 Aug. 86, 31 Oct. 86, 6 January 87, 29 Sept. 87, 7 July 88

Site No: 04016006 (16-6) Type Sampling: Physicochemical
Waterbody No: KY 5100205-022 Sediment
Stream: North Elkhorn Creek Bacteriological
County: Scott Biological
Location: West of Georgetown off 460 at Dog Pound Fish Tissue
Latitude: 38 - 12 -41 Toxicity
Longitude: 84 - 34 - 18
Stream Order: V
USGS Topo Quad: Georgetown, KY
DOW Map No.: 14 - 44
MP: 49.7
Sampling Dates: 2 & 4 June 86, 2 April 86, 6 August 86, 31 Oct. 86, 6 January 87, 29 Sept. 87, 7 July 88

Site No: 04016007 (16-7) Type Sampling: Physicochemical
Waterbody No: KY 5100205-022 Bacteriological
Stream: North Elkhorn Creek Toxicity
County: Scott
Location: Just below confluence with Royal Springs
Latitude: 38 - 13 - 04
Longitude: 84 - 33 - 55
Stream Order: V
USGS Topo Quad: Georgetown, KY
DOW Map No.: 14 - 44
MP: 50.8
Sampling Dates: 2 April 86, 2 & 4 June 86, 31 Oct. 86, 29 September 87

Site No: 04016008 Type Sampling: Physicochemical
Waterbody No: KY 5100205-022 Bacteriological
Stream: North Elkhorn Creek Fish Tissue
County: Scott Toxicity
Location: Upstream of US 25 bridge at old Mill Dam
Latitude: 38 - 13 - 06
Longitude: 84 - 33 - 50
Stream Order: V
USGS Topo Quad: Georgetown, KY
DOW Map No.: 14-44
MP: 50.9
Sampling Dates: 2 April 86, 2 & 4 June 86, 31 October 86, 10 April 87

Site No: 04016009 (16-9) Type Sampling: Physicochemical
Waterbody No: KY 5100205-022 Sediment
Stream: North Elkhorn Creek Bacteriological
County: Scott Biological
Location: Off Degaris Mill Rd Below Old Mill Dam Fish Tissue
Latitude: 38 - 13 - 19
Longitude: 84 - 32 - 45
Stream Order: V
USGS Topo Quad: Georgetown, KY
DOW Map No.: 14 - 44
MP: 53.6
Sampling Dates: 2 & 5 June 86, 7 August 86, 1, 17, & 31 October 86, 6 January 87, 29 September 87, 7 July 88

Site No: 04016010(16-10) Type Sampling: Physicochemical
Waterbody No: KY 5100205-022 Bacteriological
Stream: North Elkhorn Creek Toxicity
County: Scott
Location: Downstream of Lanes Run of Dover Rd.
Latitude: 38 - 12 - 37
Longitude: 84 - 31 - 50
Stream Order: V
USGS Topo Quad: Georgetown, KY
DOW Map No.: 14 - 44
MP: 55.5
Sampling Dates: 2 April 86, 2 & 5 June 86, 31 October 86

Site No: 04016011 (16-11) Type Sampling: Physicochemical
Waterbody No: KY 5100205-024 Bacteriological
Stream: North Elkhorn Creek Toxicity
County: Scott
Location: Just above the confluence with Lanes Run
Latitude: 38 - 12 - 42
Longitude: 84 - 31 - 39
Stream Order: V
USGS Topo Quad: Georgetown, KY
DOW Map No.: 14 - 44
MP: 55.7
Sampling Dates: 2 April 86, 2 & 5 June 86, 31 October 86

Site No: 04016012 (16-12) Type Sampling: Physicochemical
Waterbody No: KY 5100205-024 Sediment
Stream: North Elkhorn Creek Bacteriological
County: Scott
Location: At Crumbaugh Pike Bridge
Latitude: 38 - 12 - 20
Longitude: 84 - 30 - 50
Stream Order: V
USGS Topo Quad: Georgetown, KY
DOW Map No.: 14 - 44
MP: 58.3
Sampling Dates: 2,5 & 9 June 86, 31 October 86

Site No: 04016013 (16-13) Type Sampling: Physicochemical
Waterbody No: KY 5100205-024 Sediment
Stream: North Elkhorn Creek Bacteriological
County: Scott Biological
Location: At Johnson Mill Rd. Bridge Fish Tissue
Latitude: 38 - 12 - 23
Longitude: 84 - 29 - 02
Stream Order: V
USGS Topo Quad: Centerville, KY
DOW Map No.: 14 - 45
MP: 62.5
Sampling Dates: 2 & 5 June 86, 9 August 86, 1,10 & 31 Oct. 86, 6 Jan. 87, 10 April 87, 29 September 87, 7 July 88

Site No: 04016014 (16-14) Type Sampling: Physicochemical
Waterbody No: KY 5100205-024 Sediment
Stream: North Elkhorn Creek Bacteriological
County: Fayette Biological
Location: At Russel Cave Pike Bridge
Latitude: 38 - 07 - 48
Longitude: 84 - 25 - 52
Stream Order: V
USGS Topo Quad: Centerville, KY
DOW Map No.: 14 - 45
MP: 78.3
Sampling Dates: 2 & 9 June 86, 9 August 86, 31 Oct. 86, 6 Jan. 87, 29 September 87

Site No: 04016015 (16-15) Type Sampling: Physicochemical
Waterbody No: KY 5100205-024 Sediment
Stream: North Elkhorn Creek Bacteriological
County: Fayette
Location: At Bridge Crossing on Elmendroff Farm
Latitude: 38 - 06 - 51
Longitude: 84 - 24 - 31
Stream Order: IV
USGS Topo Quad: Lexington East, KY
DOW Map No.: 13 - 45
MP: 82
Sampling Dates: 2 & 10 June 86, 31 Oct. 86

Site No: 04016016 (16-16) Type Sampling: Physicochemical
Waterbody No: KY 5100205-024 Sediment
Stream: North Elkhorn Creek Bacteriological
County: Fayette Fish Tissue
Location: Johnston Road Bridge
Latitude: 38 - 05 - 05
Longitude: 84 - 24 - 24
Stream Order: IV
USGS Topo Quad: Lexington East, KY
DOW Map No.: 13 - 45
MP: 86
Sampling Dates: 2 & 9 June 86, 17 & 31 Oct. 86, 6 Jan. 87, 29 September 87

Site No: 04016017 (16-17) Type Sampling: Physicochemical
Waterbody No: KY 5100205-020 Sediment
Stream: Lecomptes Run Bacteriological
County: Scott
Location: KY 1689 Bridge
Latitude: 38 - 16 - 21
Longitude: 84 - 42 - 20
Stream Order: IV
USGS Topo Quad: Stamping Ground, KY
DOW Map No.: 15 - 43
MP: 1.5
Sampling Dates: 2 &3 June 86, 31 October 86

Site No: 04016018 (16-18) Type Sampling: Physicochemical
Waterbody No: KY 5100205-020 Sediment
Stream: McConnell Run Bacteriological
County: Scott
Location: Off White Rd at Ford near Mouth
Latitude: 38 - 14 - 33
Longitude: 84 - 41 - 10
Stream Order: IV
USGS Topo Quad: Midway, KY
DOW Map No.: 14 - 43
MP: 0.5
Sampling Dates: 2 & 3 June 86, 31 October 86

Site No: 04016019 (16-19) Type Sampling: Physicochemical
Waterbody No: KY 5100205-021 Sediment
Stream: Cane Run Bacteriological
County: Scott Toxicity
Location: At US 460 Bridge near Mouth
Latitude: 34 - 12 - 35
Longitude: 84 - 36 - 40
Stream Order: III
USGS Topo Quad: Georgetown, KY
DOW Map No.: 14 - 44
MP: 0.2
Sampling Dates: 2 April 86, 2 & 4 June 86, 31 October 86, 6 January 87

Site No: 04016020 (16-20) Type Sampling: Physicochemical
Waterbody No: KY 5100205-021 Bacteriological
Stream: Cane Run
County: Scott
Location: At US 25 Bridge
Latitude: 34 - 10 - 18
Longitude: 84 - 33 - 17
Stream Order: III
USGS Topo Quad: Georgetown, KY
DOW Map No.: 14 - 44
MP: 5.8
Sampling Dates: 2 & 5 June 86, 31 October 86

Site No: 04016021 (16-21) Type Sampling: Physicochemical
Waterbody No: KY 5100205-021 Sediment
Stream: Cane Run Bacteriological
County: Fayette
Location: KY 922 Bridge
Latitude: 38 - 04 - 50
Longitude: 84 - 29 - 34
Stream Order: III
USGS Topo Quad: Lexington East, KY
DOW Map No.: 13 - 45
MP: 15.1
Sampling Dates: 2 & 10 June 86, 31 October 86

Site No: 04016022 (16-22)0 Type Sampling: Physicochemical
Waterbody No: KY 5100205-023 Bacteriological
Stream: Royal Springs Toxicity
County: Scott
Location: Just above WWTP outfall
Latitude: 38 - 13 - 01
Longitude: 84 - 33 - 48
Stream Order: I
USGS Topo Quad: Georgetown, KY
DOW Map No.: 14 - 44
MP: 0.1
Sampling Dates: 2 April 86, 2 & 4 June 86, 31 October 86

Site No: 04016023 (16-23) Type Sampling: Physicochemical
Waterbody No: KY 5100205-023 Bacteriological
Stream: Royal Springs Toxicity
County: Scott
Location: At Water Treatment Plant (at Source)
Latitude: 38 - 12 - 31
Longitude: 84 - 33 - 42
Stream Order: I
USGS Topo Quad: Gerogetown, KY
DOW Map No.: 14 - 44
MP: 0.7
Sampling Dates: 2 April 86, 2 & 4 June 86, 31 October 86

Site No: 04016024 (16-24) Type Sampling: Physicochemical
Waterbody No: KY 5100205-023 Sediment
Stream: Dry Run Bacteriology
County: Scott Biology
Location: Off US 25 at Rosemont Farm
Latitude: 38 - 14 - 08
Longitude: 84 - 34 - 04
Stream Order: IV
USGS Topo Quad: Georgetown, KY
DOW Map No.: 14 - 44
MP: 1.2
Sampling Dates: 2 & 5 June 86, 30 April 86, 31 Ocotber 86

Site No: 04016025 (16-25) Type Sampling: Physicochemical
Waterbody No: KY 5100205-023 Sediment
Stream: Lanes Run Bacteriological
County: Scott Biological
Location: At US 460 Bridge Toxicity
Latitude: 38 - 13 - 01
Longitude: 84 - 31 - 28
Stream Order: III
USGS Topo Quad: Georgetown, KY
DOW Map No.: 14 - 44
MP: 0.5
Sampling Dates: 2 & 22 April 86, 2 June 86, 31 October 86, 6 January 87, 29 September 87

Site No: 04016026 (16-26) Type Sampling: Physicochemical
Waterbody No: KY 5100205-023 Sediment
Stream: Lanes Run Bacteriological
County: Scott Biological
Location: Delaplain Rd Bridge Toxicity
Latitude: 38 - 16 - 13
Longitude: 84 - 31 - 11
Stream Order: II
USGS Topo Quad: Delaplain, KY
DOW Map No.: 15 - 44
MP: 5.5
Sampling Dates: 2 & 22 April 86, 2 June 86, 31 October 86, 6 January 87

Site No: 04016027 (16-27) Type Sampling: Physicochemical
Waterbody No: KY 5100205-025 Bacteriological
Stream: Goose Creek
County: Scott
Location: KY 922 Bridge
Latitude: 38 - 10 - 37
Longitude: 84 - 29 - 03
Stream Order: III
USGS Topo Quad: Centerville, KY
DOW Map No.: 14-45
MP: 0.1
Sampling Dates: 2 & 9 June 86, 31 October 86

Site No: 04016028 (16-28) Type Sampling: Physicochemical
Waterbody No: KY 5100205-025 Sediment
Stream: UT to North Elkhorn Creek
County: Fayette
Location: At Bryan Station Rd Bridge on C.V. Whitney Farm
Latitude: 38 - -05 - 48
Longitude: 84 - 23 - 14
Stream Order: IV
USGS Topo Quad: Lexington East, KY
DOW Map No.: 13 - 45
MP: 1.1
Sampling Dates: 2 & 10 June 86, 31 October 86

APPENDIX B

Physiocochemical Data* for the North Elkhorn Creek Drainage During the Summer, 1986

*Units in mg/l unless noted otherwise.

