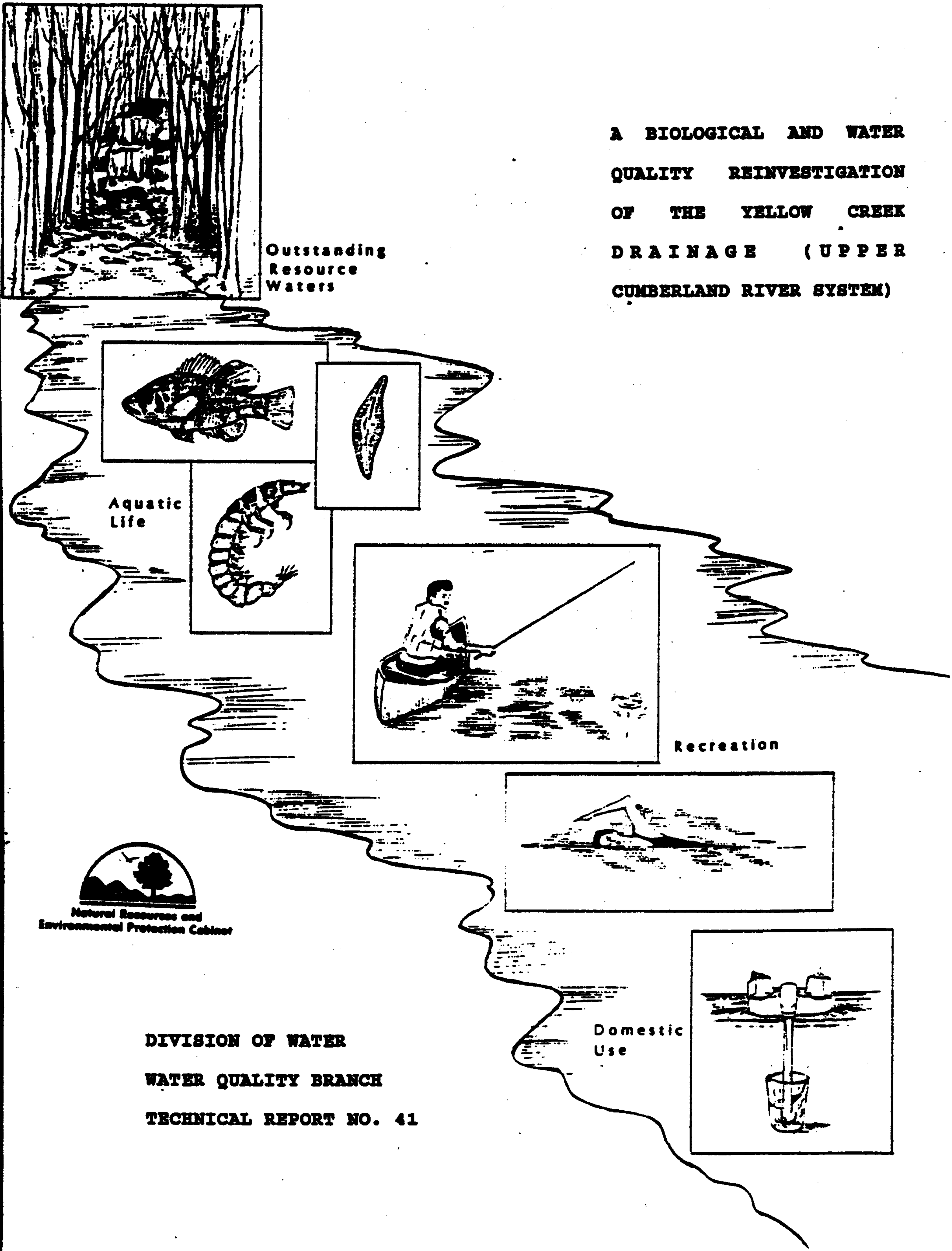
A BIOLOGICAL AND WATER QUALITY REINVESTIGATION OF THE YELLOW CREEK DRAINAGE (UPPER CUMBERLAND RIVER SYSTEM)



DIVISION OF WATER

WATER QUALITY BRANCH

TECHNICAL REPORT NO. 41

A BIOLOGICAL AND WATER QUALITY REINVESTIGATION OF THE YELLOW CREEK DRAINAGE (UPPER CUMBERLAND RIVER SYSTEM)

Kentucky Department for Environmental Protection

Division of Water

Water Quality Branch

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Summary

A biological and water quality re-investigation of the Yellow Creek drainage was conducted in October, 1988 and February, 1990 by the Ecological Support Section of the Division of Water. The purpose of the survey was to determine if the Middlesboro Wastewater Treatment Plant (WWTP) that was put into operation in October, 1986 has improved water quality in Yellow Creek.

Water quality parameters related to mining (conductivity, dissolved solids, sulfates) were elevated throughout the Yellow Creek study area, with the exception of the reference site on Little Yellow Creek. This indicated that mining and mining related activities have had an adverse impact on the system. Nutrient levels were highest immediately downstream of the WWTP. Although they decreased with distance downstream, nutrient levels below the WWTP remained well above background conditions. In 1988, Kentucky Surface Water Standards (KSWS) (401 KAR 5:031, Section 4) were violated for mercury at Stations 37-3 and 37-4 and for copper at Stations 37-2 and 37-8. No other surface water standards were exceeded in 1988. Of the parameters analyzed by the United States Environmental Protection Agency (USEPA) in 1990, none exceeded KSWS.

In 1988, fecal coliform (FC) results for the Middlesboro WWTP effluent exceeded their Kentucky Pollutant Discharge Elimination System (KPDES) permit limits of 400 colonies per 100 ml. Of the ten Yellow Creek sites sampled, two sites upstream and three sites downstream of the WWTP

exceeded KSWS for Primary Contact Recreation (PCR). Four of these five sites also exceeded KSWS for Secondary Contact Recreation (SCR). The unacceptable FC levels above the WWTP indicate other sources of FC contamination. Little Yellow Creek samples did not exceed KSWS for PCR or SCR. In 1990, the WWTP did not violate KPDES limits. The fecal coliform standard for PCR was exceeded upstream, but not downstream, of the WWTP.

Biological data (algae, macroinvertebrates and fish) indicate that the Yellow Creek system, with the exception of Little Yellow Creek, was slightly to moderately impaired during 1988 and 1990. These impairments were attributed mainly to surface mining activities, sedimentation, stream channelization and nutrient enrichment from the WWTP.

Acute toxicity tests performed by KDOW on 100% effluent from the WWTP in June, 1990 showed no toxicity. Chronic toxicity tests performed by U.S. EPA on 100% effluent in February, 1990, also showed no toxicity.

Comparison with historical information indicates that water quality in Yellow creek has improved over the last decade. Construction and operation of the new Middlesboro WWTP has been instrumental in this improvement. However, other activities (primarily mining-related) in the drainage continue to impair aquatic habitat and water quality.

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INTRODUCTION

Biological and water quality reinvestigations of the Yellow Creek drainage were conducted by the Division of Water (DOW) in October, 1988 and again in February, 1990. The purpose of these investigations was to determine if the operation of the new Middlesboro Wastewater Treatment Plant (WWTP) has improved water quality in the Yellow Creek system.

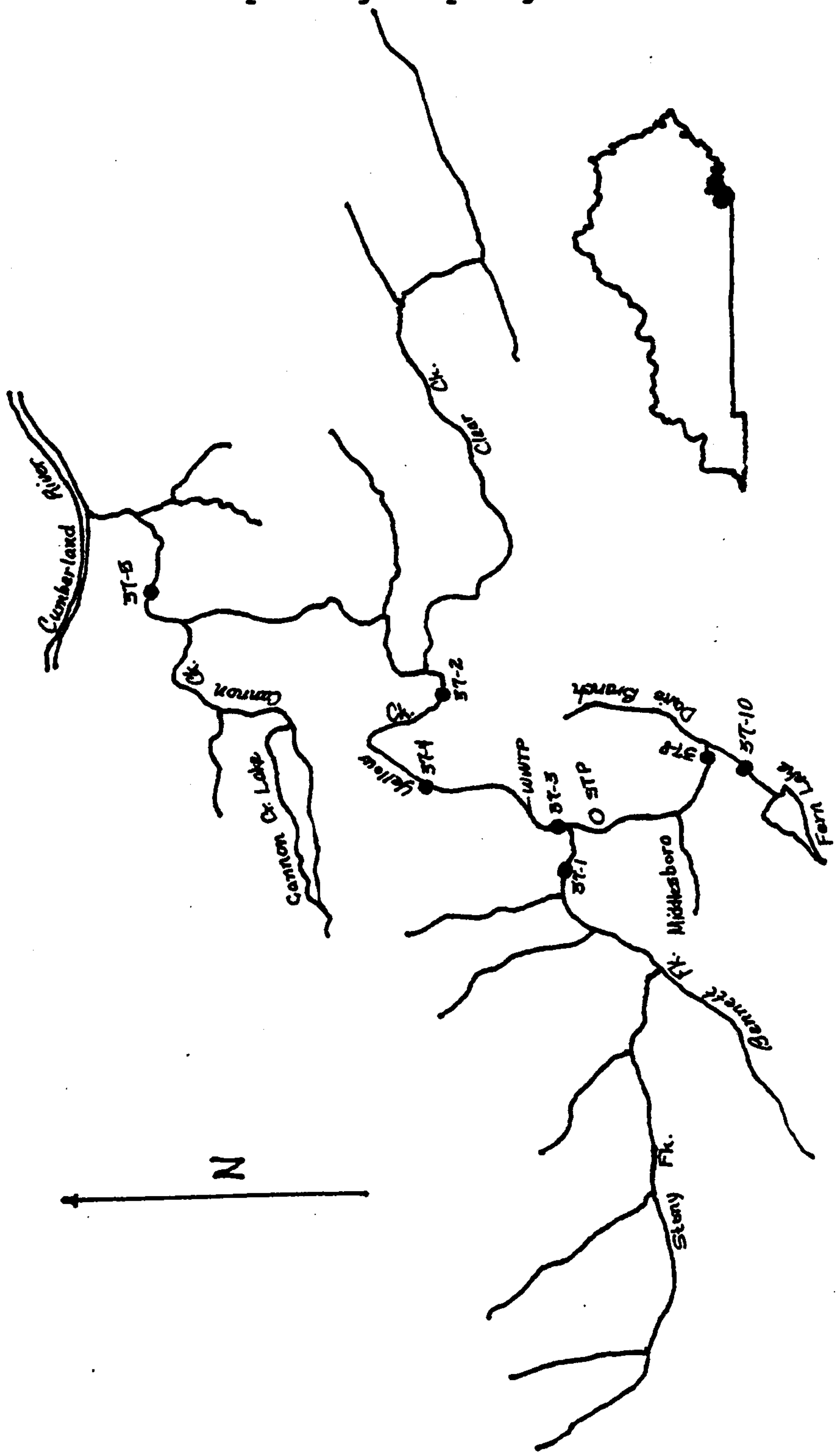
Prior to October, 1986, a 3.2 million gallon per day (mgd) WWTP discharge of municipal and industrial (tannery) waste entered Yellow Creek at milepoint (MP) 14.89. Effluent from this plant seriously degraded the water quality and aquatic life of Yellow Creek (DOWQ 1978, DOW 1981, U.S. EPA 1982, DES 1984). In 1984 construction was started on a new Middlesboro WWTP, and in October,1986 a new 2.8 mgd WWTP was put into operation. The present discharge point (at MP 14.5) is located 0.39 miles downstream from the original discharge location.

