ELK LICK CREEK DRAINAGE (KENTUCKY RIVER SYSTEM)
BIOLOGICAL AND WATER QUALITY INVESTIGATION

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SUMMARY

The Elk Lick Creek drainage is impacted by two industrial operations, the Kentucky-American Water Company (KAWC) and the Vulcan Materials Company (VMC). Water from two KAWC settling lagoons is discharging into Evans Mill Branch, a small second order tributary to Elk Lick Creek. The VMC has allowed water and quarried gravel to be discharged to the headwaters of Elk Lick Creek. The net results of these impacts are as follows:

1) The KAWC discharge has reduced or eliminated most species of algae and macroinvertebrates, and eliminated virtually all fish species from Evans Mill Branch from the discharge point on Evans Mill Branch to the Kentucky River, a distance of 1.4 miles. The toxic discharge also acts as a barrier to upstream fish migration, thus preventing recolonization.

2) The impacts to algae and aquatic macroinvertebrates from the VMC activities appear to be mainly physical in nature. During periods of high flow, quarried gravel moves downstream, scouring the substrate and eliminating both algae and macroinvertebrates. Gravel has accumulated in large quantities in the stream channel, embedding the natural substrate and, therefore, reducing or eliminating available habitat for macroinvertebrates and algae. The impacts to the fish community arising from VMC operations could not be determined.

Water samples were taken and analyzed for inorganic, nonmetalic constitutents; metals; and organic compounds for both stations on Evans Mill Branch and the lower most station (near mouth) on Elk Lick Creek. Evans Mill Branch below KAWC (the lower station) was sampled twice at the same location, once under normal flow and once during a KAWC discharge. All organics were below detection limits. Four nonmetal, inorganic parameters (alkalinity, BOD_5, fluoride, and pH) were more than one standard deviation above the STORET (1979-1988) mean; however, none of

these were considered biologically significant. Aluminum at the downstream Evans Mill Branch station was elevated above the U.S. EPA recommended acute level during the KAWC discharge, and exceeded the U.S. EPA recommended chronic toxicity level of 0.087 mg/l in the remaining samples. Iron slightly exceeded the Kentucky Surface Water Standards (KSWS) at the lower Evans Mill station during the KAWC discharge. Zinc violated KSWS at all sampled stations and exceeded the U.S. EPA recommended value for acute toxicity in Elk Lick near the mouth and Evans Mill below KAWC in both samples. Copper exceeded the U.S. EPA acute toxicity level at the control site (upper station) on Evans Mill. A Total Residual Chlorine (TRC) of 0.4 mg/l was observed at Elk Lick Creek near the mouth on Sunday, June 4, 1989. The high toxicity resulting from TRC is thought to be responsible for eliminating or reducing the aquatic life in Evans Mill Branch below the KAWC discharge and in Elk Lick Creek from the confluence with Evans Mill Branch to the Kentucky River. The acute levels of aluminum, zinc and copper may also impair the aquatic communities of Elk Lick drainage.

RECOMMENDATIONS

1) As the unpermitted discharge from the KAWC settling lagoons to the Elk Lick Creek system was shown to be toxic to indigenous aquatic life and in violation of Kentucky Surface Water Standards, 401 KAR 5:031 Section 4(1), for protection of warmwater aquatic life, the following recommendations are offered:

   a) immediately eliminate the settling lagoon discharges,

   b) renovate the settling lagoons to prevent future unpermitted discharges,

   c) because of the small size of Evans Mill and the toxic nature of the KAWC discharge, it is strongly recommended that any permitted KAWC discharge be routed to the Kentucky River, rather than Evans Mill Branch.

   d) any KAWC discharge permitted by the Division of Water should have appropriate effluent criteria and monitoring stipulations to ensure compliance and protect Evans Mill Branch and Elk Lick Creek.

2) As the quarried gravel and associated siltation from VMC physically reduce the ability of Elk Lick Creek system to support aquatic life, it is recommended that VMC be encouraged to implement appropiate BMPs for the control of nonpoint source pollution.

INTRODUCTION

A biological and water quality investigation was conducted on June 1, 1989, on the Elk Lick Creek drainage located in south-central Fayette County. The purpose of the study was to determine the source and extent of impacts to the Elk Lick Creek system. Aquatic biologists from the Water Quality Branch (WQB) of the Kentucky Division of Water (KDOW) collected water samples for analysis of inorganic, nonmetalic constitutents; metals; and organic compounds. In addition, biological collections of algae, macroinvertebrates, and fish were made.

