January 26, 1994 DRAFT

AQUATIC INVESTIGATION OF SCHRADER CREEK

INTRODUCTION

Schrader Creek was sampled on September 28 and 29, 1993 to assess the water quality and aquatic life prior to installation of devises for the treatment of acid mine drainage. The investigation was conducted by Jane Earle, Water Pollution Biologist, Bureau of Mining and Reclamation (BMR). Assisting in the investigation were Mike Wehr, Environmental Trainee, BMR, and Pam Milavec, Water Pollution Biologist, Bureau of Abandoned Mine Reclamation (BAMR).

BACKGROUND

Schrader Creek, a tributary of Towanda Creek, is located in a remote, forested portion of southwestern Bradford County, in the Allegheny Plateau Section of the Appalachian Plateau Province of northcentral Pennsylvania. About 60% of the watershed lies within State Game Lands.

The reader is referred to several previous reports by the Pennsylvania Fish Commission and the Bureau of Water Quality Management (see list of references) that detail the water quality conditions, land use and effects of mining on the Schrader Creek watershed. A brief summary is included here. Underground mining began in the Schrader Creek watershed in the 1820's. Coal reserves occupied only a small portion of the watershed; mining was confined to the northern tributary watersheds of Coal Run, Falls Creek, Long Valley Run and an area east of Long Valley Run on Cash and Lamoka Mountains. Underground mining was conducted at relatively shallow depths and numerous subsidence features, such as surface depressions and sinkholes, cause a hummocky appearance in the landscape. Some underground mines have interconnections between adjacent tributary watersheds. Degradation of Schrader Creek by acid mine drainage was first documented by the Pennsylvania Fish Commission (PFC) in the 1930's. A 1978 PFC investigation (Daniels, 1978) indicated little impact from mining in the lower section of Schrader Creek and recommended extending the downstream trout stocking limit to Bull Run. Three surface mining permits were issued to Jones and Brague Coal Co. in the late 1970's. Surface mining was conducted partly to in an attempt to remove the remaining coal pillars

Exhibit B

(daylighting) from the underground mines and improve water quality; however, water quality conditions appeared to have worsened after the surface mining (Hughey, 1984 and Daniels, 1984). In fact, trout stocking was discontinued in the lower portion of Schrader Creek after a major fish kill occurred in spring of 1983. An October 1983 aquatic investigation by the Bureau of Water Quality Management (BWQM) (Hughey, 1984) indicated that Schrader Creek was devoid of aquatic life downstream of Long Valley Run. A 1991 BWQM report (DER, 1991) to evaluate Schrader Creek's special protection status gave a summary of the water quality, land use and aquatic life of the watershed. This report recommended upgrading the Chapter 93 classification of Schrader Creek upstream of Coal Run to Exceptional Value (EV) and retaining the rest of the creek as HQ-CWF. BWQM water chemistry and macroinvertebrate samples collected in May 1989 were included in this 1991 report. Cram (1993) conducted an investigation of the acid loading and potential for treatment facilities in the Schrader Creek watershed.

Four major discharges carry acid mine drainage into Schrader Creek watershed. The Bureau of Abandoned Mine Reclamation plans to put passive treatment facilities at two discharges (#5 and #6) which flow into Falls Creek and an unnamed tributary to Long Valley Run. The Bureau of Mining and Reclamation plans to have an injection well treatment device installed near the mouth of Falls Creek if suitable stream flow is available for proper function of the well.

METHODS

Six locations on Schrader Creek and four tributaries were sampled in September 1993 to assess water quality conditions (Figure 1). Station codes names for Schrader Creek used in this report are the same as those used by the Bureau of Water Quality Management and refer to the river mile upstream of the mouth. In most instances station locations coincided with those sampled by BWQM in 1983. Several days of rain the week prior to this investigation caused high flow conditions which made sampling difficult.

Water chemistry samples were collected at all locations by grab method using one 500-ml bottle and two 125-ml bottles for metals analysis, one of which was filtered for dissolved metals analyses. Metals samples were fixed with nitric acid in the field. Pam Milavec (BAMR) collected water samples from the major acid discharges on September 28, 1993. Water chemistry samples collected during low flow conditions in July 1993 by Cory Cram, student intern with the BMR Hawk Run District Office were included in this report.

