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Environmental Control Technology Survey of Selected U. S. Strip Mining Sites Volume 2A: Ohio

Water Quality Impacts and Overburden Chemistry of Ohio Study Site

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ENVIRONMENTAL CONTROL TECHNOLOGY SURVEY OF SELECTED U.S. STRIP MINING SITES

Volume 2A: OHIO

Water Quality Impacts and Overburden Chemistry of Ohio Study Site

by

Jean E. Bogner, John D. Henricks, Richard D. Olsen,*
Jeffrey P. Schubert, Andrew A. Sobek, Michael L. Wilkey,
and Donald O. Johnson

Energy and Environmental Systems Division

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FOREWORD

The Argonne National Laboratory (ANL) program entitled "Environmental Control Technology Survey of Selected U.S. Strip Mining Sites" is being funded by the U.S. Department of Energy (DOE). The program was established in 1975 by an interagency agreement between the DOE's precursor -- the U.S. Energy Research and Development Administration -- and the U.S. Environmental Protection Agency (EPA).

This program has a twofold purpose which is related in part to the interests of its two federal sponsors. The overall issue addressed by both sponsors is the need to satisfy increased coal demand in an environmentally acceptable manner. Each sponsor, however, has particular interests: DOE is interested in the efficacy and practicability of control options currently in use for aqueous effluents, an identification of control technology problems and needs, and recommendations for research in these areas; the EPA is interested in an assessment of the validity of its effluent limitations guidelines and new source performance standards for the coal mining industry, with this assessment emphasizing seasonal and climatic variation impacts on effluent quantity and quality. A program plan was outlined to: (1) project future coal production levels for each state to the year 2000 as a basis for selection of case study sites; (2) gather data on effluent volumes and characteristics at surface mine case-study sites; (3) examine the efficacy and economics of current effluent-control systems (treatment facilities and settling ponds); (4) assess the validity of the effluent guidelines; and (5) evaluate potential water quality impacts related to increased surface mining.

Summaries of the program's various aspects are being published in a multi-volume set. Volume 1 contains the project rationale and a discussion of case-study site selection. Volume 2 is a series of reports in which water quality data gathered at the case-study sites are analyzed in terms of potential local impacts. In Volume 3, the efficacy and economics of the various types of control technologies are examined, along with physical and chemical characteristics of treatment waste products. Volume 4 contains an assessment of the EPA effluent limitations guidelines (and those of the U.S. Dept. of Interior, Office of Surface Mining) for the coal mining industry relative to the data collected under this program. Thus, the entire set of reports examines the efficacy of various control technology options and assesses the potential environmental impacts related to increased surface mining based on detailed case-study site data.

PROGRAM STAFF

From its inception the program has been managed by Donald O. Johnson.

The following staff members at ANL were responsible for specific sections of the Ohio report:

John Henricks:	General description of mine area, mining operation, general geology, and soils.
Jean Bogner:	Overburden and coal geochemistry.
Andrew Sobek:	Acid-base account and water-quality considerations related to overburden chemistry.
Richard Olsen:	Quality control for consultant data; environmental effects.
Jeffrey Schubert:	Hydrology and water quality.
Jean Bogner and Michael L. Wilkey:	Control technology.

ACKNOWLEDGMENTS

We would like to thank those individuals and organizations whose cooperation, assistance, and advice have been helpful in the preparation of this report.

Water and overburden sampling and analyses were performed under the direction of Dr. Robert G. Corbett of the Department of Geology, The University of Akron (Akron, Ohio), while under subcontract to Argonne National Laboratory. Dr. Corbett was assisted by Barbara M. Manner, Research Associate. This report utilizes analytical data and background, descriptive, and explanatory material obtained from the subcontractor's final report (Corbett and Manner, 1977). While their work forms the basis for the present report, Argonne accepts sole responsibility for the conclusions and interpretations contained herein.

We are grateful to Dr. Robert W. Doehler of Northeastern Illinois University for determining semi-quantitative mineralogy of overburden samples by X-ray diffraction. Dr. Doehler was a visiting professor at Argonne during the academic year 1977-1978 and was an integral part of the project team. We also wish to acknowledge the assistance of Mr. Neal Tostenson, Executive Vice-President of the Ohio Mining and Reclamation Association (OMRA), for information regarding the soda-ash treatment facilities maintained at this site and other sites by OMRA.

We also wish to thank the National Coal Association and its Water Quality Committee for guidance during the formation of the study and for their aid in securing the cooperation of the participating coal company. The company's cooperation and the assistance of key personnel have been acknowledged in a letter to the company's corporate office.

Special thanks are due to John Reiter for his efforts in data organization, computer storage, and retrievals; he was assisted by Madeline Antos, James McIntyre, and Janice Russell. Valuable editorial assistance was provided by Charles Malefyt and Priscilla Grundy.

This report was reviewed by representatives of the U.S. Environmental Protection Agency, The National Coal Association, and the participating coal company.

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ABSTRACT

As part of a program to examine the ability of existing control technologies to meet federal guidelines for the quality of aqueous effluents from coal mines, an intensive study of water, overburden, and coal chemistry was conducted at a large surface mine in Ohio from May 1976 through July 1977. Sampling sites were chosen to include the final mine effluent at the outflow of a large settling pond and chemically-treated drainage from a coal storage pile. Samples were collected semimonthly and analyzed for total dissolved solids, total suspended solids, alkalinity, acidity, sulfate, chloride, and 16 metals. Field measurements included pH, flow rate, dissolved oxygen, and specific conductance. The final effluent, where sampled, generally complied with Office of Surface Mining reclamation standards for pH, iron, and total suspended solids. Comparison of the final effluent with water quality of an unnamed tributary above the mine suggested that elevated values for specific conductance, total dissolved solids, sulfate, calcium, magnesium, manganese, and zinc were attributable to the mine operation. In general, there were observable seasonal variations in flow rates that correlated positively to suspended solids concentrations and negatively to concentrations of dissolved constituents in the final effluent. Drainage from the coal storage pile contained elevated levels of acidity and dissolved metals which were not reduced significantly by the soda ash treatment. The storage pile drainage was diluted, however, by large volumes of alkaline water in the settling pond. Analysis of overburden and coal indicated that the major impact on mine drainage was pyrite oxidation and hydrolysis in the Middle Kittanning Coal and in the Lower Freeport Shale overlying the coal. However, the presence of a calcite-cemented section in the Upper Freeport Sandstone contributed substantial self-neutralizing capacity to the overburden section, resulting in generally alkaline drainage at this site.

1 LOCATION AND DESCRIPTION OF THE MINE AND SURROUNDING AREA

1.1 GENERAL DESCRIPTION OF MINE AREA AND LOCAL COAL PRODUCTION

Mine OH-1 is a surface coal mine located in east central Ohio (Fig. 1). The mine occupies parts of two counties (here identified as County 1 and County 2). The coal is mined by modified contour methods, annual production (1975) is approximately 800,000 short tons (725,000 metric tons) (Keystone Coal Industry Manual, 1977). Coal is stored on the site in an open pile and is transported by conveyor to a central loading facility.