Appendix B: Physicochemical Data for the North Elkhorn Drainage During the Summer, 1986					
	Stations				
Parameter	16-1	16-2	16-3	16-5	16-6
Acidity	<0.1	5.77	0.728	7.02	9.36
Alkalinity	154	142	150	211	140
BOD	1.0	1.2	1.4	1.5	2.2
COD	13.2	14.5	12.6	13.6	14.7
Chloride	21.8	20.4	21.5	24.6	29.1
Conductivity (umhos/cm)	333	427	420	554	628
Cyanide, amenable	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoride	0.94	0.93	0.86	1.00	0.99
Hardness, total	206	191	203	195	221
Phenols	<0.005	<0.005	0.01	<0.005	<0.005
pH (SU)	8.4	8.0	8.0	7.7	6.8
TSS	12	30	8	16	13
TDS	272	216	248	260	302
Sulfate	36.1	36.5	34.9	40.8	54.2
TOC	4.2	4.3	4.2	4.3	4.2
Turbidity (NTU)	12.0	28	12	8.0	7.0
Ammonia Nitrogen	<0.05	0.159	<0.05	<0.05	<0.05
TKN	0.566	0.099	0.701	0.695	0.796
Nitrate	1.23	1.27	1.64	1.92	2.21
Phosphorus, Ortho	0.265	0.265	0.29	0.280	0.410
Phosphorus, total	0.315	0.335	0.365	0.330	0.470
Calcium	64.9	65.3	66.9	64.6	75.0
Magnesium	6.9	7.39	6.87	7.01	7.71
Potassium	2.42	2.71	2.87	2.82	2.96
Sodium	12	11.6	12.2	14.8	18.9
Aluminum, total	0.16	0.326	0.162	0.132	0.151

Appendix B: Continued					
	Stations				
Parameter	**16-1**	**16-2**	**16-3**	**16-5**	**16-6**
Arsenic, total	0.002	0.002	0.002	0.001	0.001
Barium, total	0.054	0.044	0.037	0.064	0.043
Beryllium, total	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, total	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium, total	0.25	0.003	<0.001	0.07	0.005
Copper, total	0.002	0.002	0.001	0.001	0.004
Iron, total	0.12	0.47	0.18	0.007	0.11
Lead, total	0.005	<0.001	<0.001	<0.001	0.001
Manganese, total	0.02	0.11	0.08	0.10	0.12
Mercury, total	0.0001	<0.0001	<0.0001	<0.0001	0.0001
Nickel, total	<0.001	<0.001	<0.001	0.006	0.001
Selenium, total	<0.001	<0.001	0.002	0.001	0.006
Silver, total	<0.001	<0.001	0.008	<0.001	<0.001
Zinc, total	0.014	0.017	0.010	0.015	0.019

Appendix B: Continued					
	Stations				
Parameter	16-9	16-12	16-13	16-14	16-15
Acidity	3.68	6.01	2.35	2.27	5.64
Alkalinity	157	153	161	161	145
BOD	0.9	1.6	2.3	1.5	1.8
COD	6.3	6.0	13.6	7.7	13.0
Chloride	18.0	18.8	18.8	20.3	18.8
Conductivity (umhos/cm)	538	420	557	463	424
Cyanide, amenable	0.01	<0.01	ND	<0.01	<0.01
Fluoride	0.18	0.22	0.17	0.25	0.29
Hardness, total	205	197	211	220	204
Phenols	<0.005	0.015	ND	<0.005	<0.005
pH (SU)	7.79	7.69	7.9	7.93	7.9
TSS	15.5	2	19	16	24
TDS	284	258	270	208	242
Sulfate	31.9	27.8	30.8	34.0	28.3
TOC	3.7	4.3	3.7	3.7	4.5
Turbidity (NTU)	7.0	7.0	10.0	12.0	26.0
Ammonia Nitrogen	0.143	0.118	<0.05	<0.05	<0.094
TKN	0.602	0.739	0.741	0.490	0.753
Nitrate	1.34	0.886	0.964	1.24	1.62
Phosphorus, Ortho	135	0.140	0.144	0.166	0.142
Phosphorus, total	0.154	0.188	0.174	0.230	0.240
Calcium	65.8	59.2	68.4	73.7	56.9
Magnesium	7.22	6.98	7.58	8.12	7.71
Potassium	2.69	2.61	2.51	2.5	2.94
Sodium	7.8	6.6	7.8	10.5	8.6
Aluminum, total	0.061	0.103	0.044	0.181	0.246
Arsenic, total	0.001	0.001	<0.001	0.001	0.002

Appendix B: Continued					
	Stations				
Parameter	**16-9**	**16-12**	**16-13**	**16-14**	**16-15**
Barium, total	0.074	0.067	0.043	0.046	0.03
Beryllium, total	<0.001	<0.001	ND	<0.001	<0.001
Cadmium, total	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium, total	0.004	0.005	0.008	0.008	0.004
Copper, total	0.008	0.002	0.001	0.001	0.001
Iron, total	0.05	0.11	0.180	0.21	0.28
Lead, total	<0.001	0.006	<0.001	<0.001	<0.001
Manganese, total	0.022	0.23	0.14	0.06	0.15
Mercury, total	0.001	0.0001	<0.0001	0.0001	0.0001
Nickel, total	<0.001	0.003	<0.001	0.001	<0.002
Selenium, total	<0.001	<0.001	ND	0.001	<0.001
Silver, total	<0.001	<0.001	ND	<0.001	<0.001
Zinc, total	0.004	0.007	0.006	0.01	0.025

ND - Not Determined

Appendix B: Continued					
	Stations				
Parameter	**16-16**	**16-17**	**16-18**	**16-19**	**16-20**
Acidity	3.5	<0.1	0.9	6.84	1.33
Alkalinity	131	166	138	155	181
BOD	3.5	3.4	2.7	1.7	1.5
COD	18.8	12.3	20.1	12.2	16.5
Chloride	24.7	13.3	5.2	26.9	34.9
Conductivity (umhos/cm)	377	429	418	619	797
Cyanide, amenable	<0.01	ND	ND	<0.01	ND
Fluoride	0.23	0.83	0.82	0.97	0.36
Hardness, total	180	204	167	223	262
Phenols	0.01	ND	ND	<0.005	ND
pH (SU)	7.8	8.5	8.2	6.2	8.11
TSS	59	12	17	25	19
TDS	244	246	168	254	350
Sulfate	31.5	210	21.5	34.0	63.1
TOC	6.3	5.5	6.2	4.4	4.0
Turbidity (NTU)	24.0	14.0	16.0	3.6	3.8
Ammonia Nitrogen	<0.05	0.057	<0.05	0.103	0.387
TKN	0.723	0.845	1.04	0.685	1.05
Nitrate	0.210	0.253	0.291	0.450	2.4
Phosphorus, Ortho	0.535	0.186	0.048	0.232	0.775
Phosphorus, total	0.265	0.274	0.136	0.272	0.840
Calcium	53.6	68.8	53.4	77.0	87.4
Magnesium	7.72	7.81	6.4	7.37	9.67
Potassium	2.48	3.00	3.07	3.01	1.81
Sodium	10.9	6.7	3.3	14.7	21.0
Aluminum, total	0.021	0.183	0.216	0.067	0.038
Arsenic, total	0.001	0.002	0.002	0.001	<0.001

Appendix B: Continued					
	Stations				
Parameter	**16-16**	**16-17**	**16-18**	**16-19**	**16-20**
Barium, total	0.053	0.047	0.047	0.062	0.044
Beryllium, total	<0.001	ND	ND	<0.001	ND
Cadmium, total	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium, total	0.003	<0.001	<0.001	0.002	0.006
Copper, total	0.004	0.001	0.004	0.022	0.001
Iron, total	<0.01	0.19	0.30	0.07	0.1
Lead, total	<0.001	0.001	<0.001	0.003	0.001
Manganese, total	0.12	0.23	0.22	0.19	0.05
Mercury, total	0.0001	<0.0001	0.0001	<0.0001	<0.0001
Nickel, total	0.12	ND	ND	0.001	ND
Selenium, total	<0.001	ND	ND	<0.001	ND
Silver, total	<0.001	ND	ND	<0.001	ND
Zinc, total	0.011	0.003	0.013	0.016	0.007

ND- Not Determined

Appendix B: Continued					
	Stations				
Parameter	**16-21**	**16-22**	**16-24**	**16-27**	**16-28**
Acidity	3.44	6.90	0.85	3.99	6.10
Alkalinity	143	179	129	156	149
BOD	1.4	0.5	3.0	3.6	2.1
COD	10.8	4.9	25.6	11.9	16.1
Chloride	53.9	48.6	18.8	14.0	15.2
Conductivity (umhos/cm)	737	729	447	369	421
Cyanide, amenable	<0.01	<0.01	<0.01	ND	<0.01
Fluoride	1.30	1.11	0.24	0.23	0.49
Hardness, total	269	296	164	185	191
Phenols	<0.005	<0.005	0.015	ND	<0.005
pH (SU)	8.0	6.9	8.00	7.9	7.7
TSS	4	8	27	10	88
TDS	536	378	196	226	226
Sulfate	114	60.9	20.4	20.4	24.4
TOC	4.4	2.0	8.5	5.1	7.6
Turbidity (NTU)	2.0	3.8	3.1	3.6	80.0
Ammonia Nitrogen	0.065	<0.05	<0.05	0.162	0.129
TKN	0.490	0.268	1.13	0.946	1.46
Nitrate	1.25	3.72	0.051	0.426	1.60
Phosphorus Ortho	0.207	0.212	0.105	0.112	0.147
Phosphorus total	0.260	0.248	0.126	0.182	0.488
Calcium	77.2	102.3	40.2	56.1	53.1
Magnesium	16.7	9.02	9.53	6.22	7.63
Potassium	3.69	2.30	2.53	2.42	3.35
Sodium	45.3	24.1	9.3	4.2	7.4
Aluminum, total	0.069	0.267	0.305	0.088	0.109
Arsenic, total	0.001	<0.001	0.002	0.001	0.001

Appendix B: Continued					
	Stations				
Parameter	**16-21**	**16-22**	**16-24**	**16-27**	**16-28**
Barium, total	0.098	0.063	0.069	0.055	0.072
Beryllium, total	<0.001	<0.001	<0.001	ND	<0.001
Cadmium, total	<0.001	<0.001	<0.001	<0.001	0.006
Chromium, total	0.008	0.002	0.005	0.004	0.003
Copper, total	0.014	0.003	0.001	0.001	2.03
Iron, total	0.04	0.04	<0.01	<0.09	0.004
Lead, total	0.001	0.001	0.001	<0.001	0.003
Manganese, total	0.12	0.04	0.11	0.20	0.30
Mercury, total	0.0002	0.0001	0.0001	0.0001	0.0002
Nickel, total	<0.001	0.001	0.081	ND	<0.001
Selenium, total	<0.001	0.001	<0.001	ND	0.001
Silver, total	<0.001	<0.001	<0.001	ND	<0.001
Zinc, total	0.042	0.020	0.005	0.006	0.012

ND - Not Determined

APPENDIX C

Physicochemical Data* for the North Elkhorn Creek Drainage During the Winter, 1987

*Units in mg/l unless otherwise noted.

Appendix C: Physicochemical Data for the North Elkhorn Creek Drainage During the Winter, 1987					
	Stations				
Parameter	16-1	16-5	16-6	16-9	16-13
Acidity	0.8	4.5	3.5	3.5	3.3
Alkalinity	176	175	174	170	171
BOD	1.1	1.4	1.2	1.3	1.5
COD	5.5	5.2	4.6	3.5	0.8
Chloride	17.7	17.5	14.0	16.5	10.0
Conductivity (umhos/cm)	478	488	510	510	453
Cyanide, amenable	<0.010	<0.010	<0.010	<0.010	<0.010
Fluoride	<0.1	0.26	0.27	0.24	0.22
Hardness, total	238	239	243	240	226
Phenols	<0.005	<0.005	0.006	0.009	<0.005
pH (SU)	8.2	7.9	8.0	8.1	8.1
TSS	5	6	4	4	3
TDS	296	298	309	260	284
Sulfate	42.4	45.7	46.6	49.2	36.6
TOC	2.8	2.7	2.6	1.9	1.9
Turbidity (NTU)	2.1	3.5	3.8	3.2	2.7
Ammonia Nitrogen	<0.05	<0.05	<0.05	<0.05	<0.05
TKN	0.393	0.261	0.215	0.144	0.131
Nitrate	5.12	6.00	5.80	5.50	5.10
Phosphorus, Ortho	0.160	0.220	0.240	0.090	0.112
Phosphorus, total	0.249	0.330	0.801	0.186	0.174
Calcium	88.4	88.6	84.6	83.8	81.4
Magnesium	6.18	6.19	6.48	7.32	6.12
Potassium	1.44	1.46	1.54	1.58	1.20
Sodium	7.6	8.3	10.0	10.6	4.6

Appendix C: Continued					
	Stations				
Parameter	**16-1**	**16-5**	**16-6**	**16-9**	**16-13**
Aluminum, total	0.149	0.071	0.074	0.040	0.032
Arsenic, total	<0.001	<0.001	0.001	<0.001	0.001
Barium, total	0.050	0.047	0.039	0.039	0.059
Beryllium, total	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, total	<0.001	<0.001	<0.001	<0.001	<.001
Chromium, total	<0.001	<0.001	<0.001	0.002	<0.001
Copper, total	0.018	0.011	0.015	0.003	0.002
Iron, total	0.11	0.07	0.06	0.03	0.03
Lead, total	0.072	0.003	0.003	0.097	0.001
Manganese, total	0.02	0.04	0.03	0.03	0.03
Mercury, total	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel, total	0.001	0.002	0.004	0.001	<0.001
Selenium, total	<0.001	0.004	0.009	0.008	0.006
Silver, total	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc, total	0.051	0.081	0.093	0.021	0.022

Appendix C: Continued					
	Stations				
Parameter	16-14	16-16	16-19	16-25	16-26
Acidity	2.9	3.3	4.2	2.7	2.1
Alkalinity	172	167	179	173	157
BOD	1.4	1.3	1.5	2.2	1.2
COD	6.6	3.2	5.0	1.4	3.5
Chloride	11.5	13.2	13.0	6.0	11.5
Conductivity (umhos/cm)	453	446	510	512	406
Cyanide, amenable	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoride	0.22	0.21	0.1	0.19	0.16
Hardness, total	174	183	247	264	179
Phenols	0.005	<0.005	<0.005	<0.005	<0.005
pH (SU)	8.1	8.1	8.0	8.2	8.0
TSS	3	6	4	5	9
TDS	286	278	314	334	260
Sulfate	37.1	36.2	44.5	62.5	37.8
TOC	2.7	2.7	2.8	2.1	2.4
Turbidity (NTU)	3.5	7.5	3.2	5.0	8.5
Ammonia Nitrogen	<0.05	<0.05	0.071	0.054	<0.05
TKN	0.380	0.451	0.409	0.282	0.296
Nitrate	4.10	2.95	7.70	7.20	3.30
Phosphorus, Ortho	0.116	0.052	0.336	0.228	0.025
Phosphorus, total	0.179	0.118	0.365	0.230	0.069
Calcium	77.9	73.7	97.4	107	73.9
Magnesium	8.13	8.69	6.25	6.67	7.28
Potassium	1.43	1.45	1.20	1.33	1.11
Sodium	6.0	5.5	7.5	4.1	2.8
Aluminum, total	0.046	0.107	0.153	0.137	0.122

Appendix C: Continued					
	Stations				
Parameter	16-14	16-16	16-19	16-25	16-26
Arsenic, total	<0.001	0.001	0.001	<0.001	<0.001
Barium, total	0.047	0.026	0.046	0.077	0.035
Beryllium, total	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, total	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium, total	<0.001	<0.001	0.002	<0.001	0.001
Copper, total	0.002	0.005	0.006	0.010	0.003
Iron, total	0.05	0.16	0.11	0.06	0.16
Lead, total	0.007	0.002	0.009	0.009	0.009
Manganese, total	0.03	0.05	0.05	0.02	0.03
Mercury, total	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel, total	<0.001	0.002	0.001	<0.001	<0.001
Selenium, total	0.007	0.007	0.006	0.005	0.007
Silver, total	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc, total	0.016	0.025	0.026	0.060	0.018

APPENDIX D
Physicochemical Data* for the
North Elkhorn Creek Drainage During the Fall, 1987

*Units are in mg/l unless otherwise noted.