Macroinvertebrates were sampled at nine locations. A kick screen was used in tributaries. A D-frame net was used in Schrader Creek because high flow conditions made the water too deep to use a kick screen. Riffle areas in Schrader Creek were difficult to sample even with the D-frame net; therefore, invertebrate samples from main stem Schrader Creek should not be considered as representative of the entire macroinvertebrate fauna. Sampling did, however, capture a variety of organisms and do reflect general water quality conditions. Because of high flows and poor collection conditions, no attempt was made to quantify macroinvertebrate data. Fish were not sampled due to high water conditions. Results of this investigation are presented in Tables 1, 2 and 3. Comparisons were made between present water aquatic conditions and aquatic life and those of the previous BWQM and PFC investigations.

RESULTS

Schrader Creek upstream of mined areas (SCH12)

Schrader Creek was sampled upstream of Carbon Run to describe conditions upstream of the influence of mining. September 1993 water quality results indicated a pH of 6.4, alkalinity of 10 mg/l, sulfate less than 20 mg/l and all metals concentrations less than 0.2 mg/l. A total of 13 macroinvertebrate taxa were collected, including six genera of mayflies. The presence of these mayflies indicates that the pH is likely greater than 6.0 throughout the year. Mayflies are very sensitive to acid conditions and most of these taxa would be eliminated even if episodic slugs of acidity occurred. One species of the relatively acid sensitive *Hydropsyche* caddisflies was also collected. Hughey (1984) collected a diverse invertebrate fauna consisting of 32 taxa and numerous mayflies, stoneflies and caddisflies. A total of eighteen macroinvertebrate taxa were collected by BWQM in May 1989. A native brook trout population was documented by Hughey in 1983. This location was not sampled in July 1993.

Carbon Run (CAR)

Carbon Run carries the first source of mining related acidity into Schrader Creek. Carbon Run has two discharges, #11 and #16, which result from cuts made into underground mine shafts to allow drainage of water when the mines were in use. In September, the pH of Carbon Run at the mouth was 4.9, the alkalinity was 9 mg/l and all total metals concentrations were less than 0.38 mg/l. July data showed similar water quality conditions. Macroinvertebrates reflect the weakly acidic conditions by the presence of 11 taxa, including one mayfly genus, the somewhat acid tolerant *Eurylophella*, and dominance by acid tolerant stoneflies and caddisflies.

Schrader Creek downstream of Carbon Run (SCH12A)

This location was sampled only in July 1993. Water quality results showed that the pH in Schrader Creek was 5.6 downstream of Carbon Run and total metals concentrations were less than detection limits.

Coal Run (COR)

Coal Run receives one underground mine discharge #8, known as the "Bubble-up" discharge, a mine blow-out spring that first appeared in the 1950's. Discharge #8 had a pH of 4.3, total manganese of 0.46 mg/l and total aluminum of 1.37 mg/l in September 1993. Coal Run also comes in contact with a large "Red Dog" refuse pile. Coal Run had a pH of 5.0, alkalinity of 9 mg/l, acidity of 7.2 mg/l, total iron 0.49 mg/l, total manganese of 0.57 mg/l and aluminum concentration of 0.75 mg/l. Similar water quality conditions were recorded during July, although metals concentrations were lower (iron less than 0.01 mg/l, manganese, 0.27 mg/l and aluminum, 0.40 mg/l. Ten taxa of macroinvertebrates were collected from Coal Run. The most common taxa were acid tolerant stoneflies.

Schrader Creek downstream of Coal Run (SCH09)

Water quality data in September showed a pH of 6.3, alkalinity of 11 mg/l and higher total metals concentrations than upstream at SCH12 (iron 0.75 mg/l and manganese 0.64 mg/l). The pH was 6.0 in July and metals concentrations were all less than detection limits. Macroinvertebrates were similar to those at SCH12, with a total of 11 taxa and 4 taxa of mayflies. One acid intolerant stonefly, *Isogenoides* and two *Hydropsyche* species were present. Hughey collected 22 taxa of macroinvertebrates in 1983, with many mayflies, stoneflies and caddisflies. He stated, however, that total fish species and numbers were lower than upstream. BWQM collected 13 taxa of macroinvertebrates at this location in May 1989.

Falls Creek

Falls Creek is the major source of acid mine drainage to Schrader Creek. Discharge #6, which drains mines west of Falls Creek as well as a larger regional area, contributes the highest acid loading to the watershed and provides most of the flow for Falls Creek except during high rainfall. In September 1993, discharge #6 had a pH of 3.4, total manganese 27.5 mg/l and total aluminum 16.5 mg/l.