The main industries in the mine area are agriculture and coal mining. The broad flood plains of the local river valleys (including the Muskingum, Tuscarawas, Walhonding, and Killbuck) are well adapted to crop production, while the rolling uplands are utilized for croplands and grazing. Coal mining is concentrated where the Middle Kittanning Coal (#6) is thickest and most continuous (Lamborn, 1954). Surface coal reserves of the Middle Kittanning in the two-county area total about 280 million short tons (254 million metric tons).

Surface coal production in 1975 from other mines in the two counties is shown in Table 1.

Table 1. 1975 Coal Production in Counties 1 and 2 (excluding Mine OH-1)

	County 1	County 2
Number of mines producing from Middle Kittanning (#6)	8	10
Surface production from Middle Kittanning seam	1,250,000 short tons (1,125,000 metric tons)	465,000 short tons (420,000 metric tons)
Number of mines mining other seams	4	3
Surface production from other seams	335,000 short tons (300,000 metric tons)	215,000 tons (195,000 metric tons)

SOURCE: Keystone Coal Industry Manual (1947).

1.2 PHYSIOGRAPHY, TOPOGRAPHY, AND CLIMATE

Mine OH-1 is located in the unglaciated part of the Allegheny Plateau, about 25 mi (40 km) east of the glacial boundary (Corbett and Manner, 1977). Much of the land surface in this area consists of sloping hillsides with deeply incised valleys. Flatlands are restricted to flood plains and

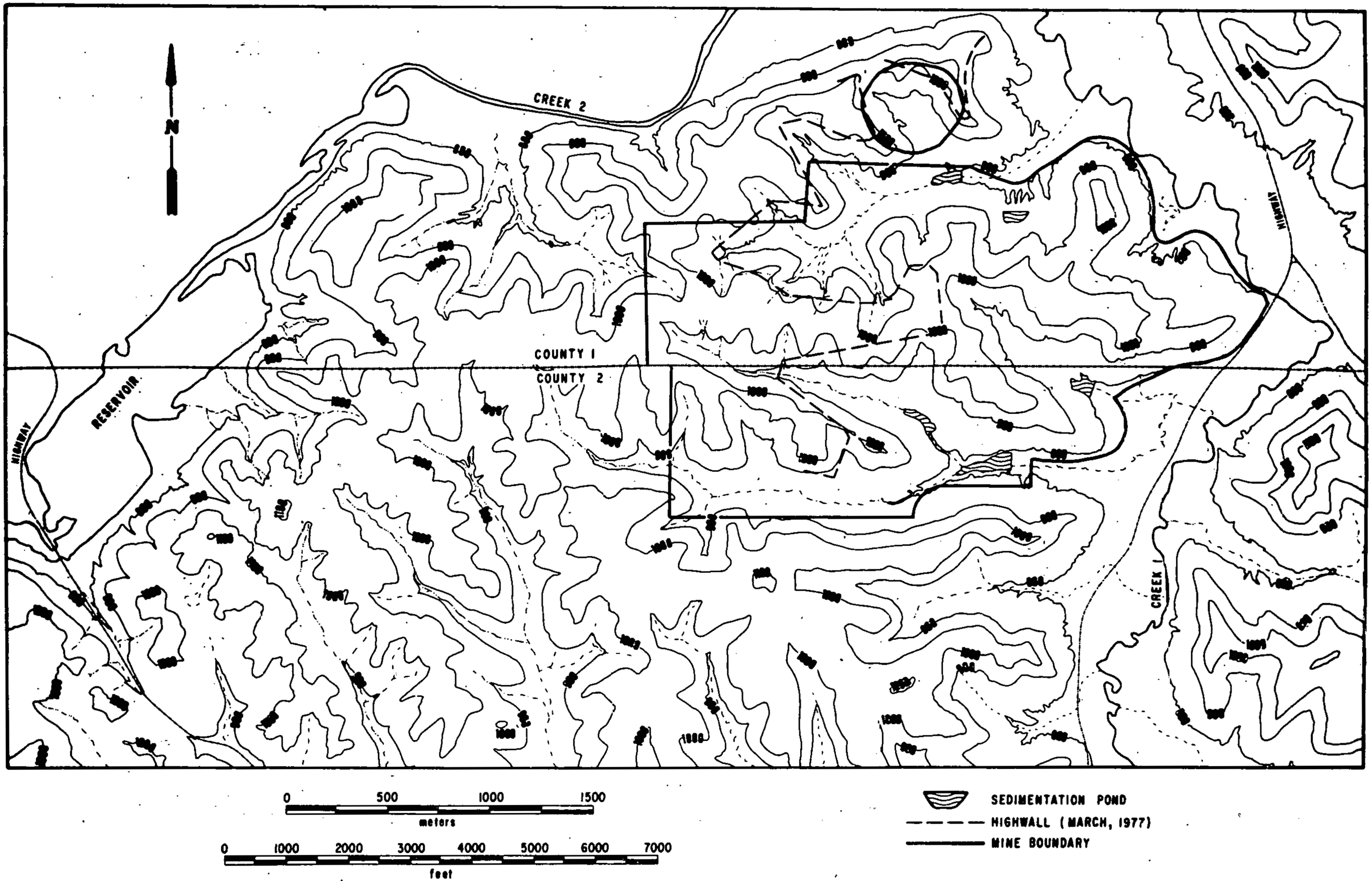

Fig. 1. Topographic Map of Mine OH-1 and Surrounding Area

terraces of the larger river valleys and the lower courses of their major tributaries (Lamborn, 1954). Both counties are entirely drained by the Muskingum River; Creek 1, the only well-developed tributary, borders the mine property on the east. Maximum relief for County 1 is 580 ft (177 m). On the mine site, relief is about 300 ft (91 m) between the stream valley elevations about 780 ft (238 m) and the sandstone-capped ridges up to 1080 ft (329 m) above sea level.

The topography of the mine area reflects the processes of stream erosion and the influence of Pleistocene glaciation. The main effect of this glaciation was the introduction of enormous amounts of outwash sediments carried by glacial meltwater; these sediments blocked pre-existing drainage lines and rerouted drainage in the eastern unglaciated areas of the two counties (Lamborn, 1954).

At present, most drainage from the mine flows into an unnamed eastward-flowing tributary of Creek 1 which flows north into Creek 2. Discharge from Creek 2 flows into the Muskingum River which, in turn, flows into the Ohio River at Marietta, Ohio. Some mine drainage also flows east and north directly into the Creek 2. The Creek 2 drainage basin occupies 815 square mi (2111 sq km) (Corbett and Manner, 1977).

The region that includes the mine has a humid continental climate, characterized by cold winters and warm summers. The average annual precipitation is about 40 in. (1 m); measured snowfall averages 30 in. (0.8 m) (Corbett and Manner, 1977).