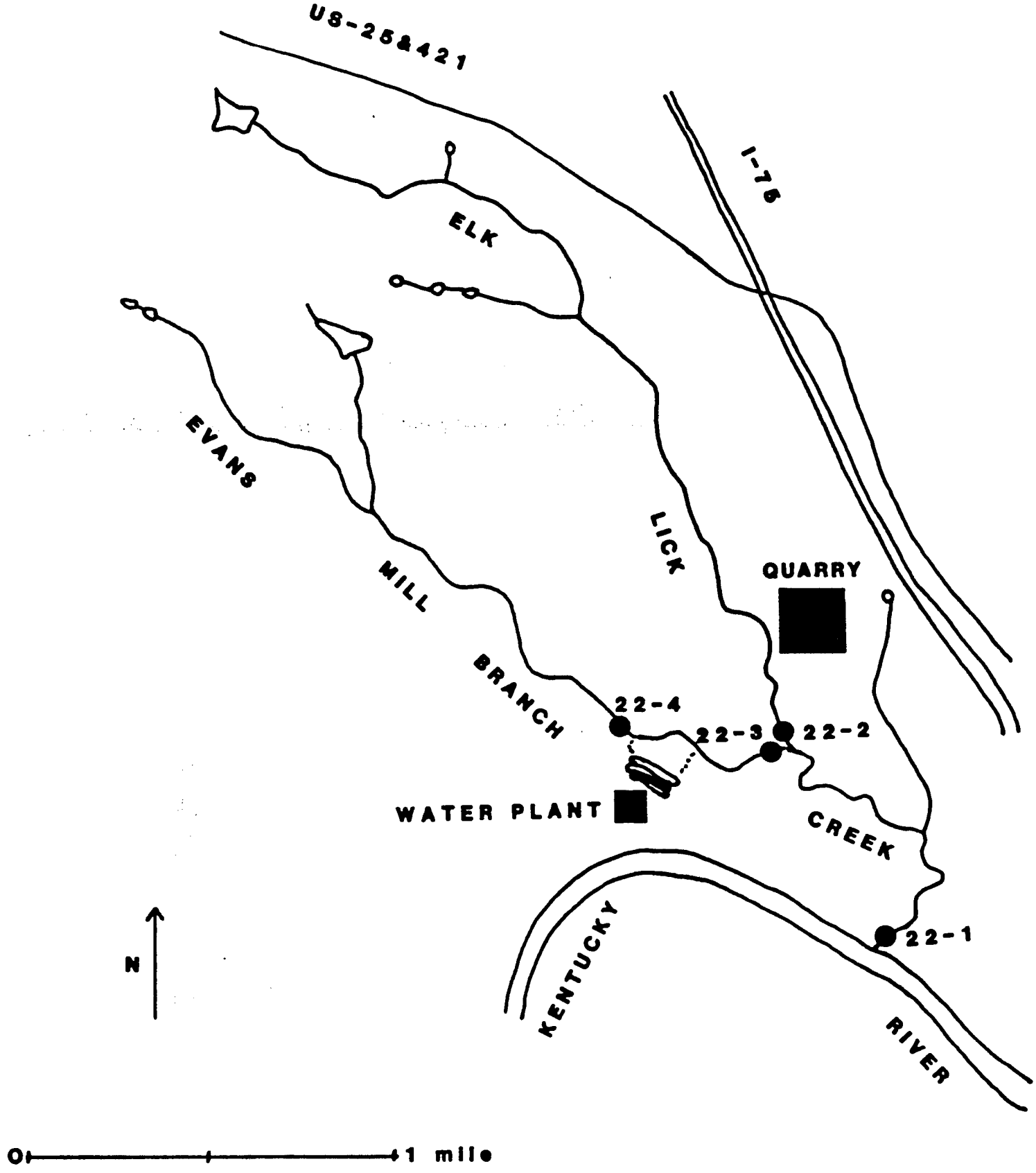
Elk Lick Creek is a third order, moderate gradient stream that discharges to the Kentucky River on the Fayette-Madison county line at Kentucky River mile 168.45 (Figure 1). The stream cuts through limestones of the High Bridge and Lexington Limestone groups. Elk Lick Creek also has numerous small waterfalls and runs, and occasional cobble-dominated riffles. Vulcan Materials Company (VMC) operates a rock quarry in the headwaters of Elk Lick Creek . Large amounts of gravel originating from the quarry have been deposited in Elk Lick Creek, filling the channel in many areas. A large gravel bar has developed at the mouth of Elk Lick Creek and extends well into the Kentucky River.

One major tributary, locally referred to as Evans Mill Branch, joins Elk Lick Creek approximately one mile upstream from the Kentucky River. The upper portion of this drainage flows through pastures, while the remainder of the watershed is forested. Evans Mill Branch is a bedrock stream with an occasional cobble-dominated riffle and numerous runs and small waterfalls. The Kentucky-American Water Company (KAWC) lies adjacent to Evans Mill Branch, approximately 0.4 mile upstream from the Elk Lick Creek-Evans Mill Branch confluence.