In September, the pH at the mouth of Falls Creek was 3.6, alkalinity 0 mg/l and acidity 42 mg/l. Metals concentrations were also elevated: total iron was 1.27 mg/l, total manganese 3.15 mg/l and total aluminum 4.2 mg/l. Water quality was slightly worse in July, when the pH was 3.3, total manganese 8.5 mg/l and total aluminum 14.1 mg/l. Only four taxa of macroinvertebrates were present. The acid tolerant alderfly, *Sialis* and midge fly larvae, Chironomids, were the dominant taxa. One individual stonefly, *Peltoperla*, and one caddisfly, *Ptilostomis*, were the only other macroinvertebrates collected. Water quality conditions appeared to have been worse in October 1983, when a water sample collected by Hughey had a pH of 2.8 and total aluminum of 28.6 mg/l.

Schrader Creek downstream of Falls Creek (SCH08 and SCH08A) and upstream of Long Valley Run (SCH07)

Water quality data collected in July 1993 indicated that Falls Creek was causing a further lowering of the pH of Schrader Creek. The pH immediately downstream of Falls Creek (SCH08) was 5.4 and metals concentrations were elevated over upstream values (total manganese 0.24 mg/l and total aluminum 0.34 mg/l). Schrader Creek was also sampled 1/4 mile downstream of Falls Creek in July (SCH08A); metals concentrations were similar to those upstream, but the pH was higher (5.7).

Water quality samples were also collected about 25 feet upstream of Long Valley Run (SCH07) in July and September 1993. In July, the pH was 5.7 and acidity 4.2 mg/l. In September, however, the higher flow conditions in Schrader Creek were negating the effects of Falls Creek, since the pH in Schrader Creek was 6.3 and all metals concentrations were less than 0.2 mg/l. Hughey (1984) and Cram (1993) stated that aluminum precipitate was present in Schrader Creek downstream of Falls Creek; however, no aluminum precipitate was visible during the September high water conditions. Only four taxa of macroinvertebrates were collected at SCH07 in September 1993. One genus of mayfly, *Habrophlebiodes*, and two species of *Hydropsyche* were present.

Long Valley Run (LVR)

Long Valley Run receives acid mine drainage from several sources. The majority of the acid flow enters a western unnamed tributary from discharge #5, an underground mine discharge located on the toe spoil of the Jones and Brague surface mine. In September 1993, discharge #5 had pH of 4.2, iron 8.8 mg/l, manganese 17.8 mg/l and aluminum 2.46 mg/l. A second discharge, #4, flows from the east side of the toe of spoil of Jones and Brague SMP#0879101 and enters main stem Long Valley Run. In September 1993, discharge #4 had a pH of 3.6, total manganese 19.7 mg/l and total aluminum 6.5 mg/l.

In September the pH near the mouth of Long Valley Run was 4.5, acidity 15.4 mg/l, total manganese 3.16 mg/l and total aluminum 0.35 mg/l. Water quality was worse in July when the pH was 3.9, acidity 36 mg/l, total manganese 3.96 mg/l and total aluminum 3.78 mg/l. Nine taxa of macroinvertebrates were present; no mayflies were collected. The fauna was dominated by acid tolerant stoneflies, caddisflies and dipterans.

Schrader Creek downstream of Long Valley Run (SCH07A)

This location was sampled only in July 1993. The pH was 4.3, acidity 4.6, total iron less than 0.01 mg/l, total manganese 0.21 mg/l and total aluminum less than 0.13 mg/l. Metals concentrations in Schrader Creek were surprisingly low, considering the elevated metals concentrations in Long Valley Run.

Schrader Creek upstream of Bull Run, 2 miles downstream of Long Valley Run, (SCH04)

This location was sampled in September 1993 to assess the effects of Long Valley Run farther downstream in Schrader Creek. The pH was 6.3 and concentrations of all metals were less than 0.25 mg/l. The September 1993 pH measurement, however, may be an anomaly resulting from high flow conditions, since a pH of 5.0 was recorded at this location in May 1989 and a sample collected in Schrader Creek downstream of the near-neutral pH tributary Bull Run (SCH04A) had a pH of only 5.8 in July 1993.

Only seven taxa of macroinvertebrates were captured at SCH04; however, high flow and lack of suitable riffles likely affected sampling efficiency. No mayflies or stoneflies were collected. Several species of the normally acid sensitive caddisfly genus *Hydropsyche* were present. Hughey found no macroinvertebrates or fish at this location in 1983. He stated that aquatic life may have been affected by elevated aluminum and acid slugs. Wash-outs of aluminum precipitate from upstream could also adversely affect aquatic life. The only macroinvertebrate collected at this location in May 1989 was the acid tolerant stonefly *Leuctra*. Additional seasonal collections of water and macroinvertebrate samples could clear up the confusion over current water quality at this location.