1.3 GENERAL GEOLOGY AND SOILS

The rocks that outcrop in the OH-1 mine area are entirely in the Pennsylvanian system. In County 1 the Pennsylvanian Pottsville, Allegheny, and the lower 170 ft (52 m) of the Conemaugh Series are present at the surface. The Pottsville strata outcrop in the western part of the county and in the valleys of the central and eastern part of the county; the Conemaugh strata outcrop at higher elevations in the central and eastern part of the county. The nearest Mississippian rocks outcrop in the western part of the County 1 and consist of interbedded sandstones and shales; no Mississippian limestones are present in County 1 (Lamborn, 1954).

Bedrock in County 1 dips 20 to 60 ft per mi (3.8 to 11.4 m per km) to the south and east (Brant and Delong, 1960). In County 2 the entire Pennsylvanian section outcrops above drainage due to the north-south trending Parkersburg-Lorain syncline, which gives an unusually steep eastward dip to the strata. As in County 1, the older units outcrop to the southeast (Brant and DeLong, 1960).

In general, coals of the Allegheny Formation thicken along a line from southeastern to northeastern Ohio as the overburden changes from a predominance of sandstone to calcareous shales, mudstones, and limestones (Arkle, 1974; Smith et al., 1974).

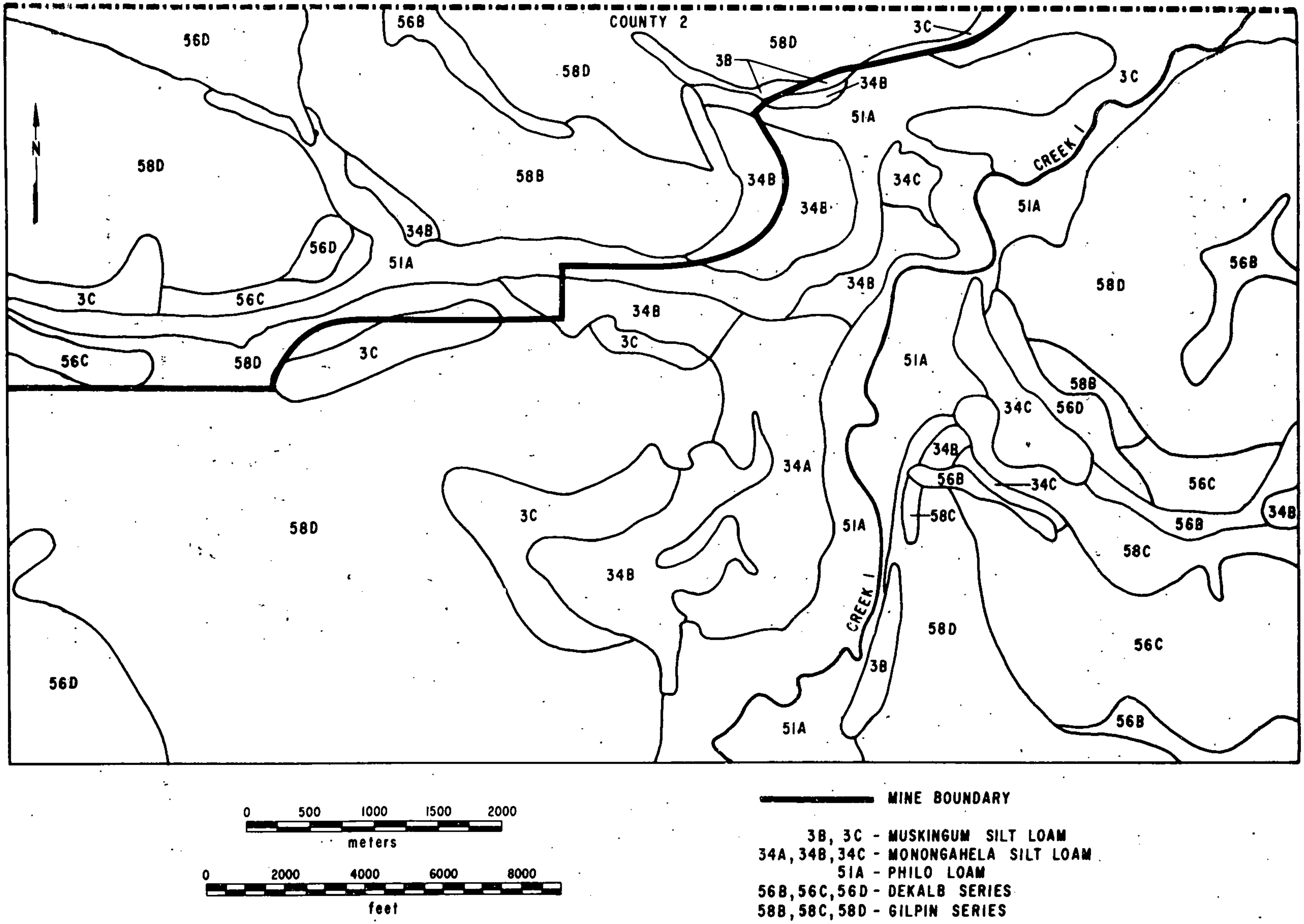

Fig. 2. Soils Map of Southern Area of Mine OH-1 in County 2.

Five major soil series had developed on the mine site prior to mining (Corbett and Manner, 1977, from Townsend personal communication). These are shown in Figure 2 and are described as follows:

1. DeKalb Series 56B, 56C, 56D. Well-drained and developed on sandstone bedrock on slopes of 6% to 35%. Strongly acid.

2. Gilpin Series 58B, 58C, 58D. Well-drained and developed on siltstone and shale bedrock on slopes of 5% to 40%. Strongly acid.

3. Muskingum Silt Loam 3B, 3C. Well-drained and developed on siltstone and shale bedrock on slopes 12% to 60%. Moderately productive agriculturally and has a severe erosion hazard. Moderately acid.

4. Monogahela Silt Loam 34A, 34B, 34C. Moderately well-drained and developed on sandstone, siltstone, and shale on slopes of 2% to 8%. Moderately productive agriculturally and has a severe erosion hazard.

5. Philo Loam 51A. Moderately well-drained and developed on silty alluvium on slopes of 0% to 2%. It is present on alluvial flood plains, natural levees, and terraces.

1.4 CONTROL TECHNOLOGY AT THE MINE

The only chemical treatment at Mine OH-1 consists of a wooden box with a bottom screen to dispense soda ash (Fig. 3). The soda ash (Na_2CO_3) treats the acid runoff from a coal storage pile, plus some effluent from the active pit which is also channeled across the coal storage pile. The remainder of the mine effluent at this site receives no chemical treatment; rather, the effluent is channeled into several settling ponds spaced at the periphery of the mine operation before being discharged into the receiving stream.