Coal mining activities have occurred throughout most of the Yellow Creek watershed. The Cannon Creek basin and the Cumberland Gap National Historical Park (NHP) are the only two areas of significant size that have not had at least some mining activities occurring. Acid mine drainage and siltation have degraded the water quality of the Yellow Creek system (OAS 1969; Mayes, Sudderth and Etherdge, Inc. 1975; and Harker et al. 1979).

Figure 1

Map of the Yellow Creek System

Depicting Sampling Stations



Five stations were sampled in October, 1989 and February, 1990 (Figure 1) by DOW staff. Site locality data are presented in Appendix A. All sites had a riffle-pool environment with at least some undercut banks. The Bennetts Fork site (37-1) and the Yellow Creek site (37-3) just downstream of the confluence with Bennetts Fork have been channelized. Site 37-8 on Little Yellow Creek was sampled just downstream of the confluence with Davis Branch in October, 1988. In February, 1990 Little Yellow Creek was sampled in Cumberland Gap NHP (site 37-10) to avoid the impact from road construction occurring at that time.

Methods

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

Qualitative biological samples were also collected in accordance with the SOP manual. These samples were taken 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 SOP (1987a) manual. Toxicity methods are outlined in DOW (1987b).

PHYSICOCHEMICAL DISCUSSION

A total of 108 physicochemical parameters were analyzed from each of the five sampling stations collected by DOW staff during the October, 1988 sampling period (Table 1

Table 1: Yellow Creek Drainage Physicochemical Data for October, 1988

Parameter (mg/l)	Stations 37-8	37-1	37-4	37-2	37-5
Acidity	5.2	1.9	4.4	3.1	1.9
Alkalinity	66	129	102	111	113
BOD	1.1	1.3	4.7	4.7	1.5
COD	4.6	2.7	18.3	8.0	6.3
Chloride	2.7	2.8	37.5	28.5	24.2
Lab. Cond., umhos/cm	172	738	692	688	949
Cyanide, amenable	<0.010	<0.010	<0.010	<0.010	<0.010
Fluoride	<0.10	0.12	0.3	0.31	0.24
Hardness	75.5	265	250	255	410
Phenols (4AAP)	<0.005	<0.005	0.005	<0.005	<0.005
Lab. pH, SU	7.8	8.2	7.8	7.9	8.1
Suspended Solids	12	6	35	30	35
Dis. Solids	130	533	444	448	674
Sulfates	16.1	257	190	178	339
Total Organic Carbon	1.9	2	5.5	3.8	3.33
Lab Turbidity, NTU	19	3.3	14	30	23
NH_3-N, total	<0.050	<0.050	0.159	0.059	<0.050
Total Kjeldahl Nitrogen	0.191	0.29	0.877	0.823	0.593
NO_2+NO_3-N	0.043	0.085	11	3.73	2.18
Phosphorus, Ortho	0.008	0.002	0.975	0.725	0.339
Phosphorus, total	0.02	0.02	1.16	0.97	0.357

Table 1: Yellow Creek Drainage Physicochemical Data for October, 1988

Parameter (mg/l)	Stations 37-8	37-1	37-4	37-2	37-5
Acidity	5.2	1.9	4.4	3.1	1.9
Calcium	26.5	92.1	67.9	54.8	88.1
Magnesium	4.02	39.6	26.1	21.8	47.9
Potassium	1.6	3.72	5.35	4.34	5.3
Sodium	3.6	24.5	42.5	33.7	57.2
Aluminum, total	0.086	0.046	0.189	0.122	0.063
Arsenic, total	<0.001	<0.001	<0.001	<0.001	<0.001
Barium, total	0.022	0.048	0.041	0.29	0.039
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	<0.001	0.005	0.002
Copper, total	0.017	0.008	0.003	0.01	0.006
Iron, total	0.07	0.02	0.67	0.46	0.20
Lead, total	<0.002	<0.002	0.005	<0.002	<0.002
Manganese, total	0.16	0.05	0.12	0.05	0.04
Mercury, total	0.0003	<0.0001	0.0002	<0.0001	<0.0001
Nickel, total	<0.002	<0.002	<0.002	<0.002	<0.002
Selenium, total	0.004	<0.001	<0.001	0.003	0.006
Silver, total	<0.001	0.001	<0.001	<0.001	<0.001
Zinc, total	0.038	0.022	0.027	0.026	0.020

and Appendix B). The analysis of 68 organic compounds yielded none that were above detection limits. These compounds and their detection limits are listed in Appendix B. In February, 1990, physicochemical samples were collected by U.S. EPA staff and the subsequent analysis conducted at U.S. EPA Region IV in Athens, Georgia.

Little Yellow Creek (station 37-8) had the best water quality during the October, 1988 sampling period. Bennetts Fork (station 37-1) had the next best water quality, while the remaining three Yellow Creek sites (37-4, 37-2, and 37-5) were impacted by the Middlesboro WWTP and/or coal mining (refer to Tables 1 and 2). The Yellow Creek stations had the greatest number of parameters that exceeded the STORET (1979-1988) mean by more than one standard deviation (Table 2). During this sampling period, the Middlesboro WWTP was discharging substantial quantities of nutrients to Yellow Creek.

During October, 1988, Kentucky Surface Water Standards (KSWS) 401 KAR 5:031, Section 4 were violated for mercury at stations 37-4 and 37-8, and for copper at 37-8. No other surface water standards violations were observed during this sampling period.

Data from past reports (OAS 1967, Harker et al. 1979 and DES 1984) and this report indicate that coal mining activities have degraded the water quality of the Yellow Creek watershed. Parameters typically elevated as a result of mining activities (conductivity, dissolved solids, sulfates, calcium, magnesium, etc.) were elevated in the Yellow Creek system.

Table 2: Yellow Creek Drainage Physicochemical Data That Exceeded the STORET (1979-1988) Mean By More Than One Standard Deviation For October, 1988

*Parameters (mg/l)	Stations 37-8	37-1	37-4	37-2	37-5	STORET MEAN
BOD	-	-	4.7	4.7	-	1.19
Lab. Cond. umhos/cm	-	738	692	688	949	320
Fluoride	-	-	-	0.31	0.24	0.14
Hardness	-	265	250	255	410	142
Dissolved Solids	-	533	444	448	674	213
Sulfates	-	257	190	178	339	66.3
NO_2+NO_3-N	-	-	11.0	3.73	2.18	0.84
Phosphorus, Ortho	0.008	-	0.975	0.725	0.339	0.005
Phosphorus, total	-	-	1.16	0.97	-	0.16
Calcium	-	92.1	67.9	-	88.1	40.3
Magnesium	-	39.6	26.1	21.8	47.9	11.1
Potassium	-	-	5.35	-		2.87
Sodium	-	-	42.5	-	57.2	16.2
Selenium	0.004	-	-	0.003	0.006	0.001
TOTAL	2	6	12	11	11	

*Parameters in mg/l unless otherwise stated

The physicochemical data collected by U.S. EPA staff in February, 1990 are presented in Tables 3 and 4. Only one parameter (conductivity) at one station (Bennetts Fork, 37-1) exceeded the STORET (1979-1988) mean by more than one standard deviation. The ammonia nitrogen (NH_3-N) concentration was low at all sites and no metals exceeded KSWS or were judged to be present in toxic amounts.

Table 3: Field Physicochemical Data for the Yellow Creek Drainage in February, 1990

	Stations				
Parameter	**37-1**	**37-3**	**37-4***	**37-5**	**37-10**
Dissolved Oxygen (mg/l)	12.02	11.63	11.18	ND	9.91
pH (SU)	7.03	6.65	6.39	ND	5.6
Conductivity (umhos/cm)	372	278	301	ND	38
Water temperature (°C)	5.3	5.0	7.88	ND	11.3

*The data presented for station 37-4 were actually collected 1.6 miles downstream at the US 25 bridge (Stn. #13-6).

Note: These data were collected by members of the Environmental Services Division of U.S. EPA, Region IV.

Table 4: Yellow Creek Drainage

Physicochemical Data for February, 1990

	Stations			
Parameters*	**37-1**	**37-3**	**37-4**	**37-10**
NH3-N	<0.05	0.07	0.08	<0.05
Barium	0.029	0.031	0.029	0.020
Zinc	0.013	0.011	0.013	ND
Aluminum	0.400	0.340	0.300	0.160
Manganese	0.130	0.150	0.140	ND
Calcium	42	32	32	2.3
Magnesium	21	16	15	1.8
Iron	0.48	0.65	0.60	0.29
Sodium	5.8	5.5	7.0	ND

*Parameters in mg/l unless otherwise stated

Note: These data were taken from a U.S. EPA report entitled "Middlesboro Wastewater Treatment Plant/Yellow Creek Study, Middlesboro, Kentucky, Permit No. KY0027235, February 1990."

Biological Discussion

Since the new plant commenced operation in October, 1986, two sets of biological data have been collected, one set in October, 1988 and the other in February, 1990. In addition, bacteriological data were collected in October, 1988 and both bacteriological and toxicity data were collected in June, 1990. The U.S. EPA collected macroinvertebrate data and performed toxicity tests in February, 1990.