Appendix D: Physicochemical Data for the North Elkhorn Creek Drianage During the Fall, 1987					
	Stations				
Parameter	**16-1**	**16-5**	**16-6**	**16-7**	**16-9**
Acidity	<0.1	<0.1	4.2	5.5	3.3
Alkalinity	165	196	174	179	180
BOD	0.5	0.4	0.8	10.9	1.1
COD	13	17.6	23.5	62.4	15.1
Chloride	37.5	75.6	89.9	111.2	23.5
Conductivity (umhos/cm)	573	781	939	1080	532
Cyanide, Amenable	<0.010	<0.010	<0.010	0.011	<0.010
Fluoride	0.36	0.63	0.74	0.87	0.23
Hardness	200	233	278	250	217
Phenol (4AAP)	<0.005	<0.005	0.007	<0.005	<0.005
pH (SU)	9.0	8.2	7.8	7.8	8.0
Suspended Solids	5	9	7	20	14
Dissolved Solids	326	448	576	684	320
Sulfate	44.2	75.6	115	138	40.6
Organic Carbon	5.81	8.60	13.7	20.7	5.63
Turbidity (NTU)	1.2	4.2	4.1	11	9.3
Ammonia-Nitrogen	<0.050	0.104	0.187	2.40	0.357
Kjeldahl Nitrogen	0.789	0.994	1.67	6.50	1.19
Sulfide	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrate	0.025	0.250	8.30	12	0.500
Phosphorus, ortho	2.98	0.640	3.60	6	0.120
Phosphorus, total	0.390	0.920	4.75	8.40	0.310
Calcium	61.9	82.0	91.1	89.4	66.3
Magnesium	9.06	9.95	10.3	11.0	8.04
Potassium	3.75	7.73	10.6	16.6	4.97
Sodium	26.5	61.3	76.4	110	16.4

Appendix D: Continued					
	Stations				
Parameter	**16-1**	**16-5**	**16-6**	**16-7**	**16-9**
Aluminum	0.046	0.134	0.330	0.221	0.032
Arsenic	<0.001	0.002	<0.001	<0.001	0.002
Barium	0.017	0.023	0.025	0.014	0.019
Beryllium	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	0.001	0.008	0.008	0.030	0.002
Copper	<0.001	<0.001	<0.001	0.010	0.003
Iron	0.02	0.014	0.45	0.09	0.09
Lead	<0.001	0.010	0.002	0.004	0.001
Manganese	0.01	0.10	0.17	0.03	0.40
Mercury	0.0002	0.0001	0.0003	0.0002	0.0002
Nickel	0.002	0.016	0.028	0.078	0.004
Selenium	<0.001	<0.001	<0.001	<0.001	<0.001
Silver	<0.001	0.001	<0.001	0.001	<0.001
Zinc	0.059	0.704	0.0019	0.166	0.075

Appendix D: Continued				
	Stations			
Parameter	**16-13**	**16-14**	**16-16**	**16-25**
Acidity	2.0	2.6	1.4	10.9
Alkalinity	182	256	135	293
BOD	1.1	0.5	1.4	0.9
COD	13.9	4.10	17.6	5.53
Chloride	13.1	26.8	12.7	13.8
Conductivity (umhos/cm)	457	688	385	843
Cyanide, Amenable	0.010	<0.010	<0.010	<0.010
Fluoride	0.18	0.19	0.19	0.47
Hardness	202	303	160	418
Phenol (4AAP)	<0.005	<0.005	0.016	<0.005
pH (SU)	8.0	8.1	8.0	7.8
Suspended Solids	7	9	29	4
Dissolved Solids	272	434	222	552
Sulfate	30.5	41.4	26.2	152
Organic Carbon	5.33	13.7	13.7	12.1
Turbidity (NTU)	2.8	1.8	21	3.7
Ammonia-Nitrogen	0.084	0.114	0.197	0.757
Kjeldahl Nitrogen	0.886	0.631	1.23	1.55
Sulfide	<0.1	ND	<0.1	<0.1
Nitrate	0.110	2.80	0.750	1.50
Phosphorus, ortho	0.033	0.088	0.022	0.018
Phosphorus, total	0.124	0.235	0.136	0.110
Calcium	57.2	102	49.3	114
Magnesium	6.87	9.56	6.52	24.0
Potassium	3.31	2.29	3.80	6.81
Sodium	9.30	18.6	8.7	13.5
Aluminum	0.008	0.035	0.250	0.042

Appendix D: Continued				
	Stations			
Parameter	**16-13**	**16-14**	**16-16**	**16-25**
Arsenic	0.002	<0.001	<0.001	<0.001
Barium	0.019	0.025	0.047	0.050
Beryllium	<0.001	<0.001	<0.001	<0.001
Cadmium	<0.001	<0.001	<0.001	<0.001
Chromium	0.001	0.001	0.002	0.001
Copper	0.001	0.004	0.005	0.001
Iron	0.09	0.04	0.42	0.16
Lead	<0.001	0.088	0.002	0.001
Manganese	0.24	0.05	0.20	0.69
Mercury	0.0001	0.0001	0.0002	0.0001
Nickel	0.003	0.003	0.004	0.003
Selenium	<0.001	<0.001	0.020	0.013
Silver	<0.001	<0.001	<0.001	<0.001
Zinc	0.025	0.040	0.046	0.029

ND - Not Determined

APPENDIX E
Physicochemical Data* for the
North Elkhorn Creek Drainage During the Summer, 1988

*Units are in mg/l unless otherwise noted.

Appendix E: Physicochemical Data for the North Elkhorn Creek Drainage During the Summer, 1988					
	Stations				
Parameter	16-1	16-5	16-6	16-9	16-13
Acidity	<0.1	<0.1	3.2	4.8	5.6
Alkalinity	74.1	143	165	151	166
BOD	1.8	4.1	2.3	1.2	1.3
COD	20.9	15.6	23.7	12.6	12.1
Chloride	17.2	51.3	95.4	48.4	19.6
Conductivity (umhos/cm)	264	573	860	548	443
Cyanide, amenable	<0.010	<0.010	<0.010	<0.010	<0.010
Fluoride	0.26	0.41	0.91	0.29	0.23
Hardness, total	104	201	266	199	191
Phenols	<0.005	<0.005	<0.005	<0.005	ND
pH (SU)	9.0	8.4	8.0	7.9	7.9
TSS	22	2	13	2	2
TDS	154	338	516	306	248
Sulfate	20.6	42	78.1	45.4	18.2
TOC	6.7	6.6	8.4	4.9	4.8
Turbidity (NTU)	24	4.0	14	2.6	4.6
Ammonia Nitrogen	0.068	0.119	0.214	0.077	0.057
TKN	1.0	1.04	1.42	0.544	0.564
Nitrate	0.055	0.060	7.80	0.225	0.185
Phosphorus, total	0.237	0.411	3.30	0.456	0.267
Calcium	37.3	72.4	98.0	69.7	66.2
Magnesium	6.95	8.49	10.3	9.08	6.92
Potassium	0.82	3.62	10.1	2.32	2.92
Sodium	12.3	34.9	71.7	32.1	8.7
Aluminum, total	0.267	0.088	0.103	0.054	0.092
Arsenic, total	0.002	<0.001	<0.001	0.005	<0.001

Appendix E: Continued					
	Stations				
Parameter	**16-1**	**16-5**	**16-6**	**16-9**	**16-13**
Barium, total	0.022	0.033	0.027	0.027	0.019
Beryllium, total	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, total	<0.001	0.001	<0.001	<0.001	<0.001
Chromium, total	<0.001	0.003	0.003	0.003	0.004
Copper, total	0.004	0.002	0.005	0.004	0.005
Iron, total	0.40	0.10	0.16	0.08	0.15
Lead, total	0.004	0.004	0.004	0.002	<0.002
Manganese, total	0.08	0.40	0.12	0.14	0.28
Mercury, total	0.0002	0.0004	0.0003	0.0002	0.0002
Nickel, total	<0.001	0.007	0.032	0.001	<0.001
Selenium, total	0.008	<0.001	<0.001	<0.001	<0.001
Silver, total	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc, total	0.007	0.008	0.027	0.005	0.007

ND - Not Determined

APPENDIX F
List of Physicochemical Parameters
That Were Below Detection Limits at all Stations
During each Sampling Period

Appendix F: Physicochemical Parameters that were Below Detection Limits At All Stations During the Summer, 1986	
Parameter	**Concentration (mg/l)**
Phenol	<0.023
Aniline	<0.023
Bis-(2-Chloroethyl) ether	<0.023
2-Chlorphenol	<0.023
1,3-Dichlorobenzene	<0.023
1,4-Dichlorobenzene	<0.023
Benzyl Alcohol	<0.023
1,2-Dichlorobenzene	<0.023
2-Methylphenol	<0.023
Bis-(2-Chloroisopropyl) ether	<0.023
4-Menthylphenol	<0.023
N-Nitroso-di-n-propylamine	<0.023
Hexachloroethane	<0.023
Nitrobenzene	<0.023
Isophorone	<0.023
2-Nitrophenol	<0.023
2,4-Dimethyphenol	<0.023
Bis-(2-Chloroethoxy)methane	<0.023
Benzoic Acid	<0.023
2,4-Dichlorophenol	<0.023
1,2,4-Trichlorobenzene	<0.023
Napthalene	<0.023
4-Chloroaniline	<0.023
1,1,2,3,4,4-Hexachloro-1,3-butadiene	<0.023
4-Chloro-3-methylphenol	<0.023
2-Methylnaphthalene	<0.023
1,2,3,4,5,5-Hexachloro-1,3-cyclopentadiene	<0.023
2,4,6-Trichlorophenol	<0.023

Appendix F: Continued	
Parameter	**Concentration (mg/l**
2,4,5-Trichlorophenol	<0.023
2-Chloronaphthalene	<0.023
2-Nitroaniline	<0.023
Dimethyl Phthalate	<0.023
Acenaphthylene	<0.023
2,6-Dinitrotoluene	<0.023
3-Nitroaniline	<0.023
Acenaphthene	<0.023
2,4-Dinitrophenol	<0.023
4-Nitrophenol	<0.023
Dibenzofuran	<0.023
2,4-Dinitrotoluene	<0.023
Diethyl Phthalate	<0.023
Fluorene	<0.023
4-Chlorophenyl phenyl ether	<0.023
4-Nitroaniline	<0.023
2-Methyl-4,6-Dinitrophenol	<0.023
N-Nitrosodiphenylamine	<0.023
4-Bromophenylphenylether	<0.023
Hexachlorobenzene	<0.023
Pentachlorophenol	<0.023
Phenanthrene	<0.023
Anthracene	<0.023
Dibutyl Phthalate	<0.023
Fluoranthene	<0.023
Benzidine	<0.023
Pyrene	<0.023
Butyl Benzyl Phthalate	<0.023

Appendix F: Continued	
Parameter	**Concentration (mg/l)**
3,3'-Dichlorobenzidine	<0.023
Benzo(A)Anthracene	<0.023
Chrysene	<0.023
Bis(2-Ethylhexyl)Phthlate	<0.023
Dioctylphthalate	<0.023
Benzo(B)Fluoranthene	<0.023
Benzo(K)Fluoranthene	<0.023
Benzo(A)Pyrene	<0.023
Indeno(1,2,3-C,D)Pyrene	<0.023
Dibenzo(A,H)Anthracene	<0.023
Benzo(G,H,I)Perylene	<0.023

Appendix F: Physicochemical Parameters that were Below Detection Limits At All Stations During the Winter, 1987	
Parameter	**Concentration (mg/l)**
Phenol	<0.020
Aniline	<0.020
Bis-(2-Chloroethyl)ether	<0.020
2-Chlorphenol	<0.020
1,3-Dichlorobenzene	<0.020
1,4-Dichlorobenzene	<0.020
Benzyl Alcohol	<0.020
1,2-Dichlorobenzene	<0.020
2-Methylphenol	<0.020
Bis-(2-Chloroisopropyl)ether	<0.020
4-Methylphenol	<0.020
N-Nitroso-di-n-propylamine	<0.020
Hexachloroethane	<0.020
Nitrobenzene	<0.020
Isophorone	<0.020
2-Nitrophenol	<0.020
2,4-Dimethyphenol	<0.020
Bis-(2-Chloroethoxy)methane	<0.020
Benzoic Acid	<0.020
2,4-Dichlorophenol	<0.020
1,2,4-Trichlorobenzene	<0.020
Napthalene	<0.020
4-Chloroaniline	<0.020
1,1,2,3,4,4-Hexachloro-1,3-butadiene	<0.020
4-Chloro-3-methylphenol	<0.020
2-Methylnaphthalene	<0.020
1,2,3,4,5,5-Hexachloro-1,3-cyclopentadiene	<0.020
2,4,6-Trichlorophenol	<0.020