All sampling sites were located in the forested section of the drainage and had riffle, run, and pool habitats. In the upper three stations (22-2, 22-3 and 22-4), the

FIGURE 1: MAP OF THE ELK LICK CREEK SYSTEM

WITH SAMPLING LOCATIONS



riffles were cobble dominated, but at station 22-1 the substrate was covered with quarry gravel. Large amounts of quarry gravel were also present at station 22-2. All sites had a limited amount of undercut banks and submerged tree root habitat. Large amounts of sediment were present at stations 22-1 and 22-3.

It is noteworthy that at the start of the sampling, water at station 22-3 was clear and flowing at what was considered a normal level. While the field team was sampling, flow increased and the water became quite turbid. Upon investigation, they found that this increased flow and turbidity was originating from the KAWC lagoons.

Water originating from KAWC operations has been observed flowing out of settling lagoons at two locations (shown as dotted lines in Figure 1) and into Evans Mill Branch. From these locations downstream to the Kentucky River, a distance of 1.4 miles, the creek was virtually devoid of algae and the substrate had a bleached, bare appearance, an indication that the impact has been occurring for a long period of time.

METHODS

Water samples were collected in accordance with KDOW's Standard Operations Procedures Manual (DOW 1984). All samples were iced and transported to the Division of Environmental Services laboratory for analysis. Total residual chlorine was analyzed with a Fischer and Porter titrator, model number ITT2012A.

Qualitative biological samples were also collected in accordance with the SOP (1984) 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 DOW (1984) manual.

PHYSICOCHEMICAL DISCUSSION

Water samples were collected from three of the four sampling locations in the Elk Lick Creek system (Figure 1). Station 22-3 on Evans Mill was sampled twice, once without the KAWC discharge (22-3) and once during the KAWC discharge (22-3A). Water samples were not collected at 22-2. Data from these samples are presented in Table 1. Analysis performed on organic constituents showed that all were below detection limits. The list of organics and detection limit are given in Appendix A.

On Sunday June 4, 1989, at about 5:00 p.m., total residual chlorine (TRC) was analyzed at Station 22-1. Even though the water was clear and the flow level was near normal, the TRC was 0.4 mg/l. Under natural conditions, no total residual chlorine would be expected. This value is considerably higher than the Kentucky Surface Water Standard (KSWS) of 0.010 mg/l as listed in 401 KAR 5:031, Section 4(1).

The toxicity of TRC to aquatic life has been well documented (Arthur and Eaton 1971; Larsen et al. 1977 a and b, Wilde et al. 1983; Brooks and Bartos 1984; U.S. EPA 1985). In general, the rate of lethality resulting from TRC is rapid and the toxicity slope is steep (U.S. EPA 1985). Therefore, small increases in concentration of TRC will significantly increase toxicity. Sublethal effect of TRC may involve reduced growth rate (Larson 1977a), reduced number of eggs and/or young (Arthur and Eaton 1971), the inability to reproduce (Arthur and Eaton 1971), or the avoidance of TRC waters (Fava and Tsai 1978). The TRC value of 0.4 mg/l observed in Elk Lick was considerably above the acute and chronic toxicity levels reported by Arthur and Eaton (1971), Larson et al. (1977 a and b) and U.S. EPA (1985) for aquatic organisms.

Data from this study show that Elk Lick and Evans Mill are alkaline, hardwater streams that have sufficient amount of nutrients to support good primary and secondary growth. This is a reflection of the area geology.

A review of the inorganic, nonmetalic consitutents (Table 1) shows that four parameters (alkalinity, BOD_5, fluoride, and pH) had values that exceeded one standard