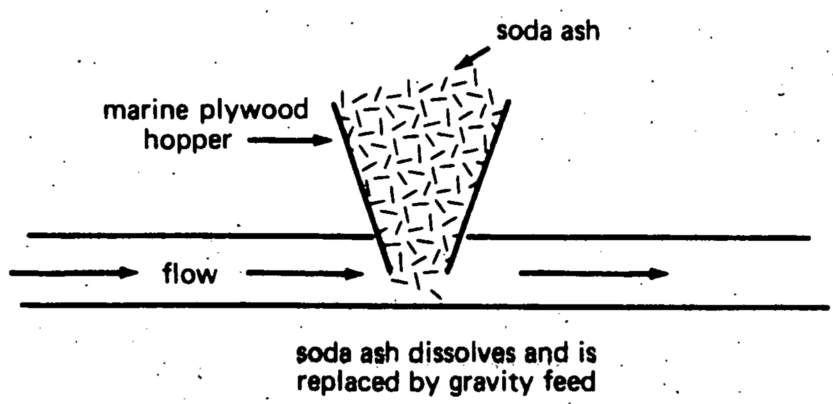

Fig. 3. Diagram of Soda Ash Treatment System (From ESCOR, Inc., 1978)

2 OVERBURDEN AND COAL CHEMISTRY

2.1 IDENTIFICATION, DISTRIBUTION, AND THICKNESS OF LITHOLOGIC UNITS

The overburden at the OH-1 mine attains a maximum thickness of about 100 ft (30 m) and consists of shale and sandstone of the Pennsylvanian age Allegheny and Conemaugh Series. The Middle Kittanning (#6) Coal mined at this site has a composite thickness of about 3 ft (0.9 m) and consists of 2 splits separated by a thin clay layer. Figure 4, a composite stratigraphic section for the mine area, includes the entire interval from the Middle Kittanning (#6) Coal to the Buffalo Sandstone, the youngest unit exposed in the area. The lower half of the overburden sequence consists of the Lower Freeport Shale (Allegheny Series); the upper half is Upper Freeport Sandstone (Allegheny) and Mahoning Sandstone (Conemaugh Series) and may include the Buffalo Sandstone (Conemaugh). The Mahoning and Buffalo sandstones unconformably overlie the Upper Freeport sandstone. Hill crests are capped by either the Mahoning or the Buffalo sandstone.

2.2 SAMPLING PROCEDURES

Both surface and subsurface samples were subjected to chemical anaylsis. Bagged chips from a drill hole constitute samples DC-2 through DC-7. Because these samples did not provide adequate detail for the scope of the study, samples were also collected from the exposed highwall for chemical analysis; these constitute samples 1 through 17. Due to problems of accessibility, samples 1-9 (to the top of the Lower Freeport Shale) were taken at one site, while samples 10-17 (the upper sandstones) were taken from another site. Both sites were on mine company property. Samples 1-17 were collected from 5 ft (1.5 m) channels except where lithologic variations dictated closer spacing. All samples are shown in Fig. 4.

2.3 LITHOLOGIC AND MINERALOGIC CHARACTERISTICS OF COAL AND OVERBURDEN

Table 2 gives detailed descriptions of the channel samples. Semi-quantitative mineralogy of powdered samples was done by X-ray diffraction using filtered copper radiation and a series of standard samples of pure minerals.

In general, the Middle Kittanning Coal at this site is a shiny black, blocky coal consisting mainly of fusain and vitrain that weathers to a very light gray or yellow. Published proximate and ultimate analyses and forms of sulfur for a composite sample of the 6 coal are given in Table 3 (Medlin, 1975). The coal is split by a thin (≈ 0.2 ft, or 0.06 m) dark gray silty clay layer that includes some coal partings.

Overlying the coal is the medium to dark gray Lower Freeport Shale (samples 1-9). This shale is approximately 45 ft (13.5 m) thick and ranges from fissile to blocky, is generally micaceous, contains siderite concretions

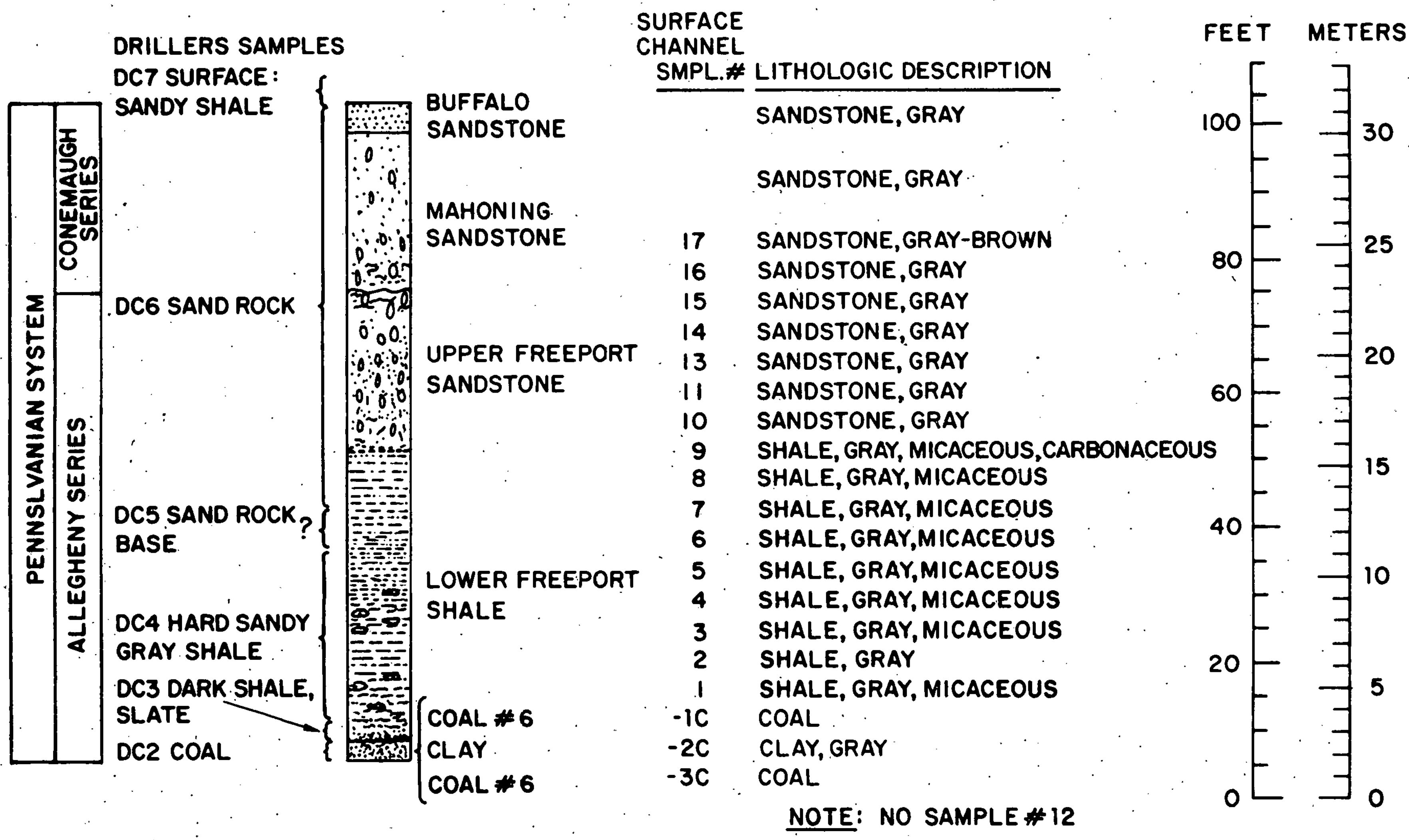

Fig. 4. Composite Stratigraphic Section with Sample Descriptions

Table 2. Description of Overburden Lithology (from Corbett and Manner, 1977)