Physicochemical and biological data were integrated to make a determination of the overall health of the biotic community. Table 5 gives individual component and composite scores for the Yellow Creek drainage during both sampling periods, and Table 6 gives interpretations of those ratings. Biological ratings of community components (algae, macroinvertebrates, fish) were based on metrics such as taxa richness, community composition, pollution tolerance or sensitivity of the taxa present and professional judgement. The final water quality assessment score is derived by combining equally weighted scores for biological and physicochemical components. Interpretation of the results of this approach, show that only the upper portion of Little Yellow Creek was unimpaired, fully supporting warmwater aquatic habitat uses, while Yellow Creek and Bennett's Fork were partially supporting uses.

Bacteriology

Thirteen bacteriological samples were collected from stations located in the Yellow Creek system and the Middlesboro WWTP on October 19, 1988 (Table 7).

Table 5: Water Quality Assessment Summary for Sampling Locations in the Yellow Creek Drainage

October, 1988

Site	P-Chem	Algae	Macroinvertebrate	Fish	Water Quality Assessment Score
37-8	4	4.0	2.3	ND	3.4
37-1	3	3.5	2.7	3.0	3.1
37-4	1	3.0	2.5	2.0	2.1
37-2	2	3.0	1.2	2.5	2.2
37-5	2	3.5	3.2	2.5	2.8

February, 1990

Site	P-Chem	Algae	Macroinvertebrate	Fish	Water Quality Assessment Score
37-10	4	3.8	4.1	ND	4.0
37-1	4	3.3	2.9	ND	3.4
37-3	4	3.5	2.1	ND	3.2
37-4	4	2.5	2.5	ND	3.0
37-5	4	2.5	2.6	ND	3.0

ND - Not Determined

Table 6: Water Quality Assessment Value Interpretation

Score	Category	
4-5	Unimpaired	Supports WAH uses
3-3.9	Slightly Impaired	Partially supports WAH uses
2-2.9	Moderately Impaired	Partially supports WAH uses
<2	Severely Impaired	Does not support WAH uses

WAH-Warmwater Aquatic Habitat

Table 7: Yellow Creek Drainage Bacteriological Results for October, 1988

Source	MP	Date	FC/100 ml	FS/100 ml	FC/FS
Yellow Creek	0.5	19 Oct. 88	150	10	NA
Yellow Creek	1.0	19 Oct. 88	30	10	NA
Yellow Creek	2.3	19 Oct. 88	<10	50	NA
Yellow Creek	6.7	19 Oct. 88	10	10	NA
Yellow Creek	8.4	19 Oct. 88	10	40	NA
Yellow Creek	11.4	19 Oct. 88	1,000	40	NA
Yellow Creek	13.1	19 Oct. 88	2,400	70	NA
Middlesboro WWTP	14.8	19 Oct. 88	2,300	40	NA
Yellow Creek	14.9	19 Oct. 88	390	60	NA
Yellow Creek	15.9	19 Oct. 88	4,000	2,000	2.0
Little Yellow Creek	0.1 (16.0)	19 Oct. 88	90/110	200/60	0.4/NA
Little Yellow Creek	1.2	19 Oct. 88	110/150	340/200	0.3/0.8
Yellow Creek	17.9	19 Oct. 88	7,000	420	17

FC = Fecal Coliform
FS = Fecal Streptococci
MP = Milepoint
NA = Not Applicable
/ = Duplicate Sample Analyses

Of the ten sites sampled from Yellow Creek, five (50 percent) were not acceptable for primary contact recreational uses, while two sites sampled on Little Yellow Creek were acceptable. Four of the Yellow Creek stations (40 percent) exceeded the FC standard for secondary contact recreation. The sample from the Middlesboro WWTP effluent violated the KPDES permit limit, which is no greater than 400/100 ml FC colonies on a daily/weekly basis.

Fecal coliform/fecal streptococcal levels indicated fecal pollution of animal origin in Little Yellow Creek and of mixed origin at one station in Yellow Creek. Fecal streptococcal levels were not high enough to apply the ratio at most stations.

In June, 1990 a series of fecal coliform tests were performed on the Middlesboro WWTP effluent, Yellow Creek 0.1 mile above the WWTP effluent, and Yellow Creek 0.1 mile below the WWTP effluent (Table 8). All samples taken from the effluent and Yellow Creek below the WWTP met the fecal coliform criterion (400FC/100ml) set forth in KSWS 401 KAR 5:031, Section 6. Three of the four samples taken upstream of the WWTP did not meet this criterion.

Algae

Algal samples were collected from Yellow Creek on three occasions: June, 1985; October, 1988; and February, 1990 (Appendix C). Because of the seasonal nature of algal communities, direct community structure comparisons cannot be made between the three sets of samples. However, each

Table 8: Middlesboro Wastewater Treatment Plant

Bacteriological Results for June, 1990

Yellow Creek

Location	Milepoint	Dates	*FC/100ml	**TRC(ppm)
Middlesboro WWTP Effluent	14.5	5-June-90	<10	0.0
		6-June-90	10	0.0
		7-June-90	<10	0.0
		8-June-90	10	0.0
Upstream of Middlesboro WWTP	14.6	5-June-90	500	0.0
		6-June-90	300	0.0
		7-June-90	570	0.0
		8-June-90	500	0.0
Downstream of Middlesboro WWTP	14.4	5-June-90	60	ND
		6-June-90	40	ND
		7-June-90	<10	ND
		8-June-90	<50	ND

*FC-Fecal Coliform

**-TRC-Total Residual Chlorine

ND-Not Determined

sampling event included samples upstream and downstream of the Middlesboro Wastewater Treatment Plant (WWTP), so longitudinal comparisons may be made among samples for each sampling period to determine the effects of the WWTP on the algal community.

In this study diatoms were used to assess the health of the algal community because diatoms can be identified to species level; there are many more species of diatoms than other algae in streams; and some diatom species are very sensitive to environmental disturbances, while others are tolerant in varying degrees to different types of pollution. Metrics (Table 9) include taxa richness, relative abundance of dominant species, relative abundance of sensitive species, and percent community similarity (PSc) to control or reference sites. Diatom diversity (Shannon diversity) was also calculated for each site for comparison with an earlier report (DES 1984). Values for these metrics were used to assign a numerical ranking between one and five to each site. These values for the algal component of the community were then used in the water quality assessment described in Tables 5 and 6.

One hundred fifty-one diatom species were collected from the Yellow Creek drainage during 1985-1990 (Appendix B). This high species richness is attained because of the influence of Little Yellow Creek (sites 37-8 and 37-10). Forty-three of the 151 diatoms identified in this study were found exclusively in Little Yellow Creek (LYC). Many of these species are sensitive to waters of elevated mineral content and thus have been eliminated in Yellow Creek and Bennetts Fork by mining, industrial, and municipal impacts. In addition, the diatom species composition of Little Yellow Creek is influenced by Fern Lake, a small reservoir in the headwaters of Little Yellow Creek within Cumberland Gap National Historic Park.

Table 9: Diatom Data for the Yellow Creek System from June 1985, October 1988 and February 1990

	Taxa Richness	Shannon Diversity	% Similarity to reference (Little Yellow Cr.)	Numerical Ranking*
1985				
37-8	55	4.6	-	NA
37-4	38	4.3	26.3	NA
37-5	29	2.4	16.5	NA
1988				
37-8	66	4.9	-	4.0
37-1	55	4.5	26.5	3.5
37-4	50	4.5	34.5	3.0
37-2	52	4.7	35.1	3.0
37-5	52	4.0	31.5	3.5
1990				
37-10	44	2.9	-	3.8
37-1	35	3.0	27.6	3.3
37-3	37	3.8	46.0	3.5
37-4	29	3.3	5.0	2.5
37-5	22	2.3	3.2	2.5

NA=Not applicable

*Numerical ranking is used in water quality assessment (Tables 5 and 6), and ranges from 1 (severely impaired) to 5 (no impairment)

The June, 1985 diatom samples were collected at Yellow Creek sites 37-4, 37-5 and LYC site 37-8. The 37-4 and 37-5 samples, collected downstream from the WWTP and tannery, indicated organic enrichment. Taxa richness was moderately low (38 and 29, respectively) and the dominant diatom species are tolerant of elevated mineral and nutrient concentration

(Lowe 1974, Patrick and Reimer 1966). Little Yellow Creek (37-8), had a much higher taxa richness (55), and was characterized by a more sensitive and diverse species assemblage.

In October of 1988, sites 37-1, 37-2, 37-4, 37-5 and 37-8 were sampled. Taxa richness (TR) ranged from 50-55 in the Yellow Creek samples, while LYC 37-8 taxa richness was 66. The higher taxa richness in LYC indicates Bennetts Fork (TR 55) and Yellow Creek (TR ranged from 50-52) may be chronically impaired by mining activities. Bennett's Fork (37-1) was dominated by Navicula salinarum var. interemedia (22%) and Achnanthes minutissima (11%), diatoms tolerant of high mineral content. Yellow Creek sites 37-4 (directly below the WWTP) and 37-2 were similar (PSc = 59.8) (Table 10) and dominated by Nitzschia palea, Navicula salinarium var. intermedia and Navicula secreta var. apiculata. Nitzschia palea is known to multiply profusely in organically polluted waters (Patrick 1977), and the Navicula species common at this site also prefer high nitrate concentrations. Site 37-5, approximately 12 miles below the WWTP, shows a change in structure to one dominated by Melosira varians, Nitzschia dissipata and Synedra ulna var. ramesii. Melosira varians and S. ulna, common in waters with high (2-3 mg/l) nitrate concentrations (Patrick 1977), reflect the still elevated nitrate concentrations (refer to Table 1) at this site.