Bull Run (BULL)

Bull Run is a small unaffected tributary of Schrader Creek. The pH was 6.6 in July 1993 and metals concentrations were all less than 0.18 mg/l. This location was not sampled in September.

Schrader Creek upstream of Millstone Creek (SCH02) and at the village of Powell (SCH01)

September 1993 samples at SCH02 indicated a further dilution of mine drainage parameters compared to upstream. The pH was 6.3 and total metals concentrations were all less than 0.21 mg/l. Millstone Creek is the largest tributary of Schrader Creek and adds considerable dilution of acidity in Schrader Creek. Water quality parameters at SCH01 were similar to those at SCH02; the only difference being slightly lower concentrations of manganese (0.10 mg/l) and aluminum (less than 0.13 mg/l). A total of 8 taxa of macroinvertebrates were present at SCH01, including 3 species of mayflies.

SUMMARY

Water chemistry data collected in July 1993 and macroinvertebrates collected in September 1993 indicate that Schrader Creek is degraded by acid water entering from Falls Creek and Long Valley Run and that Coal Run and Carbon Run also contribute acidity to Schrader Creek. Water quality conditions appear to have improved in Schrader Creek downstream of Falls Creek based on a comparison of the aquatic communities described by Hughey for his 1983 investigation and those of this 1993 investigation.

Schrader Creek appears to have some buffering capacity available downstream of Falls Creek. In July 1993, the pH in Schrader Creek dropped from 6.0 downstream of Coal Run to 5.4 just downstream of Falls Creek; but the pH rose to 5.7 at 1/4 mile downstream of Falls Creek. The entry of Long Valley Run, however, caused an additional depletion of buffering capacity, as the pH dropped to 4.3 in Schrader Creek downstream of Long Valley Run in July 1993. Treatment may have to be also placed on Long Valley Run if the rise in pH and alkalinity after treatment in Falls Creek is not sufficient to counteract the alkalinity depletion caused by Long Valley Run.

Falls Creek contributes the major acid loading to Schrader Creek. Cram's calculations for two flow measurement dates in July 1993 indicated that Falls Creek contributed 70 to 79% of the total acid load to Schrader Creek; Long Valley Run contributed 15 to 21%; Coal Run, 4.8 to 6.3% and Carbon Run, 0.4 to 1.6%. Cram measured a flow of 68 gpm in Falls Creek and a flow of 2445 gpm in Schrader Creek upstream of Falls Creek. Based on these loading calculations, abatement of Falls Creek acidity should have a significant positive effect on Schrader Creek. A combination of anoxic drains at the discharges and injection wells downstream on Falls Creek was suggested as the best solution by Cram. Low summer flows at the mouth of Falls Creek, however, may limit the effectiveness of injection wells. Precipitation and settling of metals by BAMR treatment facilities near the underground mine discharges should also help keep metals precipitates from washing downstream into Schrader Creek during high rainfall.

The more alkaline material that can be added, the better Schrader Creek would be able to handle any rainfall induced acidity or acid slugs. Treatment facilities should be able to work properly with only minimal break downs to ensure that water quality conditions remain relatively constant. If water quality fluctuates, especially if the pH becomes lower than 5.5 during the critical spring stocking season, stocked trout may not survive and macroinvertebrate numbers and taxa richness will be greatly reduced.

I believe that treatment facilities have an excellent chance of success in Schrader Creek watershed. The major acid loading is concentrated in one tributary, Falls Creek and, although all the affected tributaries have low pH and elevated metals concentrations, the pH in Schrader Creek is in the mid to upper 5.0's and metals concentrations in Schrader Creek are relatively low. Iron concentrations are especially low for acid mine drainage affected waters. Water quality conditions in Schrader Creek are more like those of a stream affected by acid precipitation, with the combination of low pH and elevated aluminum concentrations the major limiting factors. The aluminum precipitate in Schrader Creek downstream of Falls Creek during low to normal flow conditions could be a problem and could continue to cause adverse conditions for macroinvertebrate colonization and fish mortality after treatment unless the pH is raised above 6.0, the approximate pH above which aluminum compounds become soluble and less toxic. Increased calcium concentrations expected in Schrader Creek as a result of the limestone treatment wells, however, would help reduce mortality and sublethal effects of low pH and aluminum on fish (Brown and Sadler, 1989).