TABLE 1. PHYSICOCHEMICAL DATA FOR THE ELK LICK CREEK DRAINAGE

Parameter*	Station 22-1	22-3	22-3A	22-4
Acidity	<0.1	<0.1	<0.1	<0.1
Alkalinity	139	137	113	174#
BOD_5	0.5	2.08	1.87	3.39#
COD	9.46	11.0	13.8	9.79
Chloride	9.6	9.4	9.6	5.9
Conductivity (umhos/cm)	400	367	367	394
Cyanide, amenable	<0.01	<0.01	<0.01	<0.01
Fluoride	0.59#	0.58#	0.75#	0.23
Hardness	185	181	162	180
Phenol (4AAP)	<0.010	<0.010	<0.010	<0.010
pH (SU)	8.4	8.5#	8.4	8.4
Total Suspended Solids	8.0	1.0	45	1.0
Total Dissolved Solids	240	212	208	248
Sulfate	47.6	45.3	53.8	23.8
Total Organic Carbon	2.6	2.6	2.7	3.0
Turbidity (NTU)	10.0	4.9	60	3.6
Ammonia-Nitrogen	<0.05	0.097	<0.050	0.060
Total Kjeldahl Nitrogen	0.250	0.250	0.318	0.383
Nitrate-Nitrogen	0.640	0.692	0.543	0.951
Phosphorus, total	0.156	0.143	0.147	0.280
Calcium	68.0#	64.7#	56.0	73.9
Magnesium	7.42	6.97	7.75	5.16
Potassium	1.47	1.12	1.50	0.65
Sodium	8.5	5.9	8.8	3.3
Aluminum	0.617&	0.417&	2.32#&	0.162&
Arsenic	<0.001	<0.001	<0.001	<0.001
Barium	0.009	0.011	0.016	0.008
Beryllium	<0.001	<0.001	<0.001	<0.001
Cadmium	<0.001	0.001	<0.001	<0.001
Chromium	0.003	0.002	0.005	0.003
Copper	0.002	<0.001	<0.001	0.087&
Iron	0.26	0.19	1.22+	0.16
Lead	<0.001	0.004	<0.001	0.003
Manganese	0.03	0.04	0.11	0.04
Mercury	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	<0.002	<0.002	<0.002	<0.002
Selenium	<0.002	<0.001	<0.001	<0.001
Silver	0.002	0.003	0.002	<0.001
Zinc	0.349+&	0.325+&	0.283+&	0.102+

*Units in mg/l unless otherwise stated
#Parameters that are higher than one standard deviation above the STORET (1979-1988) mean
+Exceeds Kentucky Surface Waters Standards
&Exceeds U.S. EPA recommended chronic and/or acute toxicity levels.

deviation above the STORET (1979-1988) mean. However, none of these four parameters were considered biologically significant. None of the inorganic, non-metalic constutents violated Kentucky Surface Water Standards (KSWS).

Data is presented in Table 1 for 19 metalic and nonmetalic metals. Calcium at stations 22-1, 22-3 and 22-4 exceeded the STORET (1979-198) mean by more than one standard deviation; however, this was not considered biologically significant. During the KAWC discharge, aluminum at station 22-3 was elevated above the STORET (1979-1988) by almost two standard deviations. According to data presented by U.S. EPA (1988), values of this magnitude may be acutely toxic to aquatic life. Also, aluminum was above the U.S. EPA (1988) recommended chronic toxicity level of 0.087 mg/l. Zinc at all sampling locations was above the KSWS, 401 KAR 5:031 Section 4(1), of 0.047 mg/l. Hardness has an effect on the toxicity of zinc; using the formula for calculating acute and chronic toxicity presented by U.S. EPA (1986), with a hardness value of 180 mg/l, zinc exceeded the recommended acute and chronic value of 0.190 mg/l and 0.170 mg/l, respectively, at stations 22-1 and 22-3 (both samples). The copper concentration observed at station 22-4 exceeded the U.S. EPA (1986) calculated acute toxicity value of 0.031 mg/l (using a hardness value of 180 mg/l). Iron also exceeded KSWS, 401 KAR 5:031 Section 4(1), at station 22-3 during the the KAWC discharge.

BIOLOGICAL DISCUSSION

Algae, macroinvertebrates, and fish were collected at all four sampling locations in the Elk Lick Creek system (Figure 1). All the biological data indicate that Evans Mill Branch below the KAWC discharge, and Elk Lick Creek below the confluence with Evans Mill Branch, have been severely degraded. Elk Lick Creek above Evans Mill Branch showed signs of habitat impairment arising from the VMC quarry operations.

Algae

The algal community of Elk Lick Creek and Evans Mill Branch (Table 2) has been severely degraded by the discharge from the KAWC. At stations 22-1 and 22-3, only four and nine algal species, respectively, were collected. These extremely low taxa richness numbers reflect the toxicity of KAWC's discharge. At Elk Lick Creek station 22-2, below the quarry, but upstream of the KAWC impact, 26 species were collected. At Evans Mill Branch station 22-4, just above the KAWC discharge, 27 species were collected. A total of 37 algal species were recorded for the drainage.

Most disturbing was the lack of the red alga, Lemanea fucina, at either of the degraded stations (22-1 and 22-3). Lemanea is commonly found on undisturbed limestone bedrock substrates in the Blue Grass Region, and the habitat in Elk Lick Creek (fast current, sloping limestone ledges and waterfalls) is especially suitable for this clean-water species of algae. It was abundant in Evans Mill Branch and Elk Lick Creek at the sites above the discharge, but conspicuously absent in the portion of the streams below the discharge, even though nearly the entire stream was walked in search of this macroscopic alga. In addition, the common filamentous green algae, Cladophora glomerata, was absent from the impaired sites, although present in Elk Lick Creek and abundant in Evans Mill Branch.

Chlorococcum humicola, a green alga common in water supplies (Whitford and Schumacher 1973), was found at both sites below the KAWC discharge. The KAWC discharge was either the source of this alga or produced conditions conducive to its growth, since it was absent from the other two sites.