Appendix F: Continued	
Parameter	**Concentration (mg/l)**
2,4,5-Trichlorophenol	<0.020
2-Chloronaphthalene	<0.020
2-Nitroaniline	<0.020
Dimethyl Phthalate	<0.020
Acenaphthylene	<0.020
2,6-Dinitrotoluene	<0.020
3-Nitroaniline	<0.020
Acenaphthene	<0.020
2,4-Dinitrophenol	<0.020
4-Nitrophenol	<0.020
Dibenzofuran	<0.020
2,4-Dinitrotoluene	<0.020
Diethyl Phthalate	<0.020
Fluorene	<0.020
4-Chlorophenyl phenyl ether	<0.020
4-Nitroaniline	<0.020
2-Methyl-4,6-Dinitrophenol	<0.020
N-Nitrosodiphenylamine	<0.020
4-Bromophenylphenylether	<0.020
Hexachlorobenzene	<0.020
Penanthrene	<0.020
Anthracene	<0.020
Dibutyl Phthalate	<0.020
Fluoranthene	<0.020
Benzidine	<0.020
Pyrene	<0.020
Butyl Benzyl Phthalate	<0.020
3,3'-Dichlorobenzidine	<0.020

Appendix F: Continued	
Parameter	**Concentration (mg/l)**
Benzo(A)Anthracene	<0.020
Chrysene	<0.020
Dioctylphthalate	<0.020
Benzo(B)Fluoranthene	<0.020
Benzo(K)Fluoranthene	<0.020
Benzo(A)Pyrene	<0.020
Indeno(1,2,3-C,D)Pyrene	<0.020
Dibenzo(A,H)Anthracene	<0.020
Benzo(G,H,I)Perylene	<0.020
Methylene Blue Active Substances (MBAS)	<0.1

Appendix F: Physicochemical Parameters that were Below Detection Limits At All Stations During the Fall, 1987	
Parameter	**Concentration (mg/l)**
Methylene Chloride	<0.001
1,2-Dichloroethene	<0.001
Chloroform	<0.001
1,2-Dichloroethane	<0.001
1,1,1-Trichloroethane	<0.001
Carbon Tetrachloride	<0.001
Bromodichloromethane	<0.001
Trichloroethene	<0.001
1,2-Dichloropropane	<0.001
Dibromochloromethane	<0.001
Chloroethylvinyl ether	<0.001
Bromoform	<0.001
Tetrachloroethene	<0.001
Chlorobenzene	<0.001
Benzene	<0.001
Toluene	<0.001
Ethyl benzene	<0.001
o-Xylene	<0.001
m-Xylene	<0.001
p-Xylene	<0.001
Total Xylenes	<0.001
Styrene	<0.001
o-Chlorotoluene	<0.001
Phenol	<0.020
Aniline	<0.020
Bis-(2-Chloroethyl) ether	<0.020
2-Chlorophenol	<0.020
1,3-Dichlorobenzene	<0.020

Appendix F: Continued	
Parameter	**Concentration (mg/l)**
1,4-Dichlorobenzene	<0.020
Benzyl Alcohol	<0.020
1,2-Dichlorobenzene	<0.020
2-Methylphenol	<0.020
Bis-(2-Chloroisopropyl) ether	<0.020
4-Methylphenol	<0.020
N-Nitroso-di-n-propylamine	<0.020
Hexachloroethane	<0.020
Nitrobenzene	<0.020
Isophorone	<0.020
2-Nitrophenol	<0.020
2,4-Dimethyphenol	<0.020
Bis-(2-Chlorothoxy) methane	<0.020
Benzoic Acid	<0.080
2,4-Dichlorophenol	<0.020
1,2,4-Trichlorobenzene	<0.020
Napthalene	<0.020
4-Chloroaniline	<0.020
1,1,2,3,4,4-Hexachloro-1,3-butadiene	<0.020
4-Chloro-3-methylphenol	<0.020
2-Methylnaphthalene	<0.020
1,2,3,4,5,5-Hexachloro-1,3-cyclopentadiene	<0.020
2,4,6-Trichlorophenol	<0.020
2,4,5-Trichlorophenol	<0.020
2-Chloronaphthalene	<0.020
2-Nitroaniline	<0.020
Dimethyl Phthalate	<0.020
Acenaphthylene	<0.020

Appendix F: Continued	
Parameter	**Concentration (mg/l)**
2,6-Dinitrotoluene	<0.020
3-Nitroaniline	<0.020
Acenaphthene	<0.020
2,4-Dinitrophenol	<0.080
4-Nitrophenol	<0.020
Dibenzofuran	<0.020
2,4-Dinitrotoluene	<0.020
Diethyl Phthalate	<0.020
Fluorene	<0.020
4-Chlorophenyl phenyl ether	<0.020
4-Nitroaniline	<0.020
2-Methyl-4,6-Dinitrophenol	<0.020
N-Nitrosodiphenylamine	<0.020
1,2-Diphenylhydrazine	<0.020
4-Bromophenylphenylether	<0.020
Hexachlorobenzene	<0.020
Pentachlorophenol	<0.020
Phenanthrene	<0.020
Anthracene	<0.020
Dibutyl Phthalate	<0.020
Fluoranthene	<0.020
Benzidine	<0.020
Pyrene	<0.020
Butyl Benzyl Phthalate	<0.020
3,3'-Dichlorobenzidine	<0.020
Benzo(A)Anthracene	<0.020
Chrysene	<0.020
Dioctylphthalate	<0.020

Appendix F: Continued	
Parameter	**Concentration (mg/l)**
Benzo(B)Fluoranthene	<0.020
Benzo(K)Fluoranthene	<0.020
Benzo(A)Pyrene	<0.020
Indeno(1,2,3-C,D)Pyrene	<0.020
Dibenzo(A,H)Anthracene	<0.020
Benzo(G,H,I)Perylene	<0.020

Appendix F: Physicochemical Parameters that were Below Detection Limits at all Stations for the Summer, 1988	
Parameter	**Concentration (mg/l)**
Phenol	<0.021
Aniline	<0.021
Bis-(2-Chloroethyl)ether	<0.021
2-Chlorophenol	<0.021
1,3-Dichlorobenzene	<0.021
1,4-Dichlorobenzene	<0.021
Benzyl Alcohol	<0.021
1,2-Dichlorobenzene	<0.021
2-Methylphenol	<0.021
4-Methylphenol	<0.021
Bis-(2-Chloroisopropyl)ether	<0.021
N-Nitroso-di-n-propylamine	<0.021
Hexachloroethane	<0.021
Nitrobenzene	<0.021
Isophorone	<0.021
2-Nitrophenol	<0.021
2,4-Dimethyphenol	<0.021
Bis-(2-Chloroethoxy)methane	<0.021
Benzoic Acid	<0.084
2,4-Dichlorophenol	<0.021
1,2,4-Trichlorobenzene	<0.021
Napthalene	<0.021
4-Chloroaniline	<0.021
1,1,2,3,4,4-Hexachloro-1,3-butadiene	<0.021
4-Chloro-3-methylphenol	<0.021
2-Methylnaphthanlene	<0.021
1,2,3,4,5,5-Hexachloro-1,3-cyclopentadiene	<0.021
2,4,6-Trichlorophenol	<0.021
2,4,5-Trichlorophenol	<0.021
2-Chloronaphthalene	<0.021
2-Nitroaniline	<0.021

Appendix F: Continued	
Parameter	**Concentration (mg/l)**
Dimethyl Phthalate	<0.021
Acenaphthylene	<0.021
2,6-Dinitrotoluene	<0.021
3-Nitroaniline	<0.021
Acenaphthene	<0.021
2,4-Dinitrophenol	<0.021
4-Nitrophenol	<0.021
Dibenzofuran	<0.021
2,4-Dinitrotoluene	<0.084
Diethyl Phthalate	<0.021
Fluorene	<0.021
4-Chlorophenyl phenyl ether	<0.021
4-Nitroaniline	<0.021
2-Methyl-4,6-Dinitrophenol	<0.021
N-Nitrosodiphenylamine	<0.021
1,2-Diphenylhydrazine	<0.021
4-Bromophenylphenylether	<0.021
Hexachlorobenze	<0.021
Pentachlorophenol	<0.021
Phenanthrene	<0.021
Anthracene	<0.021
Dibutyl Phthalate	<0.021
Fluoranthene	<0.021
Benzidine	<0.021
Pyrene	<0.021
Butyl Benzyl Phthalate	<0.021
3,3'-Dichlorobenzidine	<0.021
Benzo(A)Anthracene	<0.021
Chrysene	<0.021
Bis(2-Ethylhexyl)Phthlate	<0.021
Dioctylphthalate	<0.021

Appendix F: Continued	
Parameter	**Concentration (mg/l)**
Benzo(B)Fluoranthene	<0.021
Benzo(K)Fluoranthene	<0.021
Benzo(A)Pyrene	<0.021
Indeno(1,2,3-C,D)Pyrene	<0.021
Dibenzo(A,H)Anthracene	<0.021
Benzo(G,H,I)Perylene	<0.021
Sulfide, total	<0.1

APPENDIX G
Sediment Data* for North Elkhorn Creek Drainage During the Spring and Summer, 1986

*Units are mg/kg unless otherwise noted.

Appendix G: Sediment Data for the North Elkhorn Creek Drainage During the Summer, 1986				
	Stations			
Parameter	16-1	16-2	16-3	16-5
Chemical Oxygen Demand	44,000[m]	46,000[m]	47,000[m]	66,000[m]
Cyanide	<0.49	<0.49	<0.51	<0.46
Oil and Grease	535	1155[m]	340	280
Total Volatile Solids %	4.5	5.1[m]	5.4[m]	5.5[m]
Total Organic Carbon %	1.47	0.94	0.79	1.8
Ammonia-Nitrogen	39.9	56.0	74.0	142[m]
Kjeldhal Nitrogen	2170[h]	1810[m]	1050[m]	4230[h]
Aluminum	11,700	12,300	11,600	10,900
Arsenic	1.56	0.675	1.39	2.47
Cadmium	<0.010	<0.010	0.075	0.493
Chromium	19.4	15.8	13.7	37.9
Copper	9.44	10.0	10.4	15.9
Iron	24,000[m]	32,100[h]	29,600[h]	17,000[m]
Lead	19.3	25.3	24.8	35.9
Manganese	1690[h]	1950[h]	2080[h]	1980[h]
Mercury	0.0574	0.0627	0.0614	0.130
Nickel	23.6[m]	22.8[m]	23.3[m]	34.6[m]
Zinc	57.6	62.5	61.2	88.3
DDT, total	<0.010	<0.010	<0.010	<0.010
P,P' - DDE	<0.010	<0.010	<0.010	<0.010

[h]Heavily polluted
[m]Moderately polluted

Appendix G: Continued				
	Stations			
Parameter	16-6	16-9	16-12	16-14
Chemical Oxygen Demand	48,000[m]	45,000[m]	43,000[m]	39,000
Cyanide	<0.44	<0.90	<0.50	<0.48
Oil and Grease	990	215	220	550
Total Volatile Solids %	6.1[m]	4.7	4.7	4.4
Total Organic Carbon %	1.2	7.3	0.89	1.1
Ammonia-Nitrogen	112[m]	37.4	50.4	141[m]
Kjeldhal Nitrogen	2410[h]	1690[m]	1710[m]	2750[h]
Aluminum	12,100	11,800	13,000	12,900
Arsenic	4.80[m]	3.86[m]	2.26	0.925
Cadmium	.0370	0.106	1.21	1.19
Chromium	64.9[m]	20.6	13.9	13.5
Copper	21.5	9.55	4.83	10.3
Iron	24,600[m]	26,200[h]	25,900[h]	25,500[h]
Lead	50.5[m]	27.0	31.7	41.5[m]
Manganese	1710[h]	2540[h]	2280[h]	1710[h]
Mercury	0.1991	0.054	0.053	0.070
Nickel	55.5[h]	14.6	8.46	7.50
Zinc	159[m]	496[h]	646[h]	704[h]
DDT, total	0.013	<0.010	<0.010	<0.010
P,P' - DDE	0.013	<0.01	<0.01	<0.01

[h]Heavily Polluted
[m]Moderately Polluted

Appendix G: Continued				
	Station			
Parameter	16-15	16-16	16-17	16-18
Chemical Oxygen Demand	31,000	46,000[m]	34,000	54,000[m]
Cyanide	<4.60	<0.49	<0.48	<0.48
Oil and Grease	160	455	100	160
Total Volatile Solids %	4.0	5.2[m]	3.6	4.2
Total Organic Carbon %	0.55	0.71	0.75	0.91
Ammonia-Nitrogen	93.1[m]	58.8	56.5	111[m]
Kjeldhal Nitrogen	2240[h]	1700[m]	1610[m]	2210[h]
Aluminum	10,200	9920	11,100	12,300
Arsenic	0.104	1.11	1.71	1.97
Cadmium	1.21	0.426	<0.010	0.010
Chromium	10.7	12.2	12.9	13.3
Copper	9.13	8.61	12.5	11.3
Iron	19,700[m]	17,400[m]	31,900[h]	30,400[h]
Lead	24.4	38.9	30.4	22.7
Manganese	1260[h]	1190[h]	3060[h]	2090[h]
Mercury	0.067	0.093	0.0471	0.0376
Nickel	6.23	9.72	20.7[m]	21.7[m]
Zinc	46.6	574[h]	53.2	60.5
DDT, total	<0.010	<0.010	<0.010	<0.010
P,P' - DDE	<0.010	<0.010	<0.010	<0.010

[h]Heavily Polluted
[m]Moderately Polluted

Appendix G: Continued				
	Stations			
Parameter	16-19	16-21	16-24	16-28
Chemical Oxygen Demand	35,000	59,000[m]	31,000	43,000[m]
Cyanide	<0.48	<0.49	<0.48	<0.496
Oil and Grease	100	8550[h]	360	285
Total Volatile Solids %	4.2	5.2[m]	3.8	4.5
Total Organic Carbon %	1.2	1.0	0.74	0.52
Ammonia-Nitrogen	95.9[m]	146[m]	36.2	78.1[m]
Kjeldhal Nitrogen	1640[m]	2290[h]	2610[h]	1660[m]
Aluminum	16,300	14,000	10,400	14,600
Arsenic	4.70[m]	2.95	2.97	5.69[m]
Cadmium	0.210	2.15	0.182	2.95
Chromium	22.5	31.3[m]	16.6	35.2[m]
Copper	14.6	86.4[h]	11.3	11.7
Iron	24,500[m]	24,200[m]	21,600[m]	54,100[h]
Lead	38.4	312[h]	26.3	40.5[m]
Manganese	2230[h]	1360[h]	1840[h]	2580[h]
Mercury	0.0823	.0193	0.057	0.714
Nickel	20.9[m]	12.2	21.9[m]	26.3[m]
Zinc	85.4	334[h]	433[h]	63.7
DDT, total	<0.010	<0.010	<0.010	<0.010
P,P′ - DDE	<0.010	<0.010	<0.010	<0.010

[h]Heavily Polluted
[m]Moderately Polluted

APPENDIX H
Sediment Data* for the North Elkhorn Creek Drainage During the Fall, 1987

*Units are mg/kg unless otherwise noted.