REFERENCES

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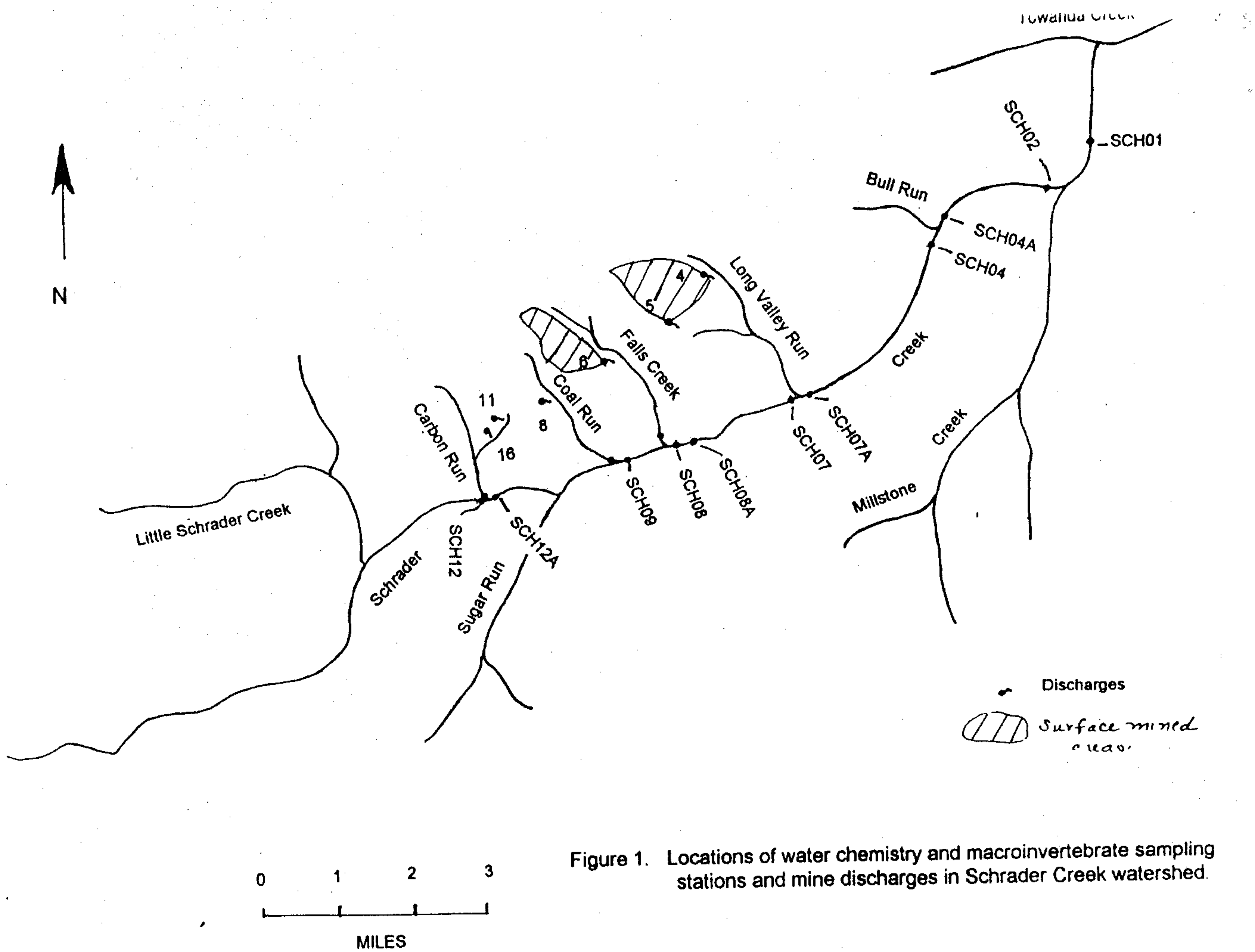

Figure 1. Locations of water chemistry and macroinvertebrate sampling stations and mine discharges in Schrader Creek watershed.

TABLE 1. CHEMISTRY DATA FOR SCHRADER CREEK WATERSHED, SEPTEMBER 28-29, 1993.