Diatom relative abundance counts showed that two species, Amphora perpusilla and Achnanthes linearis, were dominant at both severely impaired sites (22-1 and 22-3). Relative abundances of these diatoms were 86% and 11%, respectively, at station 22-1, and 61% and 36.5%, respectively, at station 22-3. Ecological data on these species is scarce; however, they appear to be early colonizers of otherwise bare

TABLE 2: ALGAL SYNOPTIC LIST FOR THE ELK LICK CREEK DRAINAGE

TAXA	Station 22-1	22-2	22-3	22-4
Chlorophyceae (Green Algae)				
Chlorococcum humicola	*	-	*	-
Cladophora glomerata	-	*	-	*
Cyanophyceae (Blue Green Algae)				
Oscillatoria sp.	-	-	*	*
Schizothrix calcicola	-	-	*	*
Rhodophyceae (Red Algae)				
Lemanea fucina	-	*	-	*
Bacillariophyceae (Diatoms)**				
Achnanthes lanceolata	-	10.9	-	0.6
A. linearis	11.0	11.9	36.5	1.2
A. pinnata	-	*	-	-
Amphora perpusilla	86.0	10.9	61.0	-
Caloneis sp.	-	-	-	*
Cocconeis pediculus	-	9.0	-	0.6
C. placentula var. euglypta	-	29.9	-	0.6
Cyclotella sp.	-	5.0	-	-
Cymbella prostrata	-	-	-	-
C. sinuata	-	-	-	*
Gomphonema olivaceum	-	0.5	-	-
G. parvulum	-	1.5	-	1.2
G. sp.	-	-	-	0.6
Meridion circulare	-	*	-	-
Navicula accomoda	-	-	-	0.6
N. cryptocephala	-	-	-	1.2
N. lanceolata	-	1.0	-	16.3
N. luzonensis	-	1.0	-	1.2
N. menisculus var. upsaliensis	-	*	-	7.2
N. radiosa var. tenella	-	1.0	*	10.8
N. salinarum var. intermedia	-	0.5	-	6.0
N. secreta var. apiculata	-	1.0	-	-
N. spp.	-	1.5	2.5	7.8
N. tripunctata	-	4.0	*	17.5
Nitzschia dissipata	-	1.0	-	10.2
N. frustulum var. perminuta	-	1.0	*	6.0
N. linearis	-	1.0	-	0.6
N. palea	-	1.0	-	*
N. spp.	3.0	-	-	2.4
Rhoicosphenia curvata	-	4.0	-	-
Stephanodiscus sp.	-	2.5	-	-
Surirella ovata	-	-	-	7.2
Taxa Richness	4	26	9	27

*present but not encountered during enumeration of diatoms.
**Numbers represent Relative Abundance of that species

substrates. Only one other diatom species was collected at station 22-1, and only four others were found at station 22-3.

In contrast, 20 diatom species were identified from station 22-2, and 21 species from station 22-4. Station 22-2, situated downstream of the VMC limestone quarry, appeared to have suffered some impairment from scouring of the substrate and deposition of fine material and gravel. Algal biomass appeared to be lower there than at the unimpaired Evans Mill Branch station (22-4) upstream of the KAWC discharge. The diatom community at station 22-2 was dominated by Cocconeis placeutula var. euglypta, C. pediculus, and Achnanthes species, all small diatoms that adhere tightly to rock substrates and would not be readily removed by the scouring action of gravel washing downstream. Station 22-4 was dominated by larger diatoms, primarily Navicula and Nitzschia species which are typical of nutrient rich Blue Grass streams. Cocconeis and Rhoicosphenia curvata were common epiphytes attached to the long Cladophora filaments present at 22-2.

Diatom Percent Community Similarity (PS_c) data (Table 3) was used to compare the diatom communities of all the stations. Station 22-4 is considered the control site. These values represent an estimate of the amount of similarity between two diatom communities. In general, values greater than 50% indicate similarity between stations, while values less than 50% indicate impairment, or a change in diatom community structure (values between 0% and 100% are possible, with similarity increasing as values approach 100%). The only stations that showed a great degree of similarity (72.0%) were station 22-1 and 22-3. This is not unusual, since only a few extremely tolerant diatom species existed at these two sites. The PS_c values between those two stations and the control station were 3.6% and 3.7%, respectively, indicating severe impairment to the diatom communities. Station 22-2, below the quarry, was dissimilar to all stations. It most closely compared to station 22-3, because of the occurrence of the small, early-colonizing diatoms, A. linearis and A. perpusilla.