Rock Type	Color	Thickness in Feet (Meters)	Variations	Weathering Characteristics
#9 shale	medium gray	5.0 (1.5)	sandy, larger mica flakes than #8, blocky, carbon streaks, banding evident	light gray
#8 shale	medium dark gray	5.0 (1.5)	hard, blocky, small mica flakes	light gray
#7 shale	very dark	5.0 (1.5)	blocky, hard, sharp angular chunks, concretions, tiny mica flakes	light gray
#6 shale	medium gray	5.0 (1.5)	fissile, hard sharp edges, small mica flakes	light gray
#5 shale	medium dark gray	5.0 (1.5)	fissile, concretions, small mica flakes	light gray
#4 shale	medium dark gray	5.0 (1.5)	blocky, concretions, fine mica flakes	orange to medium red brown
#3 shale	dark gray	5.0 (1.5)	blocky, less fissile than #2, fine-grained mica flakes	light blue gray
#2 shale	medium gray	5.0 (1.5)	very fine-grained, very fissile, concretions in lower layers	medium brown to dark red brown
#1 shale	very dark gray to black	5.0 (1.5)	jointed, fissile, concretions, mica flakes	light gray with iron oxide stain, orange, and dark red brown
coal (upper)	shiny black	1.5 (0.45)	blocky, fusain and vitrain	yellow
clay	dark gray	0.21 (0.06)	coal layers, light colored fine silt grains	
coal (lower)	shiny black	1.5 (0.45)	blocky, fusain and vitrain	very light gray

NOTE: Samples taken in five-foot channels from lower coal to top of section.

Table 2 (Contd.)

Rock Type	Color	Thickness in Feet (Meters)	Variations	Weathering Character-istics
#18 sandstone (not sampled)		4.0 (1.2)	thinly bedded	
#17 sandstone	light brown gray	5.0 (1.5) (part of 20' massive sandstone)	medium-to-fine-grained micaceous, some red grains, some black grains, friable	yellow gray
UNCONFORMITY				
#16 sandstone	dark gray		mud galls, Liesegang banding, fissile micaceous, fine-grained, very friable	light gray
#15 sandstone	medium dark gray	7.5 (2.3)	2' - resembles previous sandstone (#14) Liesegang banding, rusty friable sandy contact, micaceous in dark red brown bands.	light yellow brown to gray
#14 sandstone	medium dark gray	2.5 (0.75)	indurated, fine-grained mica flakes, calcareous cement	
#13 sandstone	medium gray	5.0 (1.5)	abundant mica flakes, indurated, larger grains, calcareous cement	light yellow gray
#12 sandstone	gray	5.0 (1.5)	---------	yellow gray to orange
#11 sandstone	darker light gray salt and pepper	5.0 (1.5)	more mica flakes than #10, larger black mineral grains, friable.	yellow to orange, deep weathering
#10 sandstone	light gray, salt and pepper	5.0 (1.5)	carbon traces, friable, fine-grained, small black mineral grains, small mica grains (sparse)	light yellow gray

Table 3. Coal Analysis

Coal Name:	Middle Kittanning (#6)
Thickness:	3 ft (1 m)
Description:	Shiny black, blocky, fusain and vitrain, weathers very light gray to yellow.
Heating Value (Btu/lb):	12120
Proximate Analysis (%):	
Moisture	5.3
Volatile	41.9
Fixed Carbon	42.7
Ash	10.1
Ultimate Analysis (%):	
Hydrogen	5.4
Carbon	67.5
Nitrogen	1.3
Oxygen	11.8
Total Sulfur	3.9
Forms of Sulfur (%):	
Pyritic (sulfide)-S	2.27
Sulfate-S	0.34
Organic S	1.31
Total S	3.92
Source of Analytical Data:	Coal analysis report, USGS, September 30, 1975, Jack H. Medlin

in the lower 25 ft (7.6 m), and weathers to a light gray (red-brown in concretionary horizons). Siderite and albite were identified in all 9 samples of the shales.

The Upper Freeport Sandstone (samples 10-15) ranges from a light gray, fine-grained "salt-and-pepper" sandstone at its base upward to a coarser-grained medium gray sandstone to a dark gray fine-grained sandstone near the top of the unit. The Upper Freeport is commonly micaceous and in this section is characterized by a zone with calcareous cement about 10 ft (3 m) below the top. The top 7-8 ft (2.1-2.4 m) is characterized by Liesegang rings. Albite was identified in all samples of the Upper Freeport, microcline was identified in all except sample 13. and siderite in samples 11 and 14. At the measured section, the Upper Freeport is about 30 ft (9 m) thick and weathers to a yellow-gray, yellow-brown or orange.

The Mahoning Sandstone, which unconformably overlies the Upper Freeport, is a fine-to-medium grained, gray, micaceous sandstone. The lower part of the Mahoning contains angular mudstone fragments and Liesegang rings. Albite and microcline were identified in both samples (16-17) of the Mahoning. The Buffalo Sandstone, which overlies the Mahoning, was not sampled. The total thickness of the Mahoning and Buffalo Sandstones at the measured section is about 30 ft (9 m).

In summary, the overburden lithology consists of gray shale (samples 1-9) overlain by gray-brown sandstones (samples 10-17). It is important to note that samples 13 and 14 were cemented by calcite. This zone may be the stratigraphic equivalent of the Freeport Limestone. Therefore, it is possible to recognize three general lithologies above the coal in this section -- shale, sandstone, and calcite-cemented sandstone.

2.4 CHEMICAL ANALYSES OF COAL AND OVERBURDEN

2.4.1 Methods of Sample Preparation and Analysis

All overburden and coal samples were crushed and subjected to total analysis for major elements according to the Two-Solution Procedure (Shapiro, 1975). Minor and trace elements were determined on totally digested samples by atomic absorption spectrophotometry. Forms of sulfur were determined using a LECO sulfur analyzer. The pH was measured by inserting the probe into a saturated paste of ground sample material. The acid-base balance was determined according to the method of Sobek and others (1978).

2.4.2 Discussion of Analytical Results

Results from an initial set of elemental analyses of the drill core chips are given in Appendix A, as are analytical results for the surface channel samples 1-17. Table 4 summarizes the analytical data for the three major lithologies. There is considerable overlap in the compositional range of the three groups. However, ranges for the silicon, aluminum, potassium, copper, chromium, and sulfide-S are relatively distinct for each of the three groups.