	SCH CK UP CARB	CARBON RN	COAL RN	SCH CK DN COAL	FALLS CK	SCH CK UP LON V	LONG VAL RN	SCH CK UP BULL	SCH CK UP MILL	SCH CK POWELL
CODE	SCH12	CAR	COR	SCH09	FAL	SCH07	LVR	SCH04	SCH02	SCH01
COLL NO.	4021001	4021002	4021003	4021008	4021004	4021007	4021006	4021005	4021010	4021009
SC	34	44	91	39	311	43	297	46	46	46
pH FIELD	6.4	4.9	5.0	6.0	3.6	6.0	4.5	6.0	6.5	6.5
pH LAB	6.5	5.0	5.0	6.3	3.6	6.3	4.6	6.3	6.3	6.4
T ALK	10	9	9	11	0	11	8	11	11	11
T ACID	0	4.8	7.2	1.8	42	1.4	15.4	4.4	4	1
T SS	14	12	10	4	8	<2	10	8	14	8
TDS	28	38	62	40	210	46	236	44	26	28
T Ca	3.6	2.3	7.6	3.9	13.0	4.1	0.3	4.5	4.4	4.3
D Ca	3.0	1.3	6.5	3.9	12.0	4.0	0.3	4.5	4.4	4.3
T Mg	0.8	1.0	3.6	1.0	8.5	1.2	0.1	1.4	1.3	1.3
D Mg	0.7	0.5	3.1	1.0	7.7	1.1	0.1	1.4	1.3	1.3
T Na	3.3	0.5	0.9	0.7	1.3	0.8	1.6	0.7	0.7	0.8
D Na	0.8	0.4	0.8	0.7	1.0	0.8	1.5	0.7	0.7	0.8
T K	1.1	0.7	1.3	0.9	1.5	1.0	1.5	0.5	1.3	1.1
D K	1.1	0.6	1.2	0.8	1.2	1.0	1.5	0.5	1.0	1.1
Cl	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
T SO4	< 20	< 20	25	< 20	66	< 20	115	< 20	< 20	< 20
T Fe	0.13	0.22	0.49	0.75	1.27	0.09	0.06	0.12	0.11	0.11
D Fe	0.10	0.10	0.11	0.40	1.19	0.04	0.02	0.05	0.05	0.04
T Mn	0.11	0.13	0.57	0.64	3.15	0.11	3.16	0.16	0.11	0.10
DMn	0.11	0.07	0.39	0.58	2.84	0.09	3.10	0.15	0.10	0.09
T Al	0.20	0.38	0.75	0.18	4.20	0.24	2.00	0.25	0.21	0.17
D Al	0.13	< 0.13	0.65	0.17	3.65	0.17	1.99	0.19	0.18	< 0.13
T Zn	0.04	0.16	0.22	0.03	0.26	0.03	0.35	0.04	0.03	0.03
D Zn	0.03	0.07	0.21	0.03	0.22	0.03	0.33	0.04	0.03	0.03

TABLE 2. CHEMISTRY DATA SCHRADER CREEK, JULY 6, 1993.

STATION	CARBON RN	SCH CK DN CARB	COAL RN MOUTH	SCH CK DN COAL	FALLS CK MOUTH	SCH CK DN FALLS	SCH CK 1/4 MI DN	SCH CK UP LONV	LONG V R MOUTH	SCH CK DN LVR	BULL RN MOUTH	SCH CK DN BULL
CODE	CAR	SCH12A	COR	SCH09	FAL	SCH08	SCH08A	SCH07	LVR	SCH07A	BUL	SCH04A
SC	42	39	100	43	730	60	62	69	524	77	126	69
pH LAB	4.8	5.6	4.4	6.0	3.3	5.4	5.7	5.7	3.9	4.3	6.6	5.8
T ALK	12	18	9	16	0	14	11	14	4	12	54	12
T ACID	3.6	6.2	8.6	0	126	4.2	5.4	4.2	36	4.6	0	4.2
TSS	< 2	10	19	6	22	6	6	8	22	16	20	8
TDS	32	13	21	14	574	22	20	30	372	16	42	12
Ca	2.4	3.3	5.8	3.7	29.1	4.4	4.6	4.5	39.7	5.6	14.2	5.5
Mg	0.9	0.8	2.7	0.7	23.9	1.6	1.7	1.5	20.7	2.2	3.2	1.9
Na	0.5	0.7	0.8	0.7	1.2	0.7	0.8	0.8	2	0.8	4.2	1.1
K	0.7	0.5	1	< 0.5	1.1	0.6	0.8	0.7	1.9	0.6	1.2	0.9
Cl	< 1	1	< 1	1	< 1	1	1	1	< 1	2	1	1
SO4	10	14	34	21	274	25	31	23	228	29	< 10	22
T Fe	0.03	< 0.01	< 0.01	< 0.01	1.52	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.18	0.09
T Mn	0.28	< 0.01	0.27	< 0.01	8.50	0.24	0.24	0.09	3.96	0.21	< 0.01	0.07
T Al	< 0.13	< 0.13	0.40	< 0.13	14.10	0.34	0.35	< 0.13	3.78	< 0.13	0.17	< 0.13
T Zn	0.11	< 0.01	0.22	< 0.01	0.67	0.02	0.02	< 0.01	0.45	0.02	< 0.01	0.08