TABLE 3: DIATOM PROPORTIONAL SIMILARITY COEFFICIENT FOR THE ELK LICK SYSTEM

	22-1	22-2	22-3
22-2	21.95		
22-3	72.00	24.38	
22-4	3.61	15.76	3.70

In summary, the toxic discharges from KAWC have severely degraded the algal community of the downstream portions of Elk Lick Creek and Evans Mill Branch. In addition, scouring and depositional effects from the VMC limestone quarry may have altered the algal community of Elk Lick Creek above the portion degraded by KAWC. The toxic water quality conditions caused by the KAWC discharge has had a far greater impact on the algal community than has the habitat disturbance attributed to VMC.

Macroinvertebrates

The macroinvertebrate data shows (Table 4) that stations 22-1 and 22-3 were severely degraded, while station 22-2 was impacted, but to a lesser extent. The Evans Mill Branch station (22-4) above the KAWC property was the only location in which the macroinvertebrate fauna was considered unimpaired and is typical of small limestone streams that cut through the palisades of the Inner Bluegrass.

The total number of individuals (TNI) and the total number of taxa (TNT) were both low at 22-1 and 22-3 (Table 4), indicating a toxic situation, probably arising from the KAWC discharges. The community structure was also dramatically altered at the two most severely impacted sites; 22-1 and 22-3 (Table 4). Beetles (Coleoptera) were the most common group observed at station 22-1; five out of the 12 taxa observed were members of this group. Station 22-3 also had only 12 taxa present, but the dipterans (true flies) were the most common group. The only organism that occured at both stations in any numbers was the "water penny" Psephenus herricki. This larval beetle typically inhabits erosional areas of streams (i.e. riffles and runs) and feeds by scraping periphyton from the substrate (Merritt and Cummins 1984). Apparently, the

KAWC discharge was not highly toxic to the mature larvae of P. herricki and they were able to scrape enough periphyton from rocks to survive.

The community at station 22-2 also appeared to be stressed but to a lesser extent than 22-1 and 22-3. The community at 22-2 was more diverse, with dipterans making up ten of the 22 taxa (Table 4). The isopod Lirceus fontinalis and the mayfly Pseudocloeon sp. were the most abundant macroinvertebrates at 22-2, but Lirceus was only rarely seen at 22-1 and 22-3, and Pseudocloeon was not found at either site. Lirceus is often the numerically dominant organism in small limestone streams of the Bluegrass. Also, the occurence of two taxa each of mayflies (Ephemeroptera) and stoneflies (Plecoptera) indicates improved water quality. These groups are generally considered to be pollution sensitive, and were absent from 22-1 and 22-3. However, the reduced diversity (compared to station 22-4) and the low number of taxa of Ephemeroptera, Plecoptera and Trichoptera indicate that station 22-2 is under some type of stress. The large amount of quarry gravel present at this site has increased the embeddedness of the substrate. This habitat disturbance was probably responsible for the reduced taxa richness in this portion of the stream.

Station 22-4 was located above all known basin impacts. The fauna was diverse and included representatives of most of the common groups of aquatic invertebrates (Table 4). With regard to numbers of taxa, the dipterans, coleopterans, and ephemeropterans, respectively, were the common groups. Again the isopod Lirceus fontinalis was the numerically dominant organism, followed by the caddisfly Hydropsyche betteni gp. and the mayfly Baetis sp. Neither of the latter two organisms were observed at stations 22-1 and 22-3. The organisms found at this location would normally be expected throughout the stream system, if it were not severely stressed.

As stated earlier, the ephemeropterans, plecopterans, and trichopterans are generally considered to be pollution sensitive organisms. Therefore, a community that has numerous taxa of these groups would be considered to be unimpacted by drainage

TABLE 4: MACROINVERTEBRATE SYNOPTIC LIST FOR THE ELK LICK CREEK DRAINAGE

Taxa	22-1	22-2	22-3	22-4
Haplotaxida				
Haplotaxidae				
Haplotaxis gordioides	-	4	-	2
Lymnophila				
Physidae				
Physella sp.	-	3	-	2
Phanorbidae				
Helisoma anceps	-	-	-	5
Isopoda				
Asellidae				
Lirceus fontinalis	5	166	1	170
Amphipoda				
Gammaridae				
Crangonyx sp.	-	1	-	-
Decapoda				
Cambaridae				
Cambarus laevis	-	-	-	2
C. ortmanni	-	1	-	4
Orconectes rusticus	-	-	-	4
Ephemeroptera				
Baetidae				
Baetis sp.	-	3	-	23
Pseudocloeon sp.	-	57	-	1
Heptageniidae				
Stenacron interpunctatum	-	-	-	11
Stenonema femoratum	-	-	-	1
Leptophlebiidae				
Paraleptophlebia sp.	-	-	-	8
Plecoptera				
Nemouridae				
Amphinemoura delosa	-	2	-	-
Perlidae				
Acroneuria evoluta	-	-	-	1
Beloneura sp.	-	-	-	17
Perlesta placidae	-	2	-	-
Odonata				
Calopterygidae				
Calopteryx maculata	-	-	-	7
Coenagrionidae				
Argia bipunctulata	-	-	1	-