Appendix H: Sediment Data for the North Elkhorn Creek Drainage During the Fall, 1987				
	Stations			
Parameter	16-1	16-5	16-6	16-9
Chemical Oxygen Demand	84,900[h]	121,000[h]	50,500[m]	70,200[m]
Cyanide	<1.70	1.78[h]	<0.822	<0.979
Oil and Grease	1,060[m]	954	286	515
Total Volatile Solids %	6.76[m]	11.3[h]	7.11[m]	8.56[h]
Total Organic Carbon %	0.84	1.3	0.44	0.74
Ammonia-Nitrogen	299[h]	484[h]	109[m]	302[h]
Kjeldhal Nitrogen	647	685	155	280
Aluminum	9,820	14,100	10,700	12,800
Arsenic	1.95	7.03[m]	7.21[m]	5.16[m]
Cadmium	0.098	0.360	0.608	0.309
Chromium	11.6	20.6	27.2[m]	19.3
Copper	9.92	19.1	18.1	9.65
Iron	21,100[m]	22,900[m]	19,200[m]	31,000[h]
Lead	15.8	33.3	65.5[h]	34.7
Manganese	972[h]	15,500[h]	2,160[h]	4,030[h]
Mercury	0.060	0.101	0.212	0.081
Nickel	20.5[m]	63.6[h]	50.0[m]	21.9[m]
Zinc	55.7	131.0[m]	186.0[m]	58.8
Pentachlorophenol	<0.01	0.014	0.017	<0.01

[h]Heavily Polluted
[m]Moderately Polluted

Appendix H: Continued				
	Stations			
Parameter	16-13	16-14	16-16	16-25
COD	108,000[h]	103,000[h]	24,800	109,000[h]
Cyanide	<1.59	<1.39	<0.750	<1.09
Oil and Grease	58.8	1,790[m]	<10.0	416
TVS %	11.1[h]	9.26[h]	4.85	9.90[h]
TOC %	1.5	0.78	0.32	0.95
Ammonia-Nitrogen	232[h]	388[h]	106[m]	306[h]
Kjeldhal Nitrogen	760	400	156	406
Aluminum	12,300	10,800	10,300	10,100
Arsenic	3.50[m]	7.02[m]	3.52[m]	6.96[m]
Cadmium	0.453	2.57	0.166	0.108
Chromium	16.0	17.6	11.5	19.6
Copper	13.3	12.0	7.45	9.84
Iron	35,800[h]	10.6	8.18	9.81
Lead	40.7[m]	54.5[m]	19.7	26.1
Manganese	4,290[h]	2,910[h]	1,900[h]	2,160[h]
Mercury	0.082	0.081	0.063	0.057
Nickel	23.5[m]	20.4[m]	16.8	23.0[m]
Zinc	99.0[m]	46.9	44.8	106[m]
Pentachlorophenol	0.060	0.014	<0.01	<0.01

[h]Heavily Polluted
[m]Moderately Polluted

APPENDIX I
Sediment Parameters* That Were Below Detection Limits At All Stations During Each Sampling Period

*Units are mg/kg unless otherwise noted.

Appendix I: Sediment Parameters that Were Below Detection Limits At All Stations for the Fall, 1987	
Parameter	**Concentration (mg/kg)**
Hexachlorobenzene	<0.01
Hexachlorocyclohexane, alpha isomer	<0.01
Hexachlorocyclohexane, beta isomer	<0.01
Hexachlorocyclohexane, gamma isomer	<0.01
Hexachlorocyclohexane, delta isomer	<0.01
Heptachlor	<0.01
Aldrin	<0.01
Heptachlor Epoxide	<0.01
Oxychlordane	<0.01
t-Chlordane	<0.01
c-Chlordane	<0.01
t-Nonachlor	<0.01
Alpha-Chlordene	<0.01
Chlordene	<0.01
gamma-Chlordene	<0.01
cis-Nonachlor	<0.01
O,P'-DDE	<0.01
P,P'-DDE	<0.01
Dieldrin	<0.01
Endrin	<0.01
O,P'-DDD	<0.01
P,P'-DDD	<0.01
O,P'-DDT	<0.01
P,P'-DDT	<0.01
Total DDT	<0.01
Methoxychlor	<0.01
Mirex	<0.01

Appendix I: Continued	
Parameter	**Concentration (mg/kg)**
Endosulfan I	<0.01
Endosulfan II	<0.01
Endosulfan Sulfate	<0.01
Endrin Aldehyde	<0.01
Endrin Ketone	<0.01
Toxaphene	<0.01
Pentachlorophenol	<0.01
2,3,4,5-Tetrachlorophenol	<0.01
2,3,4,6-Tetrachlorophenol	<0.01
Aroclor 1016	<0.1
Aroclor 1221	<0.1
Aroclor 1232	<0.1
Aroclor 1242	<0.1
Aroclor 1248	<0.1
Aroclor 1254	<0.1
Aroclor 1260	<0.1
Aroclor 1262	<0.1
Aroclor 1268	<0.1

Appendix I: Sediment Parameters that Were Below Detection Limits At All Stations for the Spring, 1986 and Summer, 1986		
Parameter	Concentration (mg/kg)	
	Spring 1986	Summer 1986
Cyanide	<0.01	-
PCBs	-	<0.1
Aldrin	<0.01	<0.01
Dieldrin	<0.01	<0.01
DDT, total	<0.01	<0.01
O,P'-DDE	<0.01	<0.01
P,P'-DDE	<0.01	<0.01
O,P'-DDD	<0.01	<0.01
P,P'-DDD	<0.01	<0.01
O,P'-DDT	<0.01	<0.01
P,P'-DDT	<0.01	<0.01
Chlordane	<0.01	<0.01
Cis-chlordane	<0.01	<0.01
Trans-chlordane	<0.01	<0.01
Trans-nonachlor	<0.01	<0.01
Endosulfan I	<0.01	<0.01
Endosulfan II	<0.01	<0.01
Endosulfan Sulfate	<0.01	<0.01
Endrin	<0.01	<0.01
Endrin Aldehyde	<0.01	<0.01
Endrin Ketone	<0.01	<0.01
Hexachlorobenzene	<0.01	<0.01
Hexachlorocyclohexane	<0.01	<0.01
Alpha BHC	<0.01	<0.01
Beta BHC	<0.01	<0.01

Appendix I: Continued		
Parameter	Concentration (mg/kg)	
	Spring 1986	Summer 1986
Gamma BHC (Lindane)	<0.1	<0.1
Delta BHC	<0.1	<0.1
Methoxychlor	<0.01	<0.01
Mirex	<0.01	<0.01
Pentachlorophenol	<0.01	<0.01
Tetrachlorophenol 2,3,4,5	<0.01	<0.01
Tetrachlorophenol 2,3,4,6	<0.01	<0.01
Toxaphene		

APPENDIX J
Synoptic List of the Diatoms from the North Elkhorn Creek Drainage

North Elkhorn Creek Intensive Survey Diatom Data, 1986-1987

Row	Species	16-1	16-5	16-6	16-9	16-13	16-14	16-24	16-25	16-26
1	Achnanthes deflexa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
2	Achnanthes hungarica	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	Achnanthes lanceolata	0.2	1.0	0.4	0.0	0.0	*	0.0	0.2	0.0
4	Achnanthes lanceolata var. dubia	0.0	0.0	0.0	0.0	0.2	0.2	1.2	1.8	1.6
5	Achnanthes linearis	0.0	0.0	*	1.2	0.0	3.0	0.0	0.0	0.0
6	Achnanthes linearis var. pusilla	0.0	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0
7	Achnanthes minutissima	2.6	0.0	0.0	0.0	0.6	6.2	0.0	1.6	6.6
8	Achnanthes pinnata	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0
9	Amphora ovalis var. pediculus	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
10	Amphora perpusilla	0.4	*	0.2	0.0	0.2	0.8	0.2	0.0	0.0
11	Amphora submontana	0.0	0.0	0.0	*	0.0	0.0	0.0	0.2	*
12	Cocconeis pediculus	1.2	7.0	*	0.2	2.4	*	2.2	0.0	0.0
13	Cocconeis placentula var. euglypta	0.0	5.2	0.0	0.0	11.8	0.2	2.4	0.0	*
14	Cocconeis placentula var. lineata	0.2	4.2	0.4	0.8	0.0	*	7.0	0.0	0.0
15	Cyclotella atomus	6.1	2.8	1.0	27.7	1.6	0.0	0.0	0.0	0.2
16	Cyclotella meneghiniana	1.0	1.0	0.0	3.8	2.6	*	0.2	0.0	0.0
17	Cyclotella pseudostelligera	0.0	0.2	0.0	0.0	3.0	0.0	0.0	0.0	0.0
18	Cyclotella sp.	0.0	7.8	1.0	32.1	24.0	0.6	0.2	0.0	0.2
19	Cyclotella striata var. ambigua	1.0	0.0	0.2	0.4	1.6	0.2	0.2	0.0	0.6
20	Cymatopleura solea	0.0	0.0	0.0	0.0	0.0	*	2.0	0.2	0.0
21	Cymbella prostrata	0.2	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	Cymbella sinuata	0.6	0.0	0.0	0.0	0.4	*	0.0	0.0	0.0
23	Cymbella triangulum	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	Cymbella tumida	0.0	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0
25	Cymbella turgidula	3.6	*	0.4	0.0	0.0	1.2	0.0	0.0	0.0
26	Diatoma vulgare	0.0	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0
27	Eunotia sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
28	Fragilaria vaucheriae	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	1.6
29	Frustulia vulgaris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*
30	Gomphonema abbreviatum	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
31	Gomphonema acuminatum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*	*
32	Gomphonema affine	0.0	0.0	0.0	*	1.2	0.0	0.0	0.0	0.0
33	Gomphonema angustatum	5.7	0.6	0.2	*	0.0	1.0	11.0	25.2	76.6
34	Gomphonema clevei	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0
35	Gomphonema gracile	0.0	*	0.0	0.2	*	*	0.0	0.0	0.0
36	Gomphonema parvulum	0.8	0.8	0.2	1.6	5.2	4.8	0.4	0.8	0.6
37	Gomphonema sphaerophorum	0.0	0.0	0.0	*	0.2	0.0	0.0	0.0	0.0
38	Gomphonema spp.	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
39	Gomphonema sp. (instabilis?)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
40	Gomphonema subclavatum	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	Gomphonema truncatum	0.0	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0
42	Gyrosigma acuminatum	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0
43	Gyrosigma scalproides	*	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0
44	Gyrosigma spencerii var. curvula	1.2	0.0	0.0	0.0	1.2	0.4	0.0	0.0	0.0
45	Hantzschia amphioxys	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
46	Melosira granulata	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0
47	Melosira varians	0.0	2.0	0.0	*	*	0.4	0.0	0.6	0.0
48	Meridion circulare	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
49	Navicula accomoda	0.2	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0
50	Navicula arvensis	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
51	Navicula confervacea	0.0	30.0	0.0	9.8	2.2	0.0	0.0	0.0	0.0
52	Navicula cryptocephala	0.2	*	*	0.4	7.6	0.6	0.8	1.2	1.0
53	Navicula cryptocephala var. exilis	1.2	0.6	0.0	0.0	0.0	0.8	0.0	0.0	0.0