TABLE 3. MACROINVEREBRATE DATA FOR SCHRADER CREEK WATERSHED, SEPTEMBER 28-29, 1993

	SCH12	CARB RN	COAL RN	SCHO9	FALLS CK	SCH07	LONG VALL	SCH04	SCH01
MAYFLIES									
Stenacron	X	-	-	X	-	-	-	-	X
Stenonema	X	-	-	X	-	-	-	-	-
Isonychia	X	-	-	X	-	-	-	-	X
Baetisca	X	-	-	-	-	-	-	-	-
Ephemera	X	-	-	-	-	-	-	-	-
Habrophlebiodes	X	-	-	X	-	X	-	-	-
Eurylophella	-	X	-	-	-	-	-	-	-
Baetis	-	-	-	-	-	-	-	-	X
DRAGONFLIES									
Erpetogomphus	-	-	-	-	-	-	-	X	-
Boyeria	-	X	-	-	-	-	-	-	-
Lanthus	-	-	-	X	-	-	-	-	-
STONEFLIES									
Paracapnia	-	-	-	-	-	-	X	-	-
Leuctra	-	C	X	-	-	-	X	-	-
Peltoperla	-	-	X	-	X	-	-	-	-
Tallaperla	-	X	-	-	-	-	-	-	-
Acroneuria	X	-	X	-	-	-	-	-	-
Agnetina	-	-	-	-	-	-	-	-	X
Isoperla	-	-	C	-	-	-	-	-	-
Isogenoides	-	-	-	X	-	-	-	-	-
CADDISFLIES									
Diplectrona modesta	-	-	X	-	-	-	X	-	-
Hydropsyche sparna	-	-	-	-	-	X	-	X	-
H. bifida gp	-	-	-	-	-	-	-	X	-
H. slossonae	X	-	-	X	-	-	-	-	-
H. morosa	-	-	-	-	-	X	-	X	X
H. alhedra	-	-	-	X	-	-	-	-	-
H. sp.	-	-	-	-	-	-	-	-	X
Parapsyche	-	-	X	-	-	-	-	-	-
Homoplectra	-	-	-	-	-	-	X	-	-
Chimarra	-	-	-	-	-	-	-	-	X
Dolophiloides	X	-	-	-	-	X	-	-	-
Rhyacophila pupa	-	X	-	-	-	-	-	-	-
Polycentropus	-	X	-	-	-	-	-	-	-
Lepidostoma	-	-	-	-	-	-	-	X	-
Pycnopsyche	-	-	-	-	-	-	-	X	-
Ptilostomis	-	-	-	-	X	-	-	-	-
Palaeagapetus	-	-	-	-	-	-	X	-	-
ALDER/FISHFLIES									
Nigronia	X	-	X	X	-	-	-	X	X
Sialis	-	X	-	-	X	-	X	-	-
TRUE FLIES	-	-	-	-	-	-	-	-	-
Chironomidae	X	X	X	X	X	-	X	-	-
Tipula	X	-	X	-	-	-	X	-	-
Hexatoma	-	-	-	X	-	-	-	-	-
MISC. TAXA									
Oligochaeta	-	X	-	-	-	-	X	-	-
Cambaridae	X	X	X	-	-	-	-	-	-
Hyalella	-	X	-	-	-	-	-	-	-
TOTAL TAXA	13	11	10	11	4	4	9	7	8
pH	6.4	4.9	5.0	6.0	3.6	6.0	4.5	6.0	6.5