Table 10: Diatom Percent Community Similarity (PSc) Values for the Yellow Creek System

<u>October 1988</u>

Stations	37-8	37-1	37-4	37-2
37-1	26.5	-	-	-
37-4	34.5	43.5	-	-
37-2	35.1	34.1	59.8	-
37-5	31.5	24.1	31.1	34.1

<u>February 1990</u>

Stations	37-10	37-1	37-3	37-4
37-1	27.6	-	-	-
37-3	46.0	45.8	-	-
37-4	5.0	23.0	27.9	-
37-5	3.2	17.9	16.8	47.8

In February of 1990, diatom samples were collected from sites 37-1, 37-3, 37-4, 37-5 and 37-10. The LYC site (37-10) was upstream of the site previously sampled, and the <u>Achnanthes</u>-<u>Fragilaria</u>-<u>Synedra</u> dominated diatom assemblage reflects the proximity to Fern Lake, as well as the low pH, conductivity, and mineral content of the stream. Taxa richness (44) was again higher in LYC than either Bennetts Fork or Yellow Creek, indicating environmental stress in the latter two sites. That stress was most likely caused by mining activities in those drainages. The community structure of Bennetts Fork (37-1) and Yellow Creek above Bennetts Fork (37-3) were similar (PSc=45.8) (Table 10) because of the abundance of <u>Achnanthes</u> <u>minutissima</u> (7.4% and 10.4%, respectively) and <u>Fragilaria</u> <u>vaucheriae</u> (17.6% and 29.0%). Little Yellow Creek (37-10), was also dominated by <u>A.</u> <u>minutissima</u> (45.4%) and <u>F.</u> <u>vaucheriae</u> (19.5%). As in the prior surveys in 1982 (DES 1984), 1985, and 1988, nutrient enrichment below the WWTP appears to have influenced the diatom community toward one tolerant of elevated nitrate, phosphorus and carbon concentrations. Sites 37-4 and 37-5 were similar in composition (PSc=47.8), primarily because of the high relative abundance of Navicula viridula (26.3% and 58.9%, respectively)at both sites. The Nitzschia-Navicula community dominant at these sites indicates continuing nutrient enrichment. These two sites show no similarity to the reference site, LYC (37-10) (PSc $\leq$5).

Earlier diatom work indicates impairment of Yellow Creek below the WWTP prior to this study period (DES 1984). Clear Fork, a third order tributary of Yellow Creek, was studied by the Kentucky Nature Preserves Commission in 1978 (Harker et al. 1979). While this site was found to be somewhat impaired by surface mining (elevated concentrations of SO_4, Mg, Ca and conductivity), a diverse diatom flora existed. Taxa richness was 52, Shannon diversity was 4.3, and the community was dominated by Achnantheses pseudolinearis, (14.9%), Cymbella turgidula (14.4%), and Nitzshia acicularis (11.5%). Two sites above and below the Middlesboro WWTP, Bennetts Fork (37-1), and Yellow Creek (37-2), were sampled in 1978 (DES 1984). The diatom community of Bennetts Fork (37-1) was similar to that at Clear Creek, but Yellow Creek (37-2) was dominated by Nitzschia palea (52.3%), Navicula pelliculosa (15.6%), and other species typically found in domestic waste impacted streams. The latter two sites were resampled in

1982, and the data suggested improved water quality at 37-2 below the WWTP (DES 1984).

In summary, Little Yellow Creek, during all three sampling periods, had higher taxa richness and a diatom flora containing more sensitive species than either Bennetts Fork or Yellow Creek. Mining activities continuing in the Yellow Creek drainage have increased suspended solids, mineral concentrations, conductivity and sedimentation. As a result, taxa richness is less than expected and sensitive species have been nearly eliminated from the drainage, as evidenced by this report and the Harker et al. (1979) data on Clear Creek. Nutrient enrichment from the WWTP effluent has encouraged growth and reproduction of a few (primarily Navicula and Nitzschia) species that prefer high nitrate and phosphorus concentrations.

The algal data show that the degree of impairment to Yellow Creek and Bennetts Fork upstream of the WWTP was slight to moderate, as a result of basin-wide mining impacts. Those impacts, combined with the nutrient enrichment caused by the WWTP effluent, contribute to the continued slight to moderate impairment at most of the sites downstream of the WWTP.

Macroinvertebrates

Macroinvertebrate data from the Yellow Creek drainage has been discussed in five previous water quality investigations (DOWQ 1978, Harker et al. 1979, U.S. EPA 1982, DES 1984 and U.S. EPA 1990). The majority of the reports place the principal responsibility on improperly treated

Table 11: Macroinvertebrate Numerical Data for the Yellow Creek System in October, 1988 and February, 1990

Metric	Stations				
	37-1	37-2	37-4	37-5	37-8
October 1988					
Total Number of Taxa (TNT)	30	16	24	30	16
Total Number of Individuals (TNI)	128	44	61	171	33
Ephemeroptera/Plecoptera/ Trichoptera Index (EPT)	8	2	6	9	5
Percent Contribution of Dominant Taxa (PCDT)	61.5	75.0	49.2	61.9	52.2

	Stations				
February 1990	37-1	37-3	37-4	37-5	37-10
Total Number of Taxa (TNT)	35	20	22	28	51
Total Number of Individuals (TNI)	107	52	62	176	332
Ephemeroptera/Plecoptera/ Trichoptera Index (EPT)	14	9	11	17	17
Percent Contribution of Dominant Taxa (PCDT)	54	62	48	68	65

municipal waste from the Middlesboro WWTP. However, Harker et al. (1979) and DES (1984) note that acid drainage and siltation arising from coal mining operations were also responsible for water quality problems in the Yellow Creek basin.

Macroinvertebrate data (Table 11 and Appendix D) show that the water quality in Yellow Creek below the Middlesboro WWTP (stations 37-4 and 37-2) was moderately to severely impaired (Table 5) in the October, 1988 sampling, and station 37-4 was moderately impaired in February, 1990.

In 1988, the macroinvertebrate community at sites not affected by the WWTP (37-1, 37-5, and 37-8) were either slightly or moderately impaired (Table 5). Stations 37-1 and 37-5 were moderately impaired in 1990, while station 37-10 on Little Yellow Creek, which was the only station not impacted by either mining or the WWTP, was rated unimpaired.

A review of past physicochemical data (DOWQ 1978, Harker et al. 1979 and, DES 1984) indicates that the water quality problems occurring above the Middlesboro WWTP were caused by coal mining. At least a portion of the water quality problems in Yellow Creek below the WWTP are also coal mining related. A review of the data presented by Harker et al. (1979) shows that drainages in eastern Kentucky impacted by coal mining activities typically have Total Number of Taxa (TNT), Total Number of Individuals (TNI), and Ephemeroptera/Trichoptera/Plecoptera index (EPT) values lower than unimpaired streams. The two stations directly below the WWTP (37-4 and 37-2) exhibited this trait during both sampling periods. Streams impaired by nontoxic municipal waste typically have large numbers of facultative to tolerant organisms present, partly because of increased nutrients. A review of the 1988 physicochemical data (Table 1) shows elevated nutrient concentrations at stations 37-4 and 37-2. With exception of ammonia nitrogen, nutrient series data were not collected in 1990. However, even WWTP's with well treated effluents typically increase nutrient values in receiving streams. Stations 37-4 and 37-2 in 1988 and station 37-4 in 1990 had TNI and TNT values less than expected. The low TNT and TNI observed during both sampling periods below the WWTP appear to be the result of coal mining activities that are occurring, or have occurred, in the drainage.

During the 1988 sampling, the site on Little Yellow Creek displayed an impaired macroinvertebrate fauna (Table 11). Road construction activities occurring adjacent to the site (37-8) caused heavy siltation, which in turn resulted in low TNI and TNT. This sampling location was moved upstream (site 37-10) in 1990 to avoid any impact resulting from road construction. As a result, the Little Yellow Creek collection was the most diverse and abundant observed in 1990 (Table 10), indicating that this portion of Little Yellow Creek has excellent water quality.

Percent community similarity (PSc) values (Table 12) were calculated for both sampling periods. Only stations 37-1 and 37-5 in the 1988 sampling period were similar (PSc=57.2) in community structure. Station 37-10 in the 1990 sampling

Table 12: Macroinvertebrate Percent Community Similarity (PSc) Values for the Yellow Creek System

October 1988

Stations	37-1	37-2	37-8	37-4
37-2	16.1			
37-8	25.7	15.5		
37-4	29.9	26.9	20.2	
37-5	57.2	25.4	24.4	30.7

February 1990

Stations	37-1	37-3	37-4	37-5
37-3	24.5			
37-4	31.4	28.3		
37-5	24.3	16.9	30.5	
37-10	14.6	8.8	3.3	8.1

was extremely dissimilar from any other station. This is understandable since Little Yellow Creek is an unimpacted, small, canopy covered, headwater stream. No other stream sampled had these characteristics. The dissimilarities found among sites in the Yellow Creek drainage can be related to both the WWTP discharge and coal mining activities in the drainage.

Fish

A total of 443 fish representing eighteen species were collected from stations 37-1, 37-2, 37-4, and 37-5 during June, 1985 and October, 1988 (Table 12). Elevated water levels precluded fish sampling in February, 1990. The Index of Biotic Integrity (IBI) as described by Karr et al. (1986) was used to characterize the fish community structure.

Station 37-1 was classified as fair by the IBI (Table 12) in 1985 and 1988. The site was previously sampled in 1978 and 1982 by DOWQ (1978) DES (1984), respectively, and was also characterized as Fair. The 1985 and 1988 collection yielded similar numbers of species (9 and 10, respectively) to the 1978 and 1982 data (9 and 12, respectively). The station has been impacted by silt and has a limited habitat diversity and the fish community appears to have been stable since 1978.

Prior fish sampling in 1978 and 1982 was conducted (DOWQ 1978 and DES 1984) at Station 37-2. This station produced 35 individuals comprising four species in 1978 and six specimens representing four species in 1982. This site locality does not appear to have improved substantially since then. The high organic loading and siltation described by DES (1984) still appeared to be limiting the diversity of the fish community, which was rated as poor, in 1988. The sample collected in 1985 was from a slightly different location with different habitat. Therefore it is not comparable with the previous data.

Station 37-4 was sampled in 1985 and 1988. The number of species and specimens collected declined from 9 and

24, respectively, in 1985 to 3 species and 9 specimens in 1988 (Table 13). The IBI was fair in 1985 and poor in 1988.

Station 37-5 yielded 181 specimens representing 14 species in 1985 and 69 comprising 9 species in 1988. No comparison can be made with prior sampling at this station. However, published records of fishes from the Yellow Creek drainage indicate that Station 37-5 produced slightly more than one-half (56%) of the 25 species reported from the drainage by Harker et. al (1979) and DES (1984). The fish community at this station is rated as good in 1985 and fair in 1988. During each sampling period, station 37-5 had higher IBI values than the other stations below the WWTP.