Considering the lithologies of the units, these distinct ranges are not surprising. The shale is lower in silicon than the bulk of the sandstone but higher in aluminum. The potassium is higher in the shale because it is the characteristic interlayer cation in illite, which accounts for a significant percentage of the shale. The sulfide (S^{-2}) values indicate that the shale has the most pyrite. With regard to the minor and trace elements, the only clear-cut ranges are those for copper (highest in shale) and chromium (highest in shale). Considering the high numbers and wide ranges reported for certain elements, there were apparently some problems with analytical detection limits; this may help account for the overlapping ranges. For comparison, Table 5 presents published ranges for selected minor and trace elements in coal and shale. Note that the ranges are quite broad and also that the No. 6 coal at this site has generally higher elemental concentrations than the reported averages for U.S. bituminous coals. Examining the averages for zinc and lead for both "marine

Table 4. Overburden Analyses -- Ranges for Major Lithologies

	Shale (Samples 1-9)	Sandstone (Samples 10, 11, 15, 16, 17)	Calcite-cemented Sandstone (Samples 13-14)
Elements (plus Phosphate)			
Phosphate (%)	0.2 or less	0.14 or less	0.09 or less
Silicon (%)	50 - 78	68 - 80	46 - 49
Aluminum (%)	17 - 18	10 - 16	9
Calcium (%)	0.02	0.04 or less	27 - 30
Magnesium (%)	2 - 3	0.05 - 1.1	1.6 - 1.7
Iron (%)	6 - 11	1 - 5	3 - 4
Manganese (%)	0.2 - 0.5	0.06 -- 0.28	0.2 - 0.4
Sodium (%)	0.5 - 1.7	1 - 2	1.3 - 1.5
Potassium (%)	6 - 8	3 - 4	2.4 - 2.5
Titanium (%)	2.2 - 3.7	0.7 - 1.9	1.2 - 1.3
Zinc (ppm)	80 - 380	105 - 200	185 - 500
Strontium (ppm)	50 or less	50 or less	150
Cadmium (ppm)	15 - 25	15 - 25	20 - 25
Cobalt (ppm)	30 - 80	30 - 500	50 - 60
Copper (ppm)	40 - 50	15 - 25	25 - 30
Lead (ppm)	65 - 145	80 - 150	30 - 130
Molybdenum (ppm)	100 or less	100 or less	100 - 150
Vanadium (ppm)	100 - 300	50 - 200	100
Nickel (ppm)	70 - 135	75 - 500	90 - 95
Chromium (ppm)	55 - 85	25 - 35	20 - 25
Sulfur (%)			
Sulfate (SO_4^{-2})	0.3 or less	0.9 or less	0.3 or less
Sulfide (S^{-2})	2 or less	0.3 or less	0.04 or less
Organic S	---	---	---
Total S	2 or less	0.9 or less	0.3 or less

argillaceous sediments" and "shale," the values for the Lower Freeport are considerably higher than the published averages. For "marine argillaceous sediments" alone, however, the published values generally include or are higher than reported elemental concentrations for the Lower Freeport Shale. Thus, the Lower Freeport may represent a more transitional environment at this site.

Figure 5 indicates selected vertical variations in geochemistry for the units above the #6 coal. The transition from the Lower Freeport Shale to the Upper Freeport Sandstone is marked by a decrease in iron (from > 5% to < 5%). The iron and manganese % show very little correlation with each other. Calcium is generally low throughout the section except for the prominent zone of calcite-cemented sandstone. Sulfate-S (SO_4^{-2}) and sulfide-S percentages change significantly (from greater than 0.75% to less than 0.25%) at the interface of the Lower Freeport Shale/Upper Freeport Sandstone.

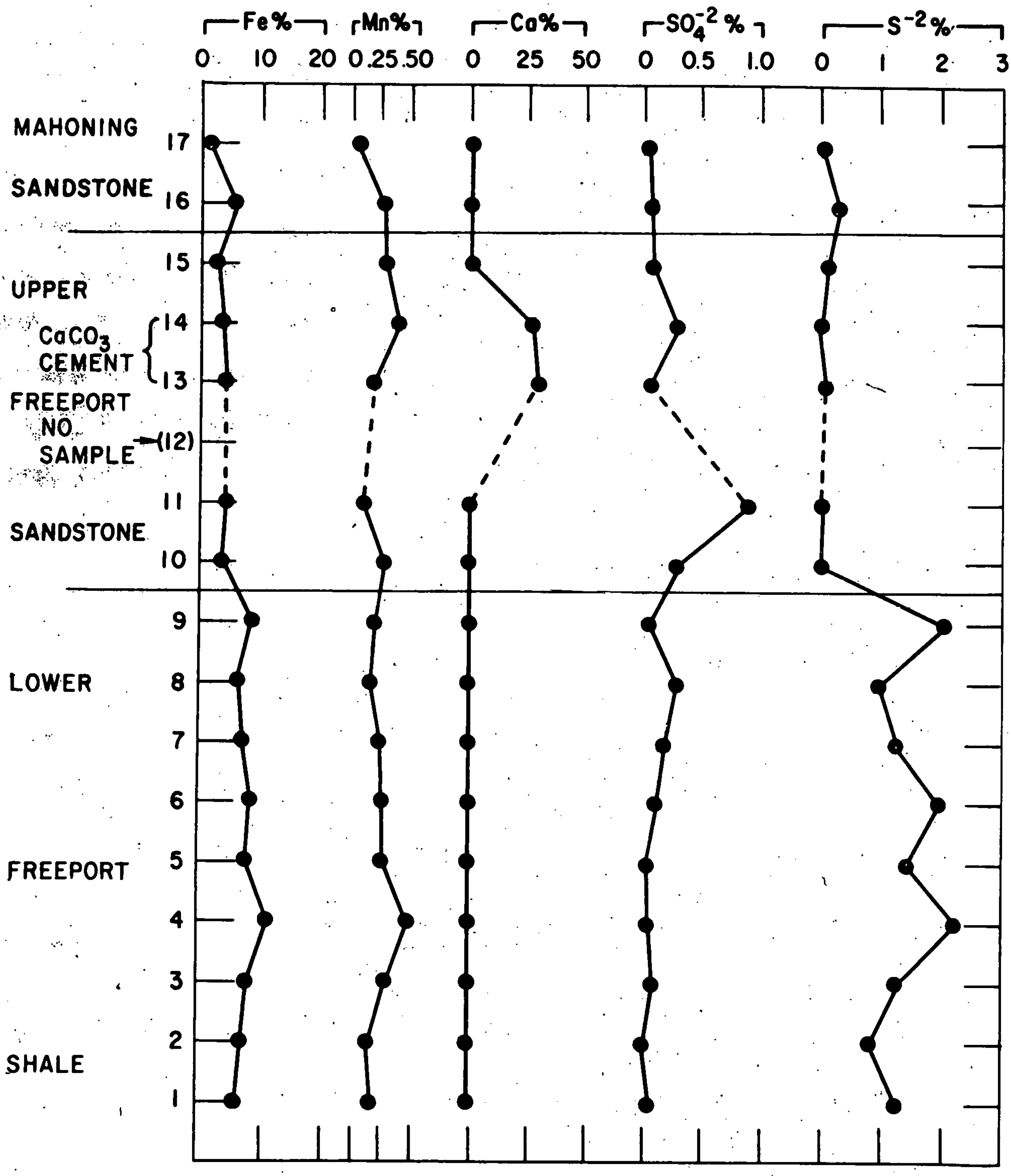

Fig. 5. Vertical Variations in Selected Geochemical Parameters

Table 5. Comparison of Selected Minor and Trace Element Concentrations in Shale and Coal, with Concentrations in No. 6 Coal and Lower Freeport Shale (Mine OH-1) (All concentrations in ppm)