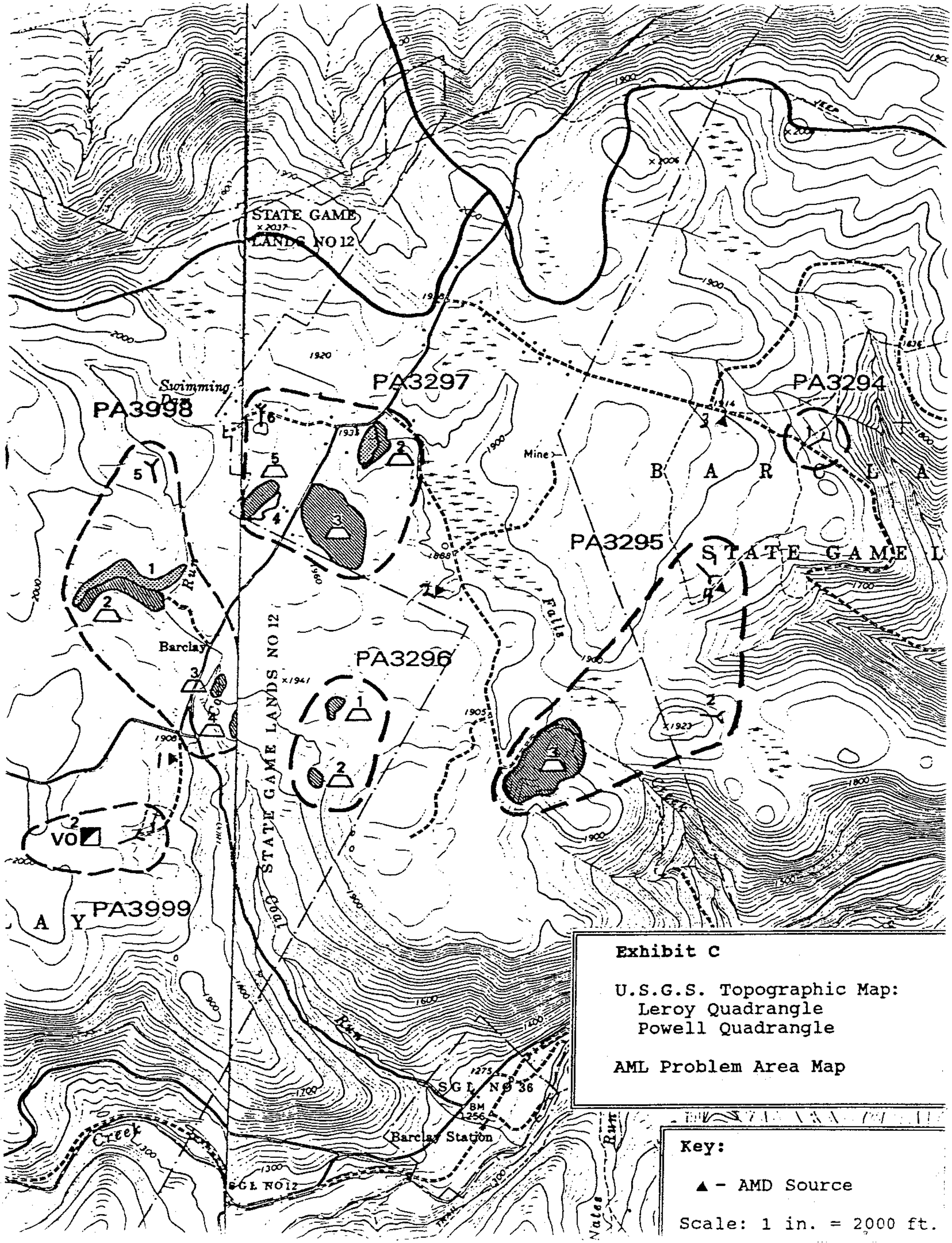

Exhibit C

U.S.G.S. Topographic Map:
Leroy Quadrangle
Powell Quadrangle

AML Problem Area Map

Key:

▲ - AMD Source

Scale: 1 in. = 2000 ft.

SOURCES OF ACID MINE DRAINAGE

No.	DESCRIPTION	FLOW (gpm)	pH	TOTAL Fe (mg/l)	FERROUS Fe (mg/l)	Mn (mg/l)	Al (mg/l)	TOTAL ALKA. (mg/l)	TOTAL ACID (mg/l)
1	Bubble Up	150->1000	4.4	.147	.026	.386	1.18	0	17
2	Falls Ck. DM Discharge	150-750	3.3	4.36	3.25	13.96	20.80	0	164
3	Long Valley SM Discharge	5-100	3.6	.602	.420	22.24	9.41	0	98
4	Long Valley DM Discharge	60-100	4.2	7.79	7.42	18.56	2.70	0	56

(above lab results are averages of samples taken 9/28, 10/14, 10/26, 11/10, & 11/26/93)

EXHIBIT D