Direct comparisons of IBI scores between the 1985 and 1988 samples cannot be made because of differences in sampling season (June 1985 vs. October 1990) and slight changes in sampling locations, especially station 37-2. In addition, the differences in most of the IBI classifications over the two time periods were marginal and do not reflect clear differences between sampling events.

In general, the fish community of the Yellow Creek drainage shows a gradual improvement with increasing distance downstream of the WWTP. The fish communities both upstream and downstream of the WWTP have been impaired by mining actvities, sedimentation, and loss of habitat resulting from stream channelization.

Table 13: Yellow Creek Fish Community Data (1985-1988)

Species	Stations							
	37-1 1985	37-4 1985	37-2 1985	37-5 1985	37-1 1988	37-4 1988	37-2 1988	37-5 1988
Campostoma anomalum	7		1	1	4			
Cyprinus carpio	5	1		2				
Notropis chrysocephalus	1	1		4	14			
Notropis rubellus		1	16	97				1
Notropis volucellus				4				5
Notropis whipplei				34		2		
Pimephales notatus	10	3	3	19	2		12	36
Semotilus atromaculatus	1							
Hypentelium nigricans	11	1	1	1	1			8
Moxostoma duquesnei								2
Moxostoma erythrurum		2	3	3				
Labidesthes sicculus			2					
Ambloplites rupestris	2				1			1
Lepomis macrochirus	1							
Lepomis megalotis	7	9	5	5	10	6	21	3
Micropterus punctulatus					3	1	1	4
Micropterus salmoides		5	1	1				
Etheostoma blennioides				2				6
Etheostoma caeruleum	2			2	9			5
Percina caprodes		1	1	6	1		1	

Table 13: Yellow Creek Fish Community Data (1985-1988)

	Stations							
Species	**37-1 1985**	**37-4 1985**	**37-2 1985**	**37-5 1985**	**37-1 1988**	**37-4 1988**	**37-2 1988**	**37-5 1988**
Total No. Species	10	9	9	14	9	3	4	9
Total No. Specimens	47	24	33	181	45	9	35	69
Index of Biotic Integrity (IBI)	42	44	46	48	44	36	38	40
IBI Class	Fair	Fair	Good	Good	Fair	Poor	Poor	Fair
Numerical Ranking	NA	NA	NA	NA	3.0	2.0	2.5	2.5

NA = Not applicable

*Numerical ranking is based on IBI score for use in water quality assessment (Table 5 & 6)

Toxicity Testing Discussion

Toxicity testing was conducted twice in 1990, in February by U.S. EPA and in June by DOW. The U.S. EPA (1990) chronic toxicity test, conducted on Ceriodaphnia dubia using three separate 24-hour composite samples collected from the Middlesboro WWTP outfall, yielded no toxicity in a 100% effluent. The DOW conducted acute 96-hour static-renewal test on the fathead minnow Pimephales promelas and a chronic 48-hour static renewal test on water flea Ceriodaphnia dubia. No toxicity in any dilution or 100% effluent was observed in either test (Table 14).

Table 14: Acute Toxicity Data for the Middlesboro Wastewater Treatment Plant for June 1990

WATER SOURCE: Final Dechlorinated Effluent
SPECIES #1: *Pimephales promelas*

% Effl	% Survival Replicate A	Replicate B	(A + B)/2
100	90	90	90
71	100	100	100
50	100	100	100
35	100	100	100
18	100	100	100
Control	100	100	100
Stream Above	100	100	100
Stream Below	100	100	100

WATER SOURCE: Final Dechlorinated Effluent
SPECIES #2: *Ceriodaphnia dubia*

% Effl	% Survival Replicate A	Replicate B	(A + B)/2
100	100	100	100
Control	100	100	100
Stream Above	100	100	100
Stream Below	100	100	100

Literature Cited

(DES) Division of Environmental Services. 1984. Yellow Creek drainage biological and water quality investigation for stream use designation. Biol. Br., Div. Environ. Serv. Frankfort, KY. Tech. Rept. No. 9.

(DOW) Division of Water. 1981. Yellow Creek/Middlesboro wastewater treatment plant follow-up survey. KY. Dept. Nat. Res. Environ. Prot. Div. of Water, Stand. Specif. Sect., Unpublished Report.

________________. 1987a. Standard Operating Procedures manual. KY Dept. Environ. Prot., Frankfort, KY.

________________. 1987b. Methods for culturing and conducting toxicity tests with _Pimephales promelas_, _Daphnia pulex_ and _Ceriodaphnia_ sp. (Second edition). KY Dept. Envir. Prot., Div. Water, Biol. Analy. Sect., Frankfort, KY.

(DOWQ) Division of Water Quality. 1978. Yellow Creek intensive survey, Bell County, Kentucky. KY Div. Water Qual., Monit. Sect., Centr. Biol. staff, Frankfort, KY, Unpublished Report.

Harker, D.F. Jr., S.M. Call, M. L. Warren, Jr., K.E. Camburn, P. Wigley. 1979. Aquatic biota and water quality survey of the Appalachian Province, eastern Kentucky. KY. Nat. Pres. Comm., Frankfort, KY, Tech. Rept.

Karr, J.R., K.D. Fauch, P.L. Angermeier, P.R. Yant and I.J. Schlosser. 1986. Assessing biological integrity in running waters. A method and its rationale. Ill. Nat. Hist. Surv., Spec. Pub. 5.

Lowe, R.L. 1974. Environmental requirements and pollution tolerance of freshwater diatoms. Nat. Environ. Res. Cent. Off. Res. Devel., U.S. EPA, Cincinnati, OH. EPA-670/4-74-005.

Mayes, Sudderth and Etheredge, Inc. 1975. The river basin water quality management plan for Kentucky. Upper Cumberland River. Kentucky Dept. for Nat. Res. and Env. Prot., Frankfort, KY.

(OAS) Office of Appalachian Studies. 1969. Report for the resources of Appalachian. Appendix C - The incidence and formation of mine drainage pollution. Vol. 18. U.S. Army Corp of Eng.., Fed. Water Poll. Contr. Admin. Bus. Mines, U.S. Dept. Int., Washington, D.C.

Patrick, R. 1977. Ecology of Freshwater Diatoms and Diatom Communities. In: The Biology of Diatoms. Dietrich Werner, ed. Botanical Monographs. Vol. 13. Blackwell Scientific Publications.

Patrick, R. and C. Reimer. 1966. The Diatoms of the United States. Vol. 1. Monographs of the Academy of Natural Sciences of Philadelphia. No. 13.

STORET, 1979-1988. United States Environmental Protection Agency water quality file. U.S. EPA, Office of Reg. and Stds., Washington, D.C.

(U.S. EPA) United States Environmental Protection Agency. 1982. Middlesboro, Kentucky Yellow Creek investigation. U.S. EPA, Environ. Serv. Div., Region IV, Atlanta,GA. Preliminary Draft.

________________. 1990. Middlesboro Wastewater Treatment Plant/Yellow Creek study, Middlesboro, Kentucky, Permit #KY0027235, February, 1990. U.S. EPA. Region IV., Athens, GA.

Appendix A

Site Information

SITE INFORMATION

Site No: 02037001 — Type Sampling: Biological, Physicochemical, Bacteriological, Fish Tissue
Stream: Bennetts Fork (Yellow Ck. Bypass)
County: Bell
Location: at KY 441 bridge
Latitude: 36 37 12
Longitude: 83 43 0
Stream Order: IV
USGS Topo Quad: Middlesboro North, KY
DOW Map No.: 2-51
RMI: 0.5
Sampling Dates: 18-May-82, 4-June-85, 18-October-88, 21-February-90

Site No: 02037002 — Type Sampling: Biological, Physicochemical, Bacteriological, Fish Tissue
Stream: Yellow Creek
County: Bell
Location: stream mile 10, off Rt. 188
Latitude: 36 39 17
Longitude: 83 40 35
Stream Order: V
USGS Topo Quad: Middlesboro North, KY
DOW Map No.: 2-51
RMI: 10.0
Sampling Dates: 18-May-82, 4-June-85, 18-October-88, 21-February-90

Site No: 02037003 — Type Sampling: Biological, Physicochemical, Bacteriological
Stream: Yellow Creek
County: Bell
Location: Just downstream of the confluence with Bennetts Fork
Latitude: 36-36-48
Longitude: 83 42 29
Stream Order: V
USGS Topo Quad: Middlesboro North, KY
DOW Map No.: 2-51
RMI: 14.8
Sampling Dates: 5-June-85, 21-February 90

Site No: 02037004 — Type Sampling: Biological, Physicochemical,
Stream: Yellow Creek
County: Bell
Location: Downstream (south) of Low Ash Hollow approximately 0.4 mile
Latitude: 36 38 07
Longitude: 83 42 06
Stream Order: V
USGS Topo Quad: Middlesboro North, KY
DOW Map No.: 2-51
RMI: 13.0
Sampling Dates: 18-October-88, 21-February-90

SITE INFORMATION

Site No: 02037005 — Type Sampling: Biological, Physicochemical, Bacteriological
Stream: Yellow Creek
County: Bell
Location: Just downstream of the railroad bridge and east of Bob Hollow about 0.9 mile
Latitude: 36 42 40
Longitude: 83 39 48
Stream Order: V
USGS Topo Quad: Middlesboro North, KY
DOW Map No.: 2-51
RMI: 2.2
Sampling Dates: 19-Ocotober-88, 21-February-90

Site No: 02037006 — Type Sampling: Physicochemical, Bacteriological
Stream: Yellow Creek
County: Bell
Location: At the US 25 bridge north of Middlesboro, KY
Latitude: 36 40 05
Longitude: 83 41 23
Stream Order: V
USGS Topo Quad: Middlesboro North, KY
DOW Map No.: 2-51
RMI: 11.4
Sampling Dates: 19-October-88, 21-February-90

Site No: 02037007 — Type Sampling: Physicochemical, Bacteriological
Stream: Yellow Creek
County: Bell
Location: Just upstream from the confluence with Bennetts Fork
Latitude: 36 37 34
Longitude: 83 42 32
Stream Order: IV
USGS Topo Quad: Middlesboro North, KY
DOW Map No.: 2-51
RMI: 15.1
Sampling Dates: 5-June-85, 21-February-90