Row	Species	16-1	16-5	16-6	16-9	16-13	16-14	16-24	16-25	16-26
54	Navicula cryptocephala var. veneta	0.0	0.0	0.0	1.0	0.6	0.0	0.6	0.0	0.8
55	Navicula cuspidata	0.0	0.0	*	0.0	*	*	0.2	*	0.0
56	Navicula hustedtii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2
57	Navicula lanceolata	0.2	0.2	0.0	0.6	1.0	*	1.0	2.0	0.0
58	Navicula luzonensis	1.6	1.0	1.4	1.0	1.0	0.4	0.0	0.0	0.0
59	Navicula menisculus var. upsaliensis	0.2	*	0.0	0.0	0.2	0.8	1.8	1.0	0.2
60	Navicula minima	34.6	20.0	45.8	0.0	3.6	16.9	0.4	7.0	0.6
61	Navicula modica	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0
62	Navicula mutica	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0
63	Navicula mutica var. cohnii	0.0	0.0	0.0	0.0	0.0	0.0	*	0.0	0.0
64	Navicula notha	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0
65	Navicula paucivisitata	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0
66	Navicula pupula	*	0.0	0.0	0.0	*	*	0.0	0.0	0.0
67	Navicula pygmaea	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
68	Navicula radiosa var. tenella	1.2	0.2	0.4	0.8	0.2	0.4	0.0	0.0	0.0
69	Navicula rhynchocephala	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*
70	Navicula rhynchocephala var. germanii	3.0	0.4	0.2	0.6	0.2	2.6	0.0	0.0	0.0
71	Navicula salinarum var. intermedia	*	0.0	0.0	0.2	0.2	0.4	0.0	0.0	*
72	Navicula secreta var. apiculata	0.0	0.0	0.0	0.0	0.0	1.4	7.8	0.0	0.0
73	Navicula seminulum	0.0	0.0	3.6	0.0	0.0	0.6	0.0	0.0	0.0
74	Navicula spp.	0.8	0.6	0.4	0.2	0.4	0.0	0.4	0.0	*
75	Navicula subminuscula	0.0	0.0	0.0	0.0	0.0	16.5	5.4	2.2	0.0
76	Navicula symmetrica	2.2	1.0	0.8	0.4	0.2	0.4	0.0	0.0	0.0
77	Navicula tenelloides	0.0	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0
78	Navicula tenera	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
79	Navicula tripunctata	*	0.0	*	0.0	0.0	0.0	0.2	0.0	0.0
80	Navicula tripunctata var. schizonemoides	3.4	0.0	0.0	0.0	2.4	1.4	0.6	0.0	0.0
81	Navicula viridula var. rostellata	6.3	*	0.0	*	1.4	1.8	0.0	0.0	0.0
82	Nitzschia acicularis	0.0	0.2	*	*	0.6	1.6	5.6	0.2	0.0
83	Nitzschia amphibia	2.6	5.0	36.3	0.6	1.4	1.8	0.0	0.0	0.0
84	Nitzschia angustata var. acuta	0.4	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
85	Nitzschia apiculata	0.2	0.0	*	0.0	0.2	*	0.0	0.2	*
86	Nitzschia dissipata	0.0	0.2	*	0.2	0.0	*	2.6	0.0	0.8
87	Nitzschia filiformis	1.4	0.0	0.4	2.6	0.2	2.8	2.6	0.0	0.0
88	Nitzschia fonticola	2.2	0.4	0.0	*	2.0	3.2	1.8	0.0	0.2
89	Nitzschia frustulum	0.0	0.0	0.0	0.0	*	0.4	0.0	0.0	0.4
90	Nitzschia ganderscheimiensis	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
91	Nitzschia gracilis	0.0	0.0	0.0	0.0	0.2	0.0	1.2	0.0	0.0
92	Nitzschia hungarica	0.0	0.0	0.0	*	*	0.0	0.2	0.0	0.0
93	Nitzschia intermedia	0.2	0.0	0.0	*	*	0.0	0.0	0.0	0.0
94	Nitzschia levidensis	0.8	0.2	0.0	0.0	0.0	0.0	0.4	0.0	0.0
95	Nitzschia linearis	0.0	0.0	0.0	*	*	0.0	0.2	1.0	1.2
96	Nitzschia palea	7.7	1.8	4.0	9.8	11.2	16.7	4.2	8.8	0.6
97	Nitzschia palea var. tenuirostris	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0
98	Nitzschia paleacea	0.0	0.0	0.0	0.0	1.6	3.8	3.6	38.6	0.8
99	Nitzschia rautenbachiae	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0
100	Nitzschia recta	*	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
101	Nitzschia spp.	0.4	0.0	0.4	0.0	0.0	0.4	0.6	0.4	0.8
102	Nitzschia sp. 1	0.0	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0
103	Nitzschia tropica	*	0.0	0.0	0.0	1.2	0.4	0.0	0.0	0.0
104	Pinnularia sp. (caudata?)	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
105	Pinnularia sp. (viridis?)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*
106	Rhoicosphenia curvata	0.2	4.4	1.4	*	*	1.0	2.4	5.2	*

North Elkhorn Creek Intensive Survey Diatom Data, 1986-1987

Row	Species	16-1	16-5	16-6	16-9	16-13	16-14	16-24	16-25	16-26
107	Skeletonema potamos	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
108	Stephanodiscus sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
109	Stephanodiscus sp. (Hantzschii)	0.0	0.0	*	1.2	0.0	0.0	0.0	0.0	0.2
110	Stephanodiscus sp. (invisitatus)	0.0	0.0	0.0	0.8	1.8	0.0	0.0	0.0	0.0
111	Surirella angustata	0.4	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.0
112	Surirella elegans	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
113	Surirella ovalis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
114	Surirella ovata	0.6	0.2	0.0	0.0	0.2	0.8	10.8	0.8	0.8
115	Synedra acus	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.8
116	Synedra ulna	0.0	0.0	0.0	0.0	0.0	1.0	6.8	0.0	0.0
117	Thalassiosira weissflogii	1.4	0.2	*	0.2	1.2	0.0	0.0	0.0	0.0
	Total number of individuals counted	506	500	504	501	500	497	500	500	500
	Total taxa (per 500 valve count)	44	31	23	27	42	42	48	25	25

* Observed but not encountered during 500 valve count

APPENDIX K
Synoptic List of the Algae, Exclusive of Diatoms, from the North Elkhorn Creek Drainage

SYNOPTIC LIST OF ALGAE, EXCLUSIVE OF DIATOMS, FROM THE NORTH ELKHORN CREEK DRAINAGE

Taxa	001	005	006	009	013	014	024	025	026
CHLOROPHYTA									
Actinastrum hantzschii					X	X	X	X	
Ankistrodesmus sp.								X	
Chlamydomonas sp.				X	X	X	X	X	
Cladophora glomerata	X	X	X	X	X	X	X	X	X
Closterium acerosum		X	X	X	X	X	X	X	X
Closterium eboracense					X		X	X	
Closterium strigosum									X
Coelastrum sphaericum					X	X	X	X	
Cosmarium spp.	X	X				X	X	X	
Gonium pectorale						X	X		
Hydrodictyon recticulum		X		X	X				
Oedogonium gracilius								X	
Oedogonium spp.				X			X	X	
Pandorina morum	X	X		X		X	X	X	
Pediastrum boryanum								X	
Pediastrum duplex		X	X		X		X		
Pediastrum simplex					X				
Quadrigula chodatii							X		
Radiofilum transversalis							X		
Rhizoclonium hieroglyphicum		X	X						
Scenedesmus acuminatus								X	
Scenedesmus acutiformes							X		
Scenedesmus bijuga	X	X	X	X	X	X	X	X	
Scenedesmus dimorphus						X	X		
Scenedesmus quadricauda		X		X	X	X	X	X	
Sphaerocystis schroeteri				X	X	X	X	X	
Spirogyra singularis									X
Spirogyra spp.		X		X	X			X	
Stigeoclonium stagnatile							X		
Stigeoclonium subsecundum								X	
Stigeoclonium tenue				X	X	X	X	X	X
Tetraspora gelatinosa	X						X	X	
Ulothrix variabilis							X		
Zygnema sp.							X		X
CHAROPHYTA									
Chara sp.		X							
CHRYSOPHYTA									
Vaucheria sp.		X					X		
CYANOPHYTA									
Agmenellum quadriduplicatum type elegans	X		X	X		X	X	X	
Agmenellum quadriduplicatum type tenuissima							X		

Anabaena spp.	X	X	X	X	X	X	X	X	
Calothrix braunii				X	X				
Chroococcus limnetica							X		
Chroococcus sp.				X	X	X		X	
Lyngbya contorta							X		
Lyngbya digueti								X	
Lyngbya major	X		X	X	X	X		X	
Microcoleus lacustris	X	X	X	X	X			X	
Microcoleus sociatus			X						
Microcystis sp.	X			X	X				
Oscillatoria spp.	X	X	X	X	X	X	X	X	X
Spirulina princeps				X					
EUGLENOPHYTA									
Euglena acus					X				
Euglena spp.							X		X
Phacus longicauda				X	X		X		
Phacus orbicularis				X	X	X	X	X	
Trachelomonas armata					X				
RHODOPHYTA									
Audouinella violacea		X							
Lemanea australis							X	X	
Taxa at Each Station	11	16	11	22	25	19	34	29	8
Total Number of Taxa					57				

APPENDIX L
Synoptic List of the Macroinvertebrates from the North Elkhorn Creek Drainage

North Elkhorn Creek Macroinvertebrate Synoptic List

Species	16-1	16-5	16-6	16-9	16-13	16-14	16-16	16-24	16-25	16-26
Lumbriculus sp		1			11				28	19
Erpobdella punctata		1								
Helobdella elongata					2	3				
Helobdella triserialis		1								
Branchiura sowerbyi				6	3					
Hymanella retenuova		9		4	11	3				
Ferrissia rivularis	2			2	13	1				
Physa sp	13	2	6	8	1	1		8	22	34
Helisoma anceps anceps	7	1	8	1	1	9		5	7	4
Elimia sp	337	14	9	12	16	13		1	5	
Campeloma crassula		3	1							
Corbicula fluminea	8	5		1		1				
Musculium partumeium					1					4
Sphaerium simile	70	1	1	3				14		5
Sphaerium striatium	57	4	1	14	25	1		1		
Lirceus fontinalis	5		2	12	8	24		11	662	347
Crangonyx sp	8		1	2		1		8	14	150
Gammurus sp		2								
Cambarus ortmani							3			20
Orconectes rusticus	15	7		3	2	2		10	7	5
Baetis tricaudatus	69	35	33	15	16	1				
Baetisca gibbera	5									
Caenis sp	22	9	5	15	28	18				
Isonychia sp	340	2			1					
Stenacron interpunctatum		3	16	7	2	9		1	18	
Stenonema femoratum	25		8		1					33
Paraleptophlebia guttata										9
Ephoron leukon		2								
Amphinemura sp										2
Acroneuria arenosa	14		1							
Eccoptura xanthenes		1							10	38
Basiaeschna janata	4									
Nasiaeschna pentacantha		3			1			1		
Argia bipunctulata		1								
Argia sp	6		1							
Enallagma basidens					2					
Enallagma divagans		16	1	21	9			2		1
Enallagma doubledayi				4						
Enallagma hageni									1	
Enallagma sp	15									
Enallagma vesperum		4	7		7			3		
Ischnura posita		7				3		2		
Ischnura verticalis					6					
Calopteryx dimidiata					2					
Calopteryx maculata	22									
Hetaerina americana		2								
Hagenius brevistylus	1									

North Elkhorn Creek Macroinvertebrate Synoptic List

Species	16-1	16-5	16-6	16-9	16-13	16-14	16-16	16-24	16-25	16-26
Lanthus parvulus			1							
Erythemis simplicicollis		1		1						
Libellula luctosa					1				3	
Pachydiplax longipennis				1						
Perithemis seminole		2								
Belostoma flumineum	3	1	1	1		1			3	1
Trichocorixa sp						9			2	3
Gerris remigis										1
Metrobates hesperius	5	2			8					
Rheumatobates rileyi	2	2		2		2				
Trepobates pictus	5	2	6		8	3				
Hydrometra martini					1					
Mesovelia mulsanti	6	2	2	1	6	1				
Ranatra buenoi		1	1	2						
Notonecta irrorata								1		
Neoplea striola	1	3	1	2					1	
Rhagovelia obesa	12	3			1					
Onychylis nigrirostris										2
Helichus lithophilus	2	1			1	1				
Celina contiger				1						
Desmopachria grana								3		1
Hydaticus sp										1
Ancyronyx variegatus	1			2	2					
Dubiraphia sp larva				1						
Dubiraphia vittata	8	3	9	7	16	2				
Stenelmis sinuata	419	30	9	12	30	20			2	11
Stenelmis sp larva	1239	18	35	7	49	9				3
Dineutus assimilis								2		5
Peltodytes lengi	15	15	1	5	1	8		1	3	10
Hydrochus rugosus					1					
Helobata striata										5
Tropisternus sp	2				3					
Tropisternus mixtus	1		6		3	4		4	2	2
Tropisternus lateralis nimbatus					1					
Hydrocanthus oblongus		4			1			4	1	
Psephenus herricki	135	1	2	15	6	6				
Cyphon sp		2		7	4	1				
Corydalus cornutus	43	2	1							
Sialis americana		2	2	6						
Helicopsyche borealis	10	7		7	3	12				
Ceratopsyche bifida	3		1							
Cheumatopsyche sp	499	65	22	38	68	1				
Hydropsyche betteni	54		7							
Hydroptila sp									19	2
Oecetis inconspicua				1						
Neophylax sp	8			29	3					
Pycnopsyche gentilis			1							

North Elkhorn Creek Macroinvertebrate Synoptic List

Species	16-1	16-5	16-6	16-9	16-13	16-14	16-16	16-24	16-25	16-26
Chimarra sp	1	6								
Neureclipsis sp		10			2				1	1
Ephoron leukon										
Rhyacophila sp									17	5
Munroessa icciusalis									1	
Parapoynx sp	1									
Petrophila fulicalis	18									
Petrophila sp						1				
Ablabesmyia mallochi						3				
Cardiocladius obscurus	1									
Chironomus decorus gr										6
Clinotanypus pinguis				1						
Corynoneura celeripes					1					
Corynoneura taris									1	
Cryptochironomus fulvus gr	2			1	5	4				
Eukiefferiella brevicalcar gr.									1	
Eukiefferiella pseudomontana gr.									1	
Eukiefferiella sp									1	
Glyptotendipes meridionalis			1	28		2				
Glyptotendipes sp					1					
Heterotrissocladius marcidus gr.									1	
Limnophora sp				2						
Microtendipes pedellus gr	2									
Natarsia baltimoreus									2	5
Nilotanypus fimbriatus					1					
Orthocladius carlatus			1							
Orthocladius obumbratus									1	
Orthocladius sp 1										1
Polypedilum convictum	296	30	6	7	35					
Polypedilum illinoense					1					
Polypedilum scalaenum	1					1				
Probezzia-Johannsonomyia gr sp									2	
Procladius bellus										3
Stictochironomus divinctus						10				
Tanytarsus guerlus gr										3
Thienemanniella xena	1									
Thienemannimyia sp.	20	1	1		1					1
Simulium sp		3		20	4				7	
Tabanus sp	1				1					1
Tipula sp				1						1