TABLE 4: MACROINVERTEBRATE SYNOPTIC LIST FOR THE ELK LICK CREEK DRAINAGE

Taxa	22-1	22-2	22-3	22-4
Hemiptera				
Corixidae				
Sigaria sp.	2	-	1	3
Coleoptera				
Dytiscidae				
Deronectes (larvae)	-	-	1	-
Hydaticus (larvae)	-	1	-	3
Hydroporus sp. 1	2	-	-	8
H. sp. 2	-	-	-	3
Ilybius oblitus	1	-	-	-
Elmidae				
Dubiraphia quadrinotata	-	-	-	5
Stenelmis crenata	-	-	-	8
Eubridae				
Ectopria nervosa (larvae)	-	-	-	3
Hydrophilidae				
Tropisternus blatchleyi	-	-	-	1
T. (larvae)	1	-	-	-
Noteridae				
Hydrocanthus iricolor	1	-	-	-
Psephenidae				
Psephenus herricki (larvae)	13	1	28	5
Megaloptera				
Corydalidae				
Nigronia serricornis	1	-	3	6
Sialidae				
Sialis sp.	-	-	7	-
Trichoptera				
Helicopsychidae				
Helicopsyche borealis	-	-	4	7
Hydropsychidae				
Ceratopsyche sparna	-	-	-	3
Hydropsyche betteni gp.	-	-	-	24
Rhyacophilidae				
Rhyacophila ledra	1	11	-	-
Hydroptilidae				
Ochrotrichia sp.	-	-	-	1
Diptera				
Ceratopogonidae				
Bezzia/Palpomia/ Johannsenomyia gp.	-	-	3	2
Simuliidae				
Prosimulium mixtum	-	18	-	1

TABLE 4: MACROINVERTEBRATE SYNOPTIC LIST FOR THE ELK LICK CREEK DRAINAGE

Taxa	22-1	22-2	22-3	22-4
Chironomidae				
Cardiocladius obsckrus	-	-	-	1
Chironomas decorus gp.	-	5	-	-
Cricotopus tremulus gp.	-	-	-	2
Cryptochironomus fulvus gp.	1	1	1	1
Eukiefferiella brevicalcar gp.	-	4	-	1
Microtendipes pedellus gp.	-	-	-	1
Paramertriocnemus lundbecki	1	1	-	2
Paratanytarsus sp.	-	-	-	3
Polypedium aviceps	-	1	-	-
P. convictum	-	-	-	3
Procladius sublettei	-	-	1	-
Stictochironomus divinctus	1	14	2	14
Thienemanniella xena	-	1	-	1
Thienemannimyia sp.	-	1	-	1
Tvetenia bavarica gp.	-	14	-	-
Total Number of Taxa (TNT)	12	22	12	42
Total Number of Individuals (TNI)	30	312	54	371
Ephemeroptera/Plecoptera/Trichoptera Index (EPT)	1	5	1	11

activities. Station 22-4 had an Ephemeroptera/Plecoptera/Trichoptera (EPT) index of 11 which is typical of small, unimpacted limestone streams in central Kentucky during the summer (Table 4). The EPT value for 22-3 was 5, which is roughly half of that at 22-4, indicating some community impairment. Stations 22-1 and 22-3 both have EPT values of 1, indicating severe degradation.

Macroinvertebrate proportional similarity coefficients (PS_c) were calculated for all station pairs (Table 5) (refer to Algae section for discussion). Station 22-4, located above all known basin impacts, was considered the control. The two most severely stressed stations (22-1 and 22-3) were similar to each other, which is accounted for by the co-existence of a few tolerant taxa found at both locations. The control station (22-4) and station 22-2 were also similar to each other. However, station 22-2 and 22-3 are extremely dissimilar. These two stations are within a hundred yards of each other and have similar habitats and, under normal circumstances, would be expected to have similar macroinvertebrate faunas. Station 22-4 and 22-3 are also very dissimilar. Since 22-4 is approximately one-half mile upstream of 22-3 and they have similar habitats, these two sites would also be expected to be similar. The PS_c data indicate that the impact from KAWC is more severe than that arising from the quarry.

TABLE 5: MACROINVERTEBRATE PROPORTIONAL SIMILARITY COEFFICIENT FOR THE ELK LICK SYSTEM

	22-1	22-2	22-3
22-2	23.55		
22-3	54.05	6.30	
22-4	27.17	54.22	12.13

In summary, the toxic discharge arising from the KAWC has dramatically altered the macroinvertebrate community of Evans Mill Branch and Elk Lick below the confluence with Evans Mill Branch. Material washing into the upper portion of Elk Lick Creek from VMC has stressed the macroinvertebrate community, but to a much lesser extent, by scouring the substrate in erosional areas and embedding the substrate in depositional areas.