Site No: 02037008 — Type Sampling: Biological, Physicochemical, Bacteriological
Stream: Little Yellow Creek
County: Bell
Location: Adjacent to and just north of the US 25 bridge
Latitude: 36 36 20
Longitude: 83 41 27
Stream Order: III
USGS Topo Quad: Middlesboro South, TN, VA, KY
DOW Map No.: 1-51
RMI: 1.5
Sampling Dates: 19-October-88, 6-December-89

SITE INFORMATION

Site No:	02037009	Type Sampling: Physicochemical, Bacteriological
Stream:	Little Yellow Creek	
County:	Bell	
Location:	At bridge on paved Park road	
Latitude:	36 36 12	
Longitude:	83 41 31	
Stream Order:	III	
USGS Topo Quad:	Middlesboro South, TN, VA, KY	
DOW Map No.:	1-51	
RMI:	1.7	
Sampling Dates:	6-December-89	

Site No:	02037010	Type Sampling: Biological, Physicochemical, Bacteriological
Stream:	Little Yellow Creek	
County:	Bell	
Location:	At railroad bridge 0.4 mile northeast of Fern Lake	
Latitude:	36 35 44	
Longitude:	83 41 57	
Stream Order:	III	
USGS Topo Quad:	Middlesboro South, TN, VA, KY	
DOW Map No.:	1-51	
RMI:	2.6	
Sampling Dates:	6-December-89, 20-February-90	

Site No:	02037011	Type Sampling: Physicochemical, Bacteriological
Stream:	Little Yellow Creek	
County:	Bell	
Location:	Just below Fern Lake Dam	
Latitude:	36 35 32	
Longitude:	83 42 15	
Stream Order:	III	
USGS Topo Quad:	Middlesboro South, TN, VA, KY	
DOW Map No.:	1-57	
RMI:	3.15	
Sampling Dates:	6-December-89	

Site No:	02037012	Type Sampling: Physicochemical, Bacteriological
Stream:	Davis Branch	
County:	Bell	
Location:	Just upstream from the mouth	
Latitude:	36 36 25	
Longitude:	83 41 18	
Stream Order:	II	
USGS Topo Quad:	Middlesboro South, TN, VA, KY	
DOW Map No.:	1-51	
RMI:	0.15	
Sampling Dates:	6-December-89	

Appendix B

List of Organic Compounds That Were Below Detection Limits in October, 1988

LIST OF ORGANIC COMPOUNDS THAT WERE BELOW DETECTION LIMITS IN OCTOBER, 1988

PARAMETER	CONCENTRATION
Phenol	< 0.020 mg/l
Aniline	< 0.020 mg/l
Bis-(2-Chloroethyl) ether	< 0.020 mg/l
2-Chlorophenol	< 0.020 mg/l
1,3-Dichlorobenzene	< 0.020 mg/l
1,4-Dichlorobenzene	< 0.020 mg/l
Benzyl Alcohol	< 0.020 mg/l
1,2-Dichlorobenzene	< 0.020 mg/l
2-Methylphenol	< 0.020 mg/l
4-Methylphenol	< 0.020 mg/l
Bis-(2-Chloroisopropyl) ether	< 0.020 mg/l
N-Nitroso-di-n-propylamine	< 0.020 mg/l
Hexachloroethane	< 0.020 mg/l
Nitrobenzene	< 0.020 mg/l
Isophorone	< 0.020 mg/l
2-Nitrophenol	< 0.020 mg/l
2,4-Dimethyphenol	< 0.020 mg/l
Bis-(2-Chloroethoxy)methane	< 0.020 mg/l
Benzoic Acid	< 0.080 mg/l
2,4-Dichlorophenol	< 0.020 mg/l
1,2,4-Trichlorobenzene	< 0.020 mg/l
Napthalene	< 0.020 mg/l
4-Chloroaniline	< 0.020 mg/l
1,1,2,3,4,4-Hexachloro-1,3-butadiene	< 0.020 mg/l
4-Chloro-3-methylphenol	< 0.020 mg/l
2-Methylnaphthalene	< 0.020 mg/l
1,2,3,4,5,5-Hexachloro-1,3-cyclopentadiene	< 0.020 mg/l
2,4,6-Trichlorophenol	< 0.020 mg/l
2,4,5-Trichlorophenol	< 0.020 mg/l
2-Chloronaphthalene	< 0.020 mg/l
2-Nitroaniline	< 0.020 mg/l
Dimethyl Phthalate	< 0.020 mg/l
Acenaphthylene	< 0.020 mg/l
2,6-Dinitrotoluene	< 0.020 mg/l
3-Nitroaniline	< 0.020 mg/l
Acenaphthene	< 0.020 mg/l
2,4-Dinitrophenol	< 0.080 mg/l
4-Nitrophenol	< 0.020 mg/l
Dibenzofuran	< 0.020 mg/l
2,4-Dinitrotoluene	< 0.020 mg/l
Diethyl Phthalate	< 0.020 mg/l
Fluorene	< 0.020 mg/l
4-Chlorophenyl phenyl ether	< 0.020 mg/l
4-Nitroaniline	< 0.020 mg/l
2-Methyl-4,6-Dinitrophenol	< 0.020 mg/l
N-Nitrosodiphenylamine	< 0.020 mg/l

LIST OF ORGANIC COMPOUNDS THAT WERE BELOW DETECTION LIMITS IN OCTOBER, 1988 (CONTINUED)

PARAMETER	CONCENTRATION
1,2-Diphenylhydrazine	< 0.020 mg/l
4-Bromophenylphenylether	< 0.020 mg/l
Hexachlorobenzene	< 0.020 mg/l
Pentachlorophenol	< 0.020 mg/l
Phenanthrene	< 0.020 mg/l
Anthracene	< 0.020 mg/l
Dibutyl Phthalate	< 0.020 mg/l
Fluoranthene	< 0.020 mg/l
Benzidine	< 0.020 mg/l
Pyrene	< 0.020 mg/l
Butyl Benzyl Phthalate	< 0.020 mg/l
3,3'-Dichlorobenzidine	< 0.020 mg/l
Benzo(A)Anthracene	< 0.020 mg/l
Chrysene	< 0.020 mg/l
Bis(2-Ethylhexyl)Phthlate	< 0.020 mg/l
Dioctylphthalate	< 0.020 mg/l
Benzo(B)Fluoranthene	< 0.020 mg/l
Benzo(K)Fluoranthene	< 0.020 mg/l
Benzo(A)Pyrene	< 0.020 mg/l
Indeno(1,2,3-C,D)Pyrene	< 0.020 mg/l
Dibenzo(A,H)Anthracene	< 0.020 mg/l
Benzo(G,H,I)Perylene	< 0.020 mg/l

Appendix C

Diatom Community Data

Yellow Creek System Diatom Data

Species	June 1985			October 1988					February 1990				
	37-8	37-4	37-5	37-8	37-1	37-4	37-2	37-5	37-10	37-1	37-3	37-4	37-5
Achnanthes deflexa	4.0	1.6	0.0	4.0	3.5	1.0	0.5	0.5	0.0	3.2	1.3	0.8	0.6
Achnanthes exigua	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes lanceolata	0.0	0.0	0.0	0.0	*	0.0	0.0	*	0.0	*	0.0	0.0	0.0
Achnanthes lanceolata var. dubia	1.8	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes linearis f. curta	0.0	7.1	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes minutissima	9.7	15.9	2.0	3.5	11.0	2.0	2.5	1.4	45.4	7.4	10.4	1.6	0.4
Achnanthes sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0
Achnanthes stewartii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0
Amphipleura pellucida	*	0.0	0.0	2.5	*	0.0	*	0.0	0.2	*	0.3	0.0	0.0
Amphora perpusilla	*	0.0	0.0	*	0.5	0.0	0.0	0.5	0.0	*	0.0	*	4.5
Amphora submontana	0.0	*	0.0	0.5	*	1.0	*	0.0	0.0	0.0	0.0	0.2	0.0
Anomoeoneis serians var. brachysira	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0
Anomoeoneis vitrea	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Bacillaria paradoxa	0.0	0.0	*	1.5	0.0	0.5	2.0	0.9	0.0	0.0	0.0	0.0	0.0
Biddulphia laevis	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0
Caloneis bacillum	*	1.1	0.0	*	1.0	0.0	*	1.9	*	1.0	1.0	0.2	1.0
Cocconeis pediculus	0.0	0.0	0.5	0.0	0.5	*	0.0	0.5	0.0	0.2	0.0	0.0	0.0
Cocconeis placentula var. euglypta	0.0	0.0	0.5	0.0	1.0	*	1.0	0.9	0.0	0.0	0.0	0.0	0.0
Cyclotella meneghiniana	0.0	0.0	*	0.0	1.0	*	0.0	0.5	0.0	0.0	0.0	0.0	0.0
Cyclotella sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*	0.0	0.2	0.0	0.0	0.0
Cyclotella stelligera	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclotella striata var. ambigua	0.0	0.0	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cylindrotheca gracilis	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymbella affinis	0.0	0.0	0.0	0.0	0.0	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Cymbella cuspidata	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymbella delicatula	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0
Cymbella lunata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Cymbella microcephala	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.2	0.0	0.0	0.0
Cymbella minuta	1.3	4.4	*	*	3.5	0.5	*	*	0.4	0.8	1.0	0.2	0.2
Cymbella naviculiformis	0.9	*	0.0	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymbella prostrata	0.0	0.0	0.0	*	*	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0
Cymbella prostrata var. auerswaldii	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymbella sinuata	0.0	0.0	0.0	0.0	*	0.5	0.5	0.9	0.0	0.0	0.0	0.4	0.0
Cymbella sp. K	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0	0.0	0.6	0.3	*	0.0
Cymbella tumida	0.0	0.0	0.0	0.5	1.0	0.0	0.0	*	0.0	0.0	1.0	0.0	0.0