APPENDIX M
Synoptic List of the Fish for the North Elkhorn Creek Drainage

Appendix M: Fish Synoptic List for the North Elkhorn Creek Drainage					
	Stations				
Species	16-1	16-5	16-6	16-9	16-13
Catostomus commersoni					
Hypentelium nigricans	4	9	1		1
Moxostoma erythrurum	1				
Campostoma anomalum	8	14	2		10
Cyprinus carpio				1	2
Lythrurus ardens	70	80	75	70	33
Luxilus chrysocephalus	9	8	16	10	80
Notropis photogenis	130	3	4		
Cyprinella spiloptera	31	13			
Notropis volucellus	1				
Pimephales notatus	9	32	37	2	23
Pimephales promelas					
Semotilus atromaculatus			1		
Ictalurus melas					
Ictalurus punctatus				1	1
Gambusia affinis		4	9	1	8
Fundulus notatus					
Labidesthes sicculus	10	23	37	50	83
Cottus carolinae		1	1		2
Ambloplites rupestris	3	8	2		3
Lepomis cyanellus	2	3		2	3
Lepomis gulosus					
Lepomis macrochirus	3	25	6	35	1
Lepomis megalotis	6	2	6	3	2
Lepomis microlophus		1			
Micropterus dolomieui	6	4		2	4
Micropterus punctulatus		4		6	3

Appendix M: Continued					
	Stations				
Species	16-1	16-5	16-6	16-9	16-13
Catostomus commersoni			2		
Pomoxis annularis					2
Ethostoma blenniodes	2	17	1	9	8
Ethostoma caeruleum		1	1		
Etheostoma flabellare	4	2	13	2	1
Etheostoma nigrum	2	4	1		
Etheostoma spectabile	1				
Total	19	21	18	14	19
34 species					

Appendix M: Continued				
	Stations			
Species	16-14	16-24	16-25	16-26
Catostomus commersoni	25			
Hypentelium nigricans				
Moxostoma erythrurum				
Campostoma anomalum	71			
Cyprinus carpio				
Lythrurus ardens	25	2		
Luxilus chrysocephalus	13			
Notropis photogenis				
Cypinella spiloptera				
Notropis volucellus	1			
Pimephales notatus	22	45	14	55
Pimephales promelas		9		
Semotilus atromaculatus	1		1	
Ictalurus melas		1	9	
Ictalurus punctatus				
Gambusia affinis	10	12	36	
Fundulus notatus		1		
Labidesthes sicculus	1		14	
Cottus carolinae	2		1	
Ambloplites rupestris				
Lepomis cyanellus	2		9	22
Lepomis gulosus			2	
Lepomis macrochirus		8	15	25
Lepomis megalotis	5			
Lepomis microlophus				
Micropterus dolomieui	3			
Micropterus punctulatus				2
Micropterus salmoides				
Pomoxis annularis				

Appendix M: Continued				
	Stations			
Species	16-14	16-24	16-25	16-26
Ethostoma blenniodes	11			
Ethostoma caeruleum				
Etheostoma flabellare		2	1	
Etheostoma nigrum	23			
Etheostoma spectabile	9	16	24	
Total	16	9	11	4
34 species				

APPENDIX N
Fish Tissue Data Summary for the North Elkhorn Creek Drainage During 1986 and 1987

Appendix N: Fish Tissue Data Summary for the North Elkhorn Creek Drainage During 1986				
Collection Date	8-5-86	8-5-86	8-6-86	8-6-86
Station No.	16-1	16-1	16-5	16-5
Species	Rockbass	Redhorse	Rockbass	Hog-sucker
Sample Type	WB	WB	WB	WB
Parameters (mg/kg)				
Aluminum	57.8	57.2	58.2	84.8
Arsenic	<0.005	<0.005	0.005	<0.005
Beryllium	0.003	0.002	0.001	0.010
Cadmium	<0.001	<0.001	<0.001	<0.001
Chromium	0.567	0.423	0.422	0.580
Copper	1.36	0.586	0.859	0.897
Lead	1.03	0.135	0.039	0.156
Manganese	7.14	23.4	9.22	33.0
Mercury	0.089	0.267	0.081	0.058
Nickel	.143	0.063	0.262	0.219
Zinc	27.1	25.7	23.9	28.5
Hexachlorobenzene	<0.01	<0.01	<0.01	<0.01
Hexachlorocyclohexane (a)	<0.01	<0.01	<0.01	<0.01
Hexachlorocyclohexane (b)	<0.01	<0.01	<0.01	<0.01
Hexachlorocyclohexane (g)	<0.01	<0.01	<0.01	<0.01
Hexachlorocyclohexane (d)	<0.01	<0.01	<0.01	<0.01
Heptachlor	<0.01	<0.01	<0.01	<0.01
Aldrin	<0.01	<0.01	<0.01	<0.01
Heptachlor Epoxide	<0.01	<0.01	<0.01	<0.01
Oxychlordane	<0.01	<0.01	<0.01	<0.01
trans-Chlordane	<0.01	<0.01	<0.01	0.011
cis-Chlordane	0.030	0.017	0.056	0.061
trans-Nonachlor	<0.01	<0.01	<0.01	<0.01
alpha-Chlordene	-	-	-	-
Chlordene	-	-	-	-
gamma-Chlordene	-	-	-	-

Appendix N: Continued				
Collection Date	8-5-86	8-5-86	8-6-86	8-6-86
Station No.	16-1	16-1	16-5	16-5
Species	Rockbass	Redhorse	Rockbass	Hog-sucker
Sample Type	WB	WB	WB	WB
Parameters (mg/kg)				
cis-Nonachlor	-	-	-	-
O,P'-DDE	<0.01	<0.01	<0.01	<0.01
P,P'-DDE	0.033	0.022	0.030	0.036
Dieldrin	0.042	0.015	0.034	0.035
Endrin	<0.01	<0.01	<0.01	<0.01
O,P'-DDD	<0.01	<0.01	<0.01	<0.01
P,P'-DDD	0.024	0.027	0.033	0.045
O,P'-DDT	<0.01	<0.01	<0.01	<0.01
P,P'-DDT	0.021	0.025	<0.01	<0.01
Total DDT	0.087	0.076	0.063	0.081
Methoxychlor	<0.01	<0.01	<0.01	<0.01
Mirex	<0.01	<0.01	<0.01	<0.01
Endosulfan I	<0.01	<0.01	<0.01	<0.01
Endosulfan II	<0.01	<0.01	<0.01	<0.01
Endosulfan Sulfate	<0.01	<0.01	<0.01	<0.01
Endrin Aldehyde	<0.01	<0.01	<0.01	<0.01
Endrin Ketone	<0.01	<0.01	<0.01	<0.01
Toxaphene	<0.1	<0.1	<0.1	<0.1
Pentachlorophenol	<0.01	<0.01	<0.01	<0.01
2,3,4,6-Tetrachloro-phenol	<0.01	<0.01	<0.01	<0.01
2,3,4,5-Tetrachloro-phenol	<0.01	<0.01	<0.01	<0.01

Appendix N: Continued				
Collection Date	8-5-86	8-5-86	8-6-86	8-6-86
Station No.	16-1	16-1	16-5	16-5
Species	Rockbass	Redhorse	Rockbass	Hog-sucker
Sample Type	WB	WB	WB	WB
Parameters (mg/kg)				
Aroclor 1016	<0.1	<0.1	<0.1	<0.1
Aroclor 1221	<0.1	<0.1	<0.1	<0.1
Aroclor 1232	<0.1	<0.1	<0.1	<0.1
Aroclor 1242	<0.1	<0.1	<0.1	<0.1
Aroclor 1248	<0.1	<0.1	<0.1	<0.1
Aroclor 1254	0.28	<0.1	<0.1	<0.1
Aroclor 1260	<0.1	0.17	0.19	0.23
Aroclor 1262	<0.1	<0.1	<0.1	<0.1
Aroclor 1268	<0.1	<0.1	<0.1	<0.1
Percent Lipid (%)	4.1	0.9	3.6	5.1
* WB = Wholebody				
F = Fillet				

Appendix N: Continued				
Collection Date	10-17-86	10-17-86	10-17-86	10-1-86
Station No.	16-9	16-9	16-9	16-9
Species	Lgm. Bass	Lgm. Bass	C. Catfish	C. Catfish
Sample Type	WB	F	F	WB
Parameters (mg/kg)				
Aluminum	45.1	27.1	48.0	69.9
Arsenic	<0.072	<0.072	0.137	<0.072
Beryllium	0.032	0.036	0.034	0.049
Cadmium	<0.005	<0.005	<0.005	<0.005
Chromium	0.031	0.078	0.108	0.155
Copper	0.268	1.44	0.333	0.529
Lead	<0.073	<0.073	<0.078	0.519
Manganese	7.46	3.21	2.45	5.83
Mercury	0.110	0.159	0.136	0.091
Nickel	0.263	<0.110	<0.110	<0.110
Zinc	16.8	13.2	10.9	22.5
Hexachlorobenzene	<0.01	<0.01	<0.01	<0.01
Hexachlorocyclohexane (a)	<0.01	<0.01	<0.01	<0.01
Hexachlorocyclohexane (b)	<0.01	<0.01	<0.01	<0.01
Hexachlorocyclohexane (g)	<0.01	<0.01	<0.01	<0.01
Hexachlorocyclohexane (d)	<0.01	<0.01	<0.01	<0.01
Heptachlor	<0.01	<0.01	<0.01	<0.01
Aldrin	<0.01	<0.01	<0.01	<0.01
Heptachlor Epoxide	<0.01	<0.01	<0.01	<0.01
Oxychlordane	0.022	<0.01	0.021	0.031
trans-Chlordane	0.012	<0.01	0.023	0.022
cis-Chlordane	0.027	<0.01	0.049	0.042
trans-Nonachlor	0.104	<0.01	0.040	0.083
alpha-Chlordene	<0.01	<0.01	<0.01	<0.01
Chlordene	<0.01	<0.01	<0.01	<0.01

Appendix N: Continued				
Collection Date	10-17-86	10-17-86	10-17-86	10-1-86
Station No.	16-9	16-9	16-9	16-9
Species	Lgm. Bass	Lgm. Bass	C. Catfish	C. Catfish
Sample Type	WB	F	F	WB
Parameters (mg/kg)				
gamma-Chlordene	<0.01	<0.01	<0.01	<0.01
cis-Nonachlor	<0.01	<0.01	<0.01	<0.01
O,P'-DDE	<0.01	<0.01	<0.01	<0.01
P,P'-DDE	0.056	<0.01	0.048	0.056
Dieldrin	0.043	<0.01	0.052	0.064
Endrin	<0.01	<0.01	<0.01	<0.01
O,P'-DDD	<0.01	<0.01	<0.01	<0.01
P,P'-DDD	0.042	<0.01	0.037	<0.01
O,P'-DDT	<0.01	<0.01	<0.01	0.047
P,P'-DDT	0.024	<0.01	0.024	0.01
Total DDT	0.12	<0.01	0.11	<0.01
Methoxychlor	<0.01	<0.01	<0.01	<0.01
Mirex	<0.01	<0.01	<0.01	<0.01
Endosulfan I	<0.01	<0.01	<0.01	<0.01
Endosulfan II	<0.01	<0.01	<0.01	<0.01
Endosulfan Sulfate	<0.01	<0.01	<0.01	<0.01
Endrin Aldehyde	<0.01	<0.01	<0.01	<0.01
Endrin Ketone	<0.01	<0.01	<0.01	<0.01
Toxaphene	<0.1	<0.1	<0.1	<0.1
Pentachlorophenol	<0.01	<0.01	<0.01	<0.01
2,3,4,5-Tetrachlorophenol	<0.01	<0.01	<0.01	<0.01
2,3,4,6-Tetrachlorophenol	<0.01	<0.01	<0.01	<0.01
Aroclor 1016	<0.1	<0.1	<0.1	<0.1
Aroclor 1221	<0.1	<0.1	<0.1	<0.1
Aroclor 1232	<0.1	<0.1	<0.1	<0.1
Aroclor 1242	<0.1	<0.1	<0.1	<0.1

Appendix N: Continued				
Collection Date	10-17-86	10-17-86	10-17-86	10-1-86
Station No.	16-9	16-9	16-9	16-9
Species	Lgm. Bass	Lgm. Bass	C. Catfish	C. Catfish
Sample Type	WB	F	F	WB
Parameters (mg/kg)				
Aroclor 1248	<0.1	<0.1	<0.1	<0.1
Aroclor 1254	<0.1	<0.1	<0.1	<0.1
Aroclor 1260	<0.1	<0.1	<0.1	0.20
Aroclor 1262	<0.1	<0.1	<0.1	<0.1
Aroclor 1268	<0.1	<0.1	<0.1	<0.1
Percent Lipid (%)	4.2	0.92	7.06	11.2
* WB = Wholebody				
F = Fillet				

Appendix N: Continued			
Collection Date	10-17-86	10-17-86	10-17-86
Station No.	16-9	16-9	16-9
Species	Carp	Carp	Bluegill
Sample Type	WB	F	WB
Parameters (mg/kg)			
Aluminum	23.4	46.0	0.540
Arsenic	<0.005	<0.072	<0.005
Beryllium	0.004	<0.005	0.008
Cadmium	<0.001	<0.005	<0.001
Chromium	0.401	0.308	0.379
Copper	0.575	1.25	0.134
Lead	0.118	0.245	0.058
Manganese	7.55	3.37	15.2
Mercury	0.075	0.092	0.064
Nickel	0.736	<0.110	0.754
Zinc	89.6	32.5	21.9
Hexachlorobenzene	<0.01	<0.01	<0.01
Hexachlorocyclohexane (a)	<0.01	<0.01	<0.01
Hexachlorocyclohexane (b)	<0.01	<0.01	<0.01
Hexachlorocyclohexane (g)	<0.01	<0.01	<0.01
Hexachlorocyclohexane (d)	<0.01	<0.01	<0.01
Heptachlor	<0.01	<0.01	<0.01
Aldrin	<0.01	<0.01	<0.01
Heptachlor Epoxide	<0.01	<0.01	<0.01
Oxychlordane	<0.01	0.020	<0.01
trans-Chlordane	0.023	0.025	<0.01
cis-Chlordane	0.13	0.016	0.045
trans-Nonachlor	<0.01	0.066	<0.01
alpha-Chlordene	-	<0.01	-
Chlordene	-	<0.01	-
gamma-Chlordene	-	<0.01	-