	A[a]	B	C	D	E	F	G
Titanium	94300	21000 - 37000	340	NM[b]	NM	NM	800
Vanadium	325	100 - 300	21	118.2	100 - 1000	130	20
Chromium	73	55 - 85	13	76.2	100 - 400	90	15
Cobalt	355	30 - 80	5.1	<25	300	19	7
Nickel	130	70 - 135	14	41.8	50 - 800	68	20
Copper	216	40 - 50	15	28.2	20 - 200	45	22
Zinc	623	240 - 350	7.6	ND	100 - 1000	95	53
Molybdenum	175	50 - 100	3.5	NM	100 - 200	2.6	3
Cadmium	33	15 - 25	NR	NR	NR	0.3	1.6
Mercury	NM	NM	NR	NR	NR	0.4	0.2
Lead	170	60 - 145	NR	NR	NR	20	22
Strontium	100	50 NR	NR	NR	NR	300	100

[a]Key:

A - This report - averages for upper and lower splits #6 coal.
B - This report - ranges for Lower Freeport Shale.
C - Zubovic, Stadnichenko, and Sheffey, 1960 - averages for Appalachian region coals.
D - Potter, Shimp, and Witters, 1963 - averages for selected "ancient marine argillaceous sediments."
E - Krauskopf, 1955 - averages for coal ash.
F - Turekian and Wedepohl, 1961 - averages for shale.
G - Swanson et al., 1976 - averages for U.S. bituminous coals (whole coal basis).

[b]Note: NM = not measured; ND = not detected; NR = not reported.

2.4.3 Pearson Correlation Coefficients for Overburden Chemistry

In order to examine the statistical interdependence of the various chemical parameters determined for the overburden units, Pearson correlation coefficients (r) were calculated. Coefficients were calculated using a standard statistical package (Nie et al., 1975). The formula used to compute r is:

$$r = \frac{\sum_{i=1}^{N} X_i Y_i - \left(\sum_{i=1}^{N} X_i\right)\left(\sum_{i=1}^{N} Y_i\right)\Big/N}{\left\{\left[\sum_{i=1}^{N} X_i^2 - \left(\sum_{i=1}^{N} X_i\right)^2\Big/N\right]\left[\sum_{i=1}^{N} Y_i^2 - \left(\sum_{i=1}^{N} Y_i\right)^2\Big/N\right]\right\}^{1/2}}$$

where:

X_i = ith observation of variable X,

Y_i = ith observation of variable Y,

N = number of observations,

$\bar{X} = \sum_{i=1}^{N} X_i/N$ = mean of variable X, and

$\bar{Y} = \sum_{i=1}^{N} Y_i/N$ = mean of variable Y.

Table 6 indicates the high positive and negative values of r (in decreasing order) for the various overburden parameters at this site. The table includes all coefficients where $r \geq |0.5|$ and $S \leq 0.1$. Note that many of the elements show significant positive or negative correlations with each other, with pH, or with forms of sulfur. In general, correlations are explainable on the basis of (1) similar goechemical behavior (i.e., lithophile vs. chalcophile elements; organic vs. inorganic affinity of particular elements) or (2) lattice substitutions by atoms or ions of similar atomic or ionic size or like ionic charge. The table among the following groups of elements: (1) iron, titanium, sulfide-S, sulfate-S, copper; (2) cadmium, lead, zinc, vanadium, molybdenum, chromium, copper; (3) calcium, strontium; and (4) magnesium, potassium, aluminum. There are generally high negative correlations of sulfate-S, titanium, iron, and copper with both pH and silicon. Since iron occurs mainly in pyrite and siderite, which are most abundant in the shale; since the pyrite weathers to hydrated iron sulfates; and since copper and titanium tend to exhibit higher concentrations in clays and shales, the correlations of group (1) are reasonable. Generally, the group (2) elements are chalcophile while the group (4) elements are lithophile. With regard to group (3), strontium commonly substitutes for calcium in $CaCO_3$; as would be expected, the strontium content is highest in the calcite-cemented sandstone samples (see Table 4). The high negative correlations of sulfate-S, titanium, iron, and copper with silicon further suggest that the weathered pyrite, titanium, and copper are more concentrated in the shales. Titanium probably occurs in resistant heavy minerals in the shales.

2.5 OVERBURDEN CHEMISTRY RELATED TO WATER QUALITY CONSIDERATIONS

Mine OH-1 is located on the western edge of the Appalachian Coal Basin, where coals and overburdens tend to be high in sulfur. Normally, this poses an acid mine drainage (AMD) problem (Arkle, 1974; Smith et al., 1974) but evidence of this problem at Mine OH-1 was found only in runoff from the coal storage pile.

Smith and others (1974) found a weathered zone that extended from the land surface to an average depth of 20 ft (6 m) in the overburden of Appalachian strip mines. The weathered zone at site OH-1 extends to a depth of 36 ft (11 m) as evidenced by Munsell color chromas of greater than 2, while sulfur and bases are both low (Table 7). The pH rises from 4.7 in sample 7 to 7.7 in sample 15 and is accompanied by an increase in the amount of bases.

Table 6. High Positive and Negative Pearson Correlation Coefficients (r) for Overburden Parameters ($r \geq |0.5|$; $S \leq 0.1$)