* Present but not encountered in 500 valve count

Yellow Creek System Diatom Data

Species	June 1985			October 1988					February 1990				
	37-8	37-4	37-5	37-8	37-1	37-4	37-2	37-5	37-10	37-1	37-3	37-4	37-5
Cymbella turgidula	0.0	0.0	0.0	*	1.5	0.0	0.0	0.0	*	2.0	0.0	*	0.0
Diatoma vulgare	0.0	1.1	0.0	0.0	1.5	0.0	0.0	2.4	0.0	0.2	0.0	0.0	0.0
Diploneis elliptica	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis oblongella	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0
Diploneis subovalis	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eunotia curvata	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0
Eunotia pectinalis var. minor	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0
Eunotia sp. 1	1.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0
Eunotia sp. 2 (small)	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fragilaria sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
Fragilaria vaucheriae	5.8	0.0	1.5	0.5	0.0	0.0	0.0	0.0	19.5	17.6	29.0	1.8	1.6
Frustulia asymmetrica	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Frustulia rhomboides	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Frustulia rhomboides var. crassinervia	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
Frustulia rhomboides v. amphipleuroides	2.2	0.0	0.0	*	0.0	0.0	0.0	0.0	*	0.4	0.0	0.0	0.0
Frustulia vulgaris	0.0	0.0	0.0	1.0	0.0	0.0	0.5	0.9	0.8	0.0	0.3	0.0	0.0
Gomphonema acuminatum	*	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gomphonema angustatum	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	2.4	5.5	1.0	*
Gomphonema olivaceum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.8	0.7	3.0	2.8
Gomphonema parvulum	3.5	5.5	0.0	1.0	0.5	*	1.5	0.0	1.4	0.6	4.2	0.2	*
Gomphonema sphaerophorum	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gomphonema spp.	*	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gomphonema sp. 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.6	*
Gomphonema subclavatum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0
Gomphonema tenellum	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gyrosigma nodiferum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0	0.0
Gyrosigma scalproides	0.0	0.0	0.0	2.0	*	*	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Gyrosigma spencerii var. curvula	0.0	0.0	0.0	0.5	*	*	*	0.0	0.0	0.0	0.0	0.0	0.0
Melosira varians	19.9	0.0	9.9	3.0	0.5	1.0	4.0	32.5	0.0	0.6	*	0.0	0.0
Meridion circulare	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Navicula anglica	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula capitata	*	*	0.0	0.0	0.0	*	1.5	*	0.0	0.0	0.0	0.0	0.0
Navicula cryptocephala	2.2	0.5	0.0	3.5	0.5	1.0	*	*	0.6	0.0	2.3	0.0	*
Navicula cryptocephala var. exilis	0.0	2.7	*	1.0	1.5	9.5	5.6	1.9	0.0	0.2	0.0	0.2	*
Navicula cryptocephala var. veneta	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

* Present but not encountered in 500 valve count

Yellow Creek System Diatom Data

Species	June 1985			October 1988					February 1990				
	37-8	37-4	37-5	37-8	37-1	37-4	37-2	37-5	37-10	37-1	37-3	37-4	37-5
Navicula decussis	1.8	*	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Navicula elginensis var. neglecta	*	0.0	0.0	*	0.0	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula gottlandica	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula lanceolata	0.0	0.0	*	1.5	*	0.0	0.0	0.0	0.0	0.0	*	0.0	0.0
Navicula luzonensis	0.0	0.5	0.0	0.0	0.0	1.5	*	0.0	0.0	0.0	0.0	0.0	0.4
Navicula menisculus var. upsaliensis	0.0	0.0	2.5	*	0.5	0.0	0.0	0.0	0.0	0.0	0.3	1.6	1.6
Navicula minima	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula mutica	0.0	9.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Navicula notha	0.0	0.0	0.0	*	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula paucivisitata	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula pelliculosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0
Navicula placenta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Navicula pupula	1.3	1.1	0.0	*	0.0	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula pupula f. rostrata	0.0	0.0	0.0	0.0	0.0	*	0.5	0.5	0.0	0.0	0.0	0.0	0.0
Navicula pupula var. elliptica	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula radiosa	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0
Navicula radiosa var. tenella	1.8	0.0	3.5	*	0.0	0.0	0.0	1.4	1.0	1.4	0.3	3.2	4.7
Navicula rhynchocephala	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula rhynchocephala var. germanii	0.0	3.8	0.0	4.5	4.5	7.5	5.6	3.8	0.0	0.0	0.7	0.0	0.0
Navicula salinarum var. intermedia	0.0	2.7	4.0	2.0	22.0	15.0	6.6	2.4	0.0	0.0	*	0.0	0.0
Navicula secreta var. apiculata	0.0	4.9	2.5	*	3.5	10.5	6.1	5.2	0.0	0.2	2.0	26.3	1.0
Navicula seminulum	0.0	0.0	0.0	0.5	*	1.5	3.5	0.9	0.0	0.0	0.0	0.0	0.0
Navicula spp.	1.3	0.5	0.0	0.5	0.0	1.0	0.5	0.9	0.0	0.2	0.7	0.0	0.0
Navicula symmetrica	0.0	14.8	0.0	7.0	2.5	4.5	0.5	1.4	0.0	0.0	0.0	0.0	0.0
Navicula tenelloides	0.0	0.0	0.0	0.0	1.0	1.0	*	0.0	0.0	0.0	0.0	0.0	0.0
Navicula tripunctata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	*	0.0	0.2	0.0
Navicula tripunctata var. schizonemoides	0.0	0.0	0.0	0.0	2.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Navicula viridula	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*	0.0	0.8	1.0	26.3	58.9
Navicula viridula var. avenacea	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula viridula var. linearis	1.8	0.0	0.0	1.0	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0
Navicula viridula var. rostellata	0.0	0.0	0.0	0.5	0.5	0.5	*	0.0	0.0	0.0	0.0	0.0	0.0
Neidium affine	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neidium binode	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neidium hercynicum	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia acicularis	2.7	0.0	0.0	0.0	1.0	2.0	3.5	0.5	0.0	0.0	0.0	0.0	0.0

* Present but not encountered in 500 valve count

Yellow Creek System Diatom Data

Species	---- June 1985 --------			---------October 1988--------					------------February 1990---------				
	37-8	37-4	37-5	37-8	37-1	37-4	37-2	37-5	37-10	37-1	37-3	37-4	37-5
Nitzschia amphibia	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0
Nitzschia angustata var. acuta	0.0	0.0	0.0	0.0	1.0	*	1.0	*	0.0	0.0	0.0	0.0	0.0
Nitzschia apiculata	0.0	1.1	*	1.0	*	6.0	1.5	*	0.0	*	0.0	0.0	0.0
Nitzschia clausii	0.0	1.6	0.0	2.0	0.5	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia communis	0.0	0.0	0.0	0.0	2.0	0.0	1.5	1.4	0.0	0.0	1.0	3.0	0.0
Nitzschia denticula	0.4	0.5	0.0	0.0	7.0	*	*	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia dissipata	0.4	0.0	0.5	15.5	1.0	3.0	2.0	10.4	0.0	5.0	5.5	10.0	6.1
Nitzschia filiformis	*	0.5	0.0	9.5	0.0	2.5	1.0	3.8	0.2	1.8	0.7	0.0	0.0
Nitzschia fonticola	*	0.0	0.0	2.0	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0
Nitzschia frustulum	0.0	*	0.0	1.0	1.5	4.5	8.1	0.0	0.2	0.0	0.0	0.0	0.0
Nitzschia frustulum var. perpusilla	0.0	1.1	1.5	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0	1.2	*
Nitzschia gracilis	0.9	0.0	0.0	*	4.0	1.5	0.0	*	0.0	0.0	0.0	0.0	0.0
Nitzschia hungarica	0.0	0.0	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia levidensis	0.0	0.0	0.0	0.0	*	0.5	0.0	*	0.0	0.0	0.0	0.0	0.0
Nitzschia linearis	2.2	1.6	*	0.5	*	1.0	0.5	*	0.0	0.0	0.0	0.0	0.0
Nitzschia microcephala	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia palea	3.5	6.6	1.0	5.5	4.0	7.0	15.2	0.9	*	0.0	0.0	2.6	0.0
Nitzschia palea var. tenuirostris	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia paleacea	0.0	0.0	0.0	3.5	0.0	0.0	2.0	*	0.0	0.0	0.0	0.0	0.0
Nitzschia recta	0.9	0.0	0.0	0.5	*	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0
Nitzschia romana	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia sigma	0.0	0.0	0.0	1.0	0.0	*	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia sinuata var. tabellaria	*	*	0.0	0.5	7.5	0.5	1.0	0.0	0.2	*	0.0	0.0	0.0
Nitzschia sociabilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	3.6	3.2	13.8
Nitzschia spp.	0.9	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.4	0.0	1.6	0.0	0.0
Nitzschia sp. 1 (parvula)	0.0	0.0	*	1.0	0.0	2.0	5.1	0.5	0.0	0.0	0.0	0.0	0.0
Nitzschia sp. 2 (subrostratoides)	0.0	0.0	0.0	0.0	0.0	0.5	0.0	*	0.0	0.0	0.0	0.0	0.0
Nitzschia tropica	0.0	1.6	0.0	0.0	0.0	0.5	0.5	0.5	0.0	0.0	0.0	0.0	0.0
Nitzschia tryblionella var. victoriae	0.0	0.0	0.0	0.0	0.0	*	0.0	*	0.0	0.0	0.0	0.0	0.0
Pinnularia biceps	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pinnularia sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*	0.0	0.3	0.0	0.0
Rhoicosphenia curvata	0.0	*	61.4	0.0	0.0	0.0	*	4.2	0.0	0.0	*	0.0	1.8
Stauroneis phoenicenteron	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*	0.0	0.0
Stauroneis smithii	2.2	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Surirella angusta	*	0.0	0.0	0.0	0.0	2.0	3.0	*	0.0	0.0	0.7	0.0	0.0

* Present but not encountered in 500 valve count

Yellow Creek System Diatom Data

Species	June 1985			October 1988					February 1990				
	37-8	37-4	37-5	37-8	37-1	37-4	37-2	37-5	37-10	37-1	37-3	37-4	37-5
Surirella ovata	0.0	1.1	1.5	0.0	0.5	4.5	5.6	2.8	0.0	3.2	8.1	10.6	0.6
Surirella spp.	*	0.0	0.0	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0	0.0	0.0
Synedra delicatissima	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0
Synedra famelica	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.6	0.0	12.4	0.0	0.0
Synedra minuscula	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0
Synedra rumpens	4.4	2.2	*	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.2	0.0
Synedra spp.	0.0	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	*	0.0	0.0	0.0
Synedra ulna	5.3	0.0	0.0	0.0	*	0.0	0.0	0.0	0.6	0.2	2.3	0.0	0.0
Synedra ulna var. contracta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Synedra ulna var. ramesii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.6	0.0	0.0	0.0	0.0	0.0
Tabellaria fenestrata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Total	55	38	29	66	55	50	52	52	42	35	37	29	22