Fish

The fish community in the Elk Lick Creek system is depauperate. Only the creek chub Semotilus atromaculatus was found at station 22-2 and 22-4, while one bluegill Lepomis macrochirus was collected from 22-1. No fish were found at 22-3.

Data presented by Kuehne (1962) and Jones (1973) indicate that third order streams in the Kentucky River drainage, such as Elk Lick Creek at Station 22-1, would be expected to have from 10 to 22 species of fish. Furthermore, the fish community would be composed of bass and sunfish, suckers, minnows, and darters. Even if the severe drought of 1988 had reduced the fish fauna in this portion of the stream, the abundant rainfall occurring in the winter and spring of 1989 would have allowed recolonization by fish species from lower stream reaches on Elk Lick and the Kentucky River.

According to Kuehne (1962), second order streams in the Kentucky River basin, such as Evans Mill and Elk Lick above Evans Mill, would be expected to have from three to eleven species of fish. Again, suckers, minnows, darters, and an occasional bass and/or sunfish would normally be found inhabiting these stream reaches. Since only the creek chub was found in Elk Lick above Evans Mill and in Evans Mill above the KAWC discharge, we assume the drought of 1988 has eliminated several fish species from these stream reaches. However, it would be reasonable to conclude that, under normal circumstances, the upper reaches would have been recolonized. The toxic discharge of KAWC has provided a barrier to upstream migration and recolonization of fish.

As noted earlier, station 22-3 did not support a fish fauna; however, creek chubs were found at adjacent sites (22-2 and 22-4). If 22-3 were not severely impacted by the KAWC discharge, it is reasonable to believe that the creek chub would also be found there.

In summary, the toxic discharge coming from KAWC has essentially eliminated the fish community in Evans Mill Branch from the discharge points downstream and in Elk Lick Creek from the confluence with Evans Mill to the mouth. Furthermore, this discharge has effectively formed a barrier against recolonization. Any impairment to the fish community arising from VMC operations could not be determined.

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APPENDIX A

LIST OF ORGANIC COMPOUNDS AND ASSOCIATED DETECTION LIMITS

LIST OF ORGANIC COMPOUNDS AND ASSOCIATED DETECTION LIMITS

Phenol
Aniline
Bis-(2-Chloroethyl) ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Benzyl Alcohol
1,2-Dichlorobenzene
2-Methylphenol
4-Methylphenol
Bis-(2-Chloroisopropyl) ether
N-Nitroso-di-n-propylamine
Hexachloroethane
Nitrobenzene
Isophorone
2-Nitrophenol
2,4-Dimethyphenol
Bis-(2-Chloroethoxy)methane
Benzoic Acid
1,2,4-Trichlorobenzene
Napthalene
4-Chloroaniline
1,1,2,3,4,4-Hexachloro-1,3-butadiene
4-Chloro-3-methylphenol
2-Methylnaphthalene
1,2,3,4,5,5-Hexachloro-1,3-cyclopentadiene
2,4,6-Trichlorophenol
2,4,5-Trichlorophenol
2-Chloronaphthalene
2-Nitroaniline
Dimethyl Phthalate
Acenaphthylene
2,6-Dinitrotoluene
3-Nitroaniline
Acenaphthene
2,4-Dinitrophenol
Dibenzofuran
2,4-Dinitrotoluene
Diethyl Phthalate
Fluorene
4-Chlorophenyl phenyl ether
4-Nitroaniline
2-Methyl-4,6-Dinitrophenol
N-Nitrosodiphenylamine
1,2-Diphenylhydrazine
4-Bromophenylphenylether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Anthracene
Dibutyl Phthalate
Fluoranthene
Benzidine
Pyrene
Butyl Benzyl Phthalate
3,3'-Dichlorobenzidine
Benzo(A)Anthracene
Chrysene
Bis(2-Ethylhexyl)Phthlate
Dioctylphthalate
Benzo(B)Fluoranthene
Benzo(K)Fluoranthene
Benzo(A)Pyrene
Indeno(1,2,3-C,D)Pyrene
Dibenzo(A,H)Anthracene
Benzo(G,H,I)Perylene

The detection limit for stations 22-1 and 22-4 for all organics except Benzoic Acid and 2,4-Dinitrophenol was 0.022 mg/l. The detection limit for the remaining two compounds at these two stations was 0.110 mg/l.

The detection limit for both samples at station 22-3 (labeled as 22-3 and 22-3A) for all organics except Benzoic Acid and 2,4-Dinitrophenol was 0.023 mg/l. The limit for the remaining two compounds at station 22-3 was 0.115 mg/l.