Appendix N: Continued			
Collection Date	10-17-86	10-17-86	10-17-86
Station No.	16-9	16-9	16-9
Species	Carp	Carp	Bluegill
Sample Type	WB	F	WB
Parameters (mg/kg)			
cis-Nonachlor	-	<0.01	-
O,P'-DDE	<0.01	<0.01	<0.01
P,P'-DDE	0.072	0.051	0.030
Dieldrin	0.060	0.057	0.040
Endrin	<0.01	<0.01	<0.01
O,P'-DDD	<0.01	<0.01	<0.01
P,P'-DDD	0.052	0.053	0.026
O,P'-DDT	<0.01	<0.01	<0.01
P,P'-DDT	<0.01	<0.01	<0.01
Total DDT	0.12	0.10	0.056
Methoxychlor	<0.01	<0.01	<0.01
Mirex	<0.01	<0.01	<0.01
Endosulfan I	<0.01	<0.01	<0.01
Endosulfan II	<0.01	<0.01	<0.01
Endosulfan Sulfate	<0.01	<0.01	<0.01
Endrin Aldehyde	<0.01	<0.01	<0.01
Endrin Ketone	<0.01	<0.01	<0.01
Toxaphene	<0.1	<0.1	<0.1
Pentachlorophenol	<0.1	<0.01	<0.01
2,3,4,5-Tetrachlorophenol	<0.1	<0.01	<0.01
2,3,4,6-Tetrachlorophenol	<0.1	<0.01	<0.01
Aroclor 1016	<0.1	<0.1	<0.1
Aroclor 1221	<0.1	<0.1	<0.1
Aroclor 1232	<0.1	<0.1	<0.1
Aroclor 1242	<0.1	<0.1	<0.1
Aroclor 1248	<0.1	<0.1	<0.1

Appendix N: Continued			
Collection Date	10-17-86	10-17-86	10-17-86
Station No.	16-9	16-9	16-9
Species	Carp	Carp	Bluegill
Sample Type	WB	F	WB
Parameters (mg/kg)			
Aroclor 1254	<0.1	<0.1	<0.1
Aroclor 1260	<0.1	<0.1	<0.1
Aroclor 1262	<0.1	<0.1	<0.1
Aroclor 1268	<0.1	<0.1	<0.1
Technical Chlordane	0.15	-	0.045
Percent Lipid (%)	11.0	8.9	6.4
* WB = Wholebody			
F = Fillet			

Appendix N: Continued				
Collection Date	10-17-86	10-17-86	10-1-86	10-1-86
Station No.	16-13	16-13	16-13	16-13
Species	Carp	Carp	Catfish	Catfish
Sample Type	WB	F	WB	F
Parameters (mg/kg)				
Aluminum	33.8	87.2	25.8	31.7
Arsenic	<0.072	<0.072	<0.072	<0.072
Beryllium	0.045	0.041	0.030	0.012
Cadmium	<0.005	<0.005	<0.005	<0.005
Chromium	0.088	0.032	0.350	0.034
Copper	0.882	0.807	0.413	0.488
Lead	0.118	0.093	<0.073	<0.073
Manganese	7.35	3.68	7.28	2.67
Mercury	0.112	0.147	0.035	0.079
Nickel	<0.110	<0.110	0.126	<0.110
Zinc	70.2	22.7	17.4	8.35
Hexachlorobenzene	<0.01	<0.01	<0.01	<0.01
Hexachlorocyclohexane (a)	<0.01	<0.01	<0.01	<0.01
Hexachlorocyclohexane (b)	<0.01	<0.01	<0.01	<0.01
Hexachlorocyclohexane (g)	<0.01	<0.01	<0.01	<0.01
Hexachlorocyclohexane (d)	<0.01	<0.01	<0.01	<0.01
Heptachlor	<0.01	<0.01	<0.01	<0.01
Aldrin	<0.01	<0.01	<0.01	<0.01
Heptachlor Epoxide	<0.01	0.020	<0.01	<0.01
Oxychlordane	0.07	0.036	0.035	0.023
trans-Chlordane	0.087	0.048	0.034	0.027
cis-Chlordane	0.15	0.087	0.11	0.051
trans-Nonachlor	0.22	0.14	0.21	0.091
alpha-Chlordene	<0.01	<0.01	<0.01	<0.01
Chlordene	0.039	<0.01	<0.01	<0.01
gamma-Chlordene	<0.01	<0.01	0.025	0.016

Appendix N: Continued				
Collection Date	10-17-86	10-17-86	10-1-86	10-1-86
Station No.	16-13	16-13	16-13	16-13
Species	Carp	Carp	Catfish	Catfish
Sample Type	WB	F	WB	F
Parameters (mg/kg)				
cis-Nonachlor	<0.01	<0.01	<0.01	<0.01
O,P'-DDE	<0.01	<0.01	<0.01	<0.01
P,P'-DDE	0.095	0.088	0.046	0.039
Dieldrin	0.050	0.054	0.067	0.037
Endrin	<0.01	<0.01	<0.01	<0.01
O,P'-DDD	<0.01	<0.01	<0.01	<0.01
P,P'-DDD	0.055	0.058	0.054	0.030
O,P'-DDT	<0.01	<0.01	<0.01	<0.01
P,P'-DDT	<0.01	0.044	<0.01	<0.01
Total DDT	0.11	0.16	0.12	0.069
Methoxychlor	<0.01	<0.01	<0.01	<0.01
Mirex	<0.01	<0.01	<0.01	<0.01
Endosulfan I	<0.01	<0.01	<0.01	<0.01
Endosulfan II	<0.01	<0.01	<0.01	<0.01
Endosulfan Sulfate	<0.01	<0.01	<0.01	<0.01
Endrin Aldehyde	<0.01	<0.01	<0.01	<0.01
Endrin Ketone	<0.01	<0.01	<0.01	<0.01
Toxaphene	<0.1	<0.1	<0.1	<0.1
Pentachlorophenol	<0.01	<0.01	<0.01	<0.01
2,3,4,5-Tetrachlorophenol	<0.01	<0.01	<0.01	<0.01
2,3,4,6-Tetrachlorophenol	<0.01	<0.01	<0.01	<0.01
Aroclor 1016	<0.1	<0.1	<0.1	<0.1
Aroclor 1221	<0.1	<0.1	<0.1	<0.1
Aroclor 1232	<0.1	<0.1	<0.1	<0.1
Aroclor 1242	<0.1	<0.1	<0.1	<0.1
Aroclor 1248	<0.1	<0.1	<0.1	<0.1

Appendix N: Continued				
Collection Date	10-17-86	10-17-86	10-1-86	10-1-86
Station No.	16-13	16-13	16-13	16-13
Species	Carp	Carp	Catfish	Catfish
Sample Type	WB	F	WB	F
Parameters (mg/kg)				
Aroclor 1254	<0.1	<0.1	<0.1	<0.1
Aroclor 1260	<0.1	<0.1	<0.1	<0.1
Aroclor 1262	<0.1	<0.1	<0.1	<0.1
Aroclor 1268	<0.1	<0.1	<0.1	<0.1
Percent Lipid (%)	12.4	6.19	10.3	4.3
* WB = Wholebody				
F = Fillet				

Appendix N: Continued		
Collection Date	10-17-86	10-17-86
Station No.	16-16	16-16
Species	Carp	Carp
Sample Type	WB	F
Parameters (mg/kg)		
Aluminum	62.1	5.09
Arsenic	<0.005	<0.005
Beryllium	0.005	0.014
Cadmium	<0.001	<0.001
Chromium	0.366	0.366
Copper	0.849	0.425
Lead	0.249	0.117
Manganese	7.46	3.27
Mercury	0.089	0.128
Nickel	0.095	0.701
Zinc	48.9	47.1
Hexachlorobenzene	<0.01	<0.01
Hexachlorocyclohexane (a)	<0.01	<0.01
Hexachlorocyclohexane (b)	<0.01	<0.01
Hexachlorocyclohexane (g)	<0.01	<0.01
Hexachlorocyclohexane (d)	<0.01	<0.01
Heptachlor	<0.01	<0.01
Aldrin	<0.01	<0.01
Heptachlor Epoxide	<0.01	<0.01
Oxychlordane	<0.01	<0.01
trans-Chlordane	0.077	0.044
cis-Chlordane	0.53	0.24
trans-Nonachlor	<0.01	<0.01
alpha-Chlordene	-	-
Chlordene	-	-
gamma-Chlordene	-	-

Appendix N: Continued		
Collection Date	10-17-86	10-17-86
Station No.	16-16	16-16
Species	Carp	Carp
Sample Type	WB	F
Parameters (mg/kg)		
cis-Nonachlor	-	-
O,P'-DDE	<0.01	<0.01
P,P'-DDE	0.11	0.055
Dieldrin	0.041	0.021
Endrin	<0.01	<0.01
O,P'-DDD	<0.01	<0.01
P,P'-DDD	0.10	0.050
O,P'-DDT	<0.01	<0.01
P,P'-DDT	<0.01	<0.01
Total DDT	0.21	.011
Methoxychlor	<0.01	<0.01
Mirex	<0.01	<0.01
Endosulfan I	<0.01	<0.01
Endosulfan II	<0.01	<0.01
Endosulfan Sulfate	<0.01	<0.01
Endrin Aldehyde	<0.01	<0.01
Endrin Ketone	<0.01	<0.01
Toxaphene	<0.3	<0.1
Pentachlorophenol	<0.01	<0.01
2,3,4,5-Tetrachlorophenol	<0.01	<0.01
2,3,4,6-Tetrachlorophenol	<0.01	<0.01
Aroclor 1016	<0.3	<0.1
Aroclor 1221	<0.3	<0.1
Aroclor 1232	<0.3	<0.1
Aroclor 1242	<0.3	<0.1
Aroclor 1248	<0.3	<0.1

Appendix N: Continued		
Collection Date	10-17-86	10-17-86
Station No.	16-16	16-16
Species	Carp	Carp
Sample Type	WB	F
Parameters (mg/kg)		
Aroclor 1254	<0.3	<0.1
Aroclor 1260	<0.3	<0.1
Aroclor 1262	<0.3	<0.1
Aroclor 1268	<0.3	<0.1
Technical Chlordane	-	0.28
* WB = Wholebody		
F = Fillet		

Appendix N: Fish Tissue Data for the North Elkhorn Creek Drainage During 1987			
Collection Date	4-10-87	4-10-87	4-10-87
Station No.	16-8	16-13	16-13
Species	Bluegill	Largemouth Bass	Black Crappie
Sample Type	WB*	F*	F
Parameters (mg/kg)			
Aluminum	NA*	NA	2.84
Arsenic	NA	NA	NA
Beryllium	NA	NA	NA
Cadmium	NA	NA	NA
Chromium	NA	NA	NA
Copper	NA	NA	NA
Lead	NA	NA	NA
Manganese	NA	NA	NA
Mercury	NA	NA	NA
Nickel	NA	NA	NA
Zinc	NA	NA	NA
Hexachlorobenzene	0.047	0.144	0.021
Hexachlorocyclohexane (a)	NA	NA	NA
Hexachlorocyclohexane (b)	NA	NA	NA
Hexachlorocyclohexane (g)	<0.005	<0.005	<0.005
Hexachlorocyclohexane (d)	<0.005	<0.005	<0.005
Heptachlor	<0.005	<0.005	<0.005
Aldrin	<0.005	<0.005	<0.005
Heptachlor Epoxide	<0.005	<0.005	<0.005
Oxychlordane	<0.005	<0.005	<0.005
trans-Chlordane	<0.005	<0.005	0.007
cis-Chlordane	<0.005	<0.005	<0.005
trans-Nonachlor	<0.005	<0.005	0.006
alpha-Chlordene	<0.005	<0.005	<0.005
Chlordene	<0.005	<0.005	<0.005

Appendix N: Continued			
gamma-Chlordene	<0.005	<0.005	<0.005
cis-Nonachlor	<0.005	<0.005	<0.005
O,P'-DDE	<0.005	<0.005	<0.005
P,P'-DDE	0.014	0.017	<0.005
Dieldrin	0.024	0.009	0.007
Endrin	<0.005	<0.005	<0.005
O,P'-DDD	<0.005	<0.005	<0.005
P,P'-DDD	<0.005	<0.005	<0.005
O,P'-DDT	<0.005	<0.005	<0.005
P,P'-DDT	<0.005	<0.005	<0.005
Total DDT	0.014	<0.005	<0.005
Methoxychlor	<0.005	<0.005	<0.005
Mirex	<0.005	<0.005	<0.005
Endosulfan I	<0.005	<0.005	<0.005
Endosulfan II	<0.005	<0.005	<0.005
Endosulfan Sulfate	<0.005	<0.005	<0.005
Endrin Aldehyde	<0.005	<0.005	<0.005
Endrin Ketone	<0.005	<0.005	<0.005
Toxaphene	<0.050	<0.050	<0.050
Atrazine	<0.050	<0.050	<0.050
Alachlor	<0.050	<0.050	<0.050
Pentachlorophenol	<0.005	<0.005	<0.005
2,3,4,5-Tetrachlorophenol	<0.005	<0.005	<0.005
2,3,4,6-Tetrachlorophenol	<0.005	<0.005	<0.005
Aroclor 1016	<0.050	<0.050	<0.050
Aroclor 1221	<0.050	<0.050	<0.050
Aroclor 1232	<0.050	<0.050	<0.050
Aroclor 1242	<0.050	<0.050	<0.050
Aroclor 1248	<0.050	<0.050	<0.050
Aroclor 1254	<0.050	<0.050	<0.050
Aroclor 1260	<0.050	<0.050	<0.050

Appendix N: Continued			
Aroclor 1262	<0.050	<0.050	<0.050
Aroclor 1268	<0.050	<0.050	<0.050
Percent Lipid (%)	8.4	1.6	1.2
* WB = Wholebody			
F = Fillet			
NA = Not Analyzed			