Appendix D

Macroinvertebrate Community Data

Macroinvertebrate Synoptic List for the Yellow Creek Drainage in October, 1988

Order/Family/Taxa	37-1	37-2	37-8	37-4	37-5
Rhynchobdellida					
Glossiphoniida					
Helobdella triverialis	-	1	-	1	-
Limnophila					
Lymnaeidae					
Stagnicola sp.	1	-	-	-	-
Physidae					
Physella sp.	1	-	-	-	1
Heterodonta					
Corbiculidae					
Corbicula fluminea	-	-	-	-	4
Decapoda					
Cambaridae					
Cambarus distans	-	-	-	1	-
Ephemeroptera					
Baetidae					
Baetis sp.1	-	-	-	1	-
B. sp.2	1	-	-	-	3
B. sp.3					
Centroptilum	-	2	2	-	-
Caenidae					
Caenis sp.	-	1	-	-	-
Ephemeridae					
Ephemera sp.	-	-	-	-	2
Heptageniidae					
Stenacron interpunctatum	1	-	-	5	2
Stenonoma femoratum	2	-	1	-	-
S. terminatum	49	-	2	8	40
Oligoneuriidae					
Isonychia sp.	3	-	-	-	10
Tricorythidae					
Tricorythodes sp.	4	-	-	3	1
Collembola					
Isotomidae					
Isotomurus palustris	-	1	-	-	-
Odonata					
Aeschnidae					
Bayeria vinosa	3	3	-	-	8
Corduliidae					
Corbicula fluminea	-	-	-	1	-
Gomphidae					
Dromogomphus spoliatus	-	-	-	1	-
Libellulidae					
Sympetrum sp.	1	-	-	-	-
Macromiidae					
Macromia sp.	-	-	-	-	1
Coenagrionidae					
Argia bipunctulata	3	19	-	10	10
Enallagma sp.	17	5	2	4	38

Macroinvertebrate Synoptic List for the
Yellow Creek Drainage in October, 1988

Order/Family/Taxa	37-1	37-2	37-8	37-4	37-5
Calopterygidae					
Calopteryx maculata	6	-	1	-	7
Hemiptera					
Gerridae					
Metrobates hesperius	2	-	-	-	-
Rheumatobates rileyi	-	1	-	-	-
Trepobates inermis	-	-	-	1	-
T. pictus					
Hydromotridae					
Hydrometra australis	-	1	-	-	-
Veliidae					
Microvelia americana	-	-	1	-	-
Rhagovelia obesa					
Coleoptera					
Dryopidae					
Helichus lithophilus	-	-	-	-	1
Elmidae					
Ancyronyx variegata	-	-	-	1	-
Dubiraphia vittata	1	-	-	-	10
Macronychus glabratus	1	-	-	-	1
Haliplidae					
Haliplus sp. (larvae)	-	1	-	-	-
Peltodytes duodecimpunctatus	-	-	1	-	-
Hydrophlidae					
Berosus sp.(larvae)	1	-	-	-	-
Psephenidae					
Psephenus herricki	-	-	-	1	-
Megaloptera					
Corydalibdae					
Corydalus cornatus	1	-	-	1	3
Nigronia serricornia	-	-	1	-	2
Sialidae					
Sialis sp.	-	-	-	-	1
Trichoptera					
Hydropsychidae					
Ceratopsyche bifida gp.	9	-	-	-	5
Cheumatopsyche sp.	-	-	-	1	2
Limnephilidae					
Hydatophylax argus	-	-	1	-	-
Phryganeidae					
Ptilostomis sp.	-	-	-	-	1
Polycentropodidae					
Polycentrpus sp.	-	-	1	-	-
Diptera					
Athericidae					
Atherix lantha	1	-	-	-	6
Ceratopogonidae					
Bezzia/*Johannsenomyia*/*Palpomyia* gp.	-	1	-	-	-

Macroinvertebrate Synoptic List for the Yellow Creek Drainage in October, 1988

Order/Family/Taxa	37-1	37-2	37-8	37-4	37-5
Culicidae					
Anopheles sp.	-	-	1	1	-
Simuliidae					
Simulium vittitum	2	-	-	2	-
Tipulidae					
Hexatoma sp.	-	-	1	-	-
Tipula sp.	-	-	-	-	1
Chironomidae					
Cricoptopus annulator	-	-	-	-	2
C. binctus	-	-	-	3	-
C. tremulus	-	-	-	-	1
Cricotapus/Orthocladius gp.	1	-	-	-	-
Chironomus sp.	-	1	-	-	-
Glyptotendipes sp.	-	-	-	1	-
Harnischia curtilamellata	-	-	1	-	-
Hydrobaenus pilipes gp.	1	-	-	-	-
H. sp.	-	-	-	1	-
Orthodadius obumbratus gp.	3	-	-	-	-
Phaenopsectra dyari gp.	-	1	-	-	-
P. sp.	-	-	-	4	-
Polypedilum convictum	-	-	-	2	-
P. illinoense	-	4	-	-	5
Procladius subletti	-	1	-	-	-
Rheotanytarsus exiguus gp.	3	-	-	-	-
Tanytarsus sp.	1	-	-	-	-
Thienemannimyia sp. gp.	2	-	-	5	-

Yellow Creek System Macroinvertebrate Data February 1990

Order	Family	Species	37-1	37-3	37-4	37-5	37-10
Lumbriculida	Lumbriculidae	Eclipidrilus sp.	2	3	2		2
Haplotaxida	Naididae	Chaetogaster sp					1
	Tubificidae	Limnodrilus/Tubifex sp	1		2		
Gastropoda	Ancylidae	Ferrissia rivularis				7	
	Limnaeidae	Fossaria sp					1
	Planorbidae	Helisoma anceps anceps					1
	Pleuroceridae	Elimia sp	2				37
Heterodonta	Corbiculidae	Corbicula fluminea				1	
	Sphaeriidae	Pisidium sp					1
		Sphaerium simile					1
Isopoda	Asellidae	Asellus sp	1				
Amphipoda	Gammaridae	Crangonyx sp		3	2		1
Decapoda	Cambaridae	Cambarus sp	1				1
		Orconectes putmani			1		
Ephemeroptera	Baetidae	Baetis brunneicolor			5	3	
		Paracloeodes sp					3
	Ephemerellidae	Ephemerella catawba	2	1	4	85	5
		Eurylophella temporalis	28	3	5	8	1
	Heptageniidae	Epeorus dispar			7	2	
		Stenonema exiguum	1				
		Stenonema femoratum		2			
		Stenonema meririvulanum					2
		Stenonema terminatum	3	1	4	2	
		Stenonema vicarium				2	32
	Leptophlebiidae	Leptophebia sp		14	4	5	
	Oligoneuriidae	Isonychia sp				2	19
	Siphlonuridae	Ameletus sp	2		2	7	
Plecoptera	Capniidae	Nemocapnia carolina			2	3	
	Leuctridae	Leuctra sp					1
		Megaleuctra sp					2
	Nemouridae	Ostrocerca sp				5	
	Perlodidae	Isoperla clio				1	
		Isoperla similis					5
		Isoperla sp					1
		Unidentifed larvae	1			1	
	Taeniopterygida	Strophopteryx fasciata	1	1	9	3	
		Taeniopteryx burksi	2				
Odonata	Calopterygidae	Calopteryx maculata	4				4
	Coenagrionidae	Enallagma sp.	2		2		2
	Aeshnidae	Basiaeschna janata					1
		Boyeria grafina					1
		Boyeria vinosa		1			1
	Gomphidae	Dromogomphus sp.		1			
		Stylogomphus albistylus	2				
	Macromiidae	Macromia sp.		1			
Coleoptera	Dytiscidae	Hydroporus oblitus					1
	Elmidae	Dubiraphia vittata					1
		Optioservus sp larva					1
		Stenelmis sp larva				1	
	Hydrophilidae	Berosus sp	12	8			
	Psephenidae	Psephenus herricki	1				
	Ptilodactylidae	Anclytarsus bicolor					1
Megaloptera	Corydalidae	Corydalus cornutus					14

Yellow Creek System Macroinvertebrate Data February 1990

Order	Family	Species	37-1	37-3	37-4	37-5	37-10
		Nigronia serricornis					7
Trichoptera	Brachycentridae	Micrasema sp					1
	Glossosomatidae	Glossosoma sp					1
	Hydropsychidae	Cheumatopsyche sp	5	2		4	48
		Ceratpsyche cheilonis	3			13	
		Ceratopsyche sparna	1	1			17
		Hydropsyche betteni gp	5	1	2	1	
	Lepidostomatidae	Lepidostoma sp					1
	Limnephilidae	Pycnopsyche sp			1		
	Limnephilidae	Hydatophylax argus	2				
	Philopotamidae	Chimarra aterrima					75
	Phryganeidae	Ptilostomis sp	1				
	Rhyacophilidae	Rhyacophila torva					7
Diptera	Chironomidae	Chironomus decorus gr					1
		Chironomus sp			1		
		Clinotanypus pinguis	1				
		Conchapelopia sp	1				
		Cricotopus annulator		2			
		Cricotopus bicinctus	7		1		
		Cricotopus/Orthocladius sp		4			
		Cricotopus tremulus gp	3		1	5	
		Cricotopus triannulatus				1	
		Eukiefferiella brevicalcar gr.	1			1	13
		Glyptotendipes sp	1				1
		Heterotrissocladius marcidus gr.					2
		hydrobaenus pilipes gp			1	3	
		Orthocladius obumbratus	3	1	3	4	
		Parakiefferialla sp	1				
		Parametriocnemus lundbecki	1			3	1
		Procladius sublettei					1
		Rheocricotopus robacki					1
		Rheotanytarsus exiguus gr	2	1			
		Stictochironomus divinctus					1
		Tanytarsus sp					1
		Thienemannimyia sp.			1		
		Tribelos jucundus					2
	Simuliidae	Prosimulium mixtum					3
	Tipulidae	Antocha sp					1
		Hexatoma sp	1	1			
		Tipula abdominalis				1	1
		Tipula sp				2	2