High +		High +		High -	
Fe:Ti	.96	Mn:SO_4^{-2}	.65	pH:SO_4^{-2}	-.81
S^{-2}:SO_4^{-2}	.96	Al:Mg	.65	Si:Ti	-.79
Ca:Pb	.86	Cd:Cr	.64	Ph:Ti	-.77
Ti:SO_4^{-2}	.86	Sr:Mo	.63	Si:Fe	-.75
Cu:SO_4	.85	Co:Cu	.61	pH:Cu	-.74
Ca:Sr	.84	Co:Ni	.61	pH: Total S	-.71
Cu:Zn	.82	Cr:SO_4^{-2}	.60	Si:SO_4^{-2}	-.68
Fe:SO_4^{-2}	.81	Fe: total S	.60	pH:Fe	-.64
Fe:Cu	.77	Cu:Pb	.59	Si:Cu	-.63
Cd:Mo	.74	Cu:Cr	.59	K:SO_4^{-2}	-.59
V:Cr	.74	Pb:Ni	.59	Al:Ca	-.59
Al:K	.74	Cr: total S	.59	Si: total S	-.58
Mg:K	.73	Zn:Cr	.58	Na:S^{-2}	-.58
Ti:Cu	.73	Si:Na	.57	Si:Sr	-.57
Zn:Cd	.73	Cd:SO_4^{-2}	.53	pH:Pb	-.56
Mn:pH	.70	Pb:Mo	.53	Pb:PO_4^{-3}	-.55
Ti: total S	.70	Fe:Zn	.52	pH:S^{-2}	-.55
Cd:V	.70	Cu: total S	.52	Na:PO_4^{-2}	-.53
Pb:Cr	.69	Ti:S^{-2}	.52	Cd:PO_4^{-3}	-.52
Pb:SO_4^{-2}	.69	Mg:Mn	.51	pH:Mo	-.51
Zn:Mo	.68	Mg:pH	.51	Zn:Si	-.50
Cu:Mo	.66	K:Cr	.51	Al:Sr	-.50
Pb:V	.66	Zn:Co	.51		
Cd:Cu	.65	Zn:SO_4^{-2}	.51		
Co:SO_4^{-2}	.65	Zn:Sr	.51		

Also, the lithologic descriptions (Table 2) indicate that weathering had progressed to this depth before the overburden was disturbed by mining operations. This zone of material does not contribute to the production of AMD.

The section of sandstone at a depth of 36 ft (11 m) to 44 ft (13.4 m) is cemented with calcite (Table 2) and contains an average excess neutralizing capacity of 394 tons $CaCO_3$ equivalent/1000 tons of material. Although samples 10 and 11 are sandstones not cemented by calcite, they also contain an excess of neutralizers (bases). The Munsell color chromas are 2 or less indicating that this section of rock has not undergone subaerial weathering. Below this section, at a depth of 59 ft (18 m), the overburden changes from sandstone to shale, and sulfur increases while bases decrease. Thus, the remaining 45 ft (13.7 m) of overburden directly over the coal have a net potential deficiency of bases with the exceptions of samples 3 and 2. If samples 4 and 9 were left exposed to the atmosphere without treatment, they would be active producers of AMD.

Table 7. Sulfur Forms and Acid-Base Account for OH-1 Overburden Samples

Sample No.	Depth (ft)	Munsell Value and Chroma	pH	Rock Type[a]	Percent Sulfate-S	Percent Sulfide-S	Tons $CaCO_3$ Equivalent/1000 Tons Material: Maximum From % Sulfide-S (Acid Potential)	Amount Present (Neutralization Potential)	Maximum Needed (pH 7.0)	Excess $CaCO_3$
17	19 - 24	8/4	4.7	SS	0.27	0.06	1.87	-0.36	2.23	----
16	24 - 29	7/4	6.4	SS	0.06	0.29	9.06	5.52	3.54	----
15	29 - 36.5	7/4	7.7	SS	0.08	0.09	2.81	6.33	----	3.51
14	36.5 - 39	8/1	8.3	SS	0.28	----	----	378.63	----	378.63
13	39 - 44	8/1	8.4	SS	0.06	0.04	1.25	401.31	----	400.06
11	49 - 54	8/2	7.4	SS	0.89	----	----	12.26	----	12.26
10	54 - 59	7/1	7.4	SS	0.29	----	----	16.78	----	16.78
9	59 - 64	6/1	7.1	SH	0.05	2.06	64.37	18.84	45.53	----
8	64 - 69	7/1	7.4	SH	0.29	0.96	30.00	19.80	10.20	----
7	69 - 74	5/1	7.3	SH	0.18	1.26	39.37	38.60	0.77	----
6	74 - 79	7/1	7.6	SH	0.13	1.94	60.62	34.41	26.61	----
5	79 - 84	6/1	7.6	SH	0.03	1.41	44.06	38.16	5.90	----
4	84 - 89	6/1	7.7	SH	0.03	2.18	68.12	64.34	3.78	----
3	89 - 94	6/1	7.8	SH	0.08	1.25	39.06	44.22	----	5.16
2	94 - 99	6/2	7.7	SH	----	0.80	25.00	33.20	----	8.20
1	99 - 104	7/2	5.6	SH	0.07	1.22	38.12	10.55	27.57	----
-1C	104.0 - 105.5	2/0	---	Middle Kittanning Coal (#6)			----	----	----	----
-2C	105.5 - 105.7	4/0	1.9	Clay	1.10	6.57	205.31	-7.97	213.58	----
-3C	105.7 - 107.2	2/0	---	Middle Kittanning Coal (#6)			----	----	----	----

[a]SS = Sandstone; SH = Shale.

The effect of overburden chemistry on water quality will be dependent upon final placement and treatment of the spoil material. The acid-base account of the overburden (Table 7), determined according to the method of Sobek and others (1978), indicates a section of potentially favorable material (samples 10 through 17) and a section of potentially acid toxic materials (samples 5 through 9 and sample 1). For a further discussion of the acid-base account method, see Smith et al., 1974. Manipulation of these overburden materials during regrading can be accomplished to provide a stable non-acid producing spoil. The calcareous sandstones should be mixed with the high sulfur shales. This mixture should then be placed on a layer of calcareous material in the base of the pit. Soil treated with limestone should then be placed on the surface of the spoil. This regrading scheme would insure that water percolating through the spoil will interact with enough bases to neutralize any acid produced by the oxidation of pyritic material. Moreover, the alkaline conditions provided would possibly inhibit microbial populations that catalyze the pyritic oxidation process.

The major potential impact to water quality at this site comes from the coal itself. The coal contains 2.27% sulfide-S, while the clay parting in the coal contains 6.5% sulfide-S. If all the sulfide-S in the clay parting were completely oxidized, almost 260 tons of limestone/1000 tons of clay material would be required to neutralize the resultant acid. However, this does not take into account the intensified chemical weathering that would occur when the acid reacts with additional iron sulfides encountered in spoil materials. At this site the evidence suggests that the clay and coal were properly handled and that excessive pyrite oxidation did not occur.

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3 HYDROLOGY AND WATER QUALITY

3.1 INTRODUCTION

Six settling ponds are located at the periphery of the mining operation on the northeast, east, and south sides (Fig. 6). The largest settling pond (P001) has been created by damming a small stream which enters the pond from the west. This stream flows all year and provides the majority of water entering the pond. Other waters entering the main pond include a pumped pit discharge, intermittent runoff from active and reclaimed spoil areas, intermittent runoff from a coal storage pile (site 2), flow from a smaller settling pond (P006) northwest of the main pond, and possibly groundwater seepage from the mine area. The other ponds receive runoff water from active and reclaimed spoil areas; pond P002 (and perhaps others) receives a pumped discharge from the mine pit as well.

Discharges from all settling ponds flow eastward or northeastward into Creek 1, which flows north and joins Creek 2 upstream of the large reservoir. Downstream of the reservoir, Creek 2 flows into the Muskingum River. The Creek 2 watershed consists of about 815 mi^2 (2111 km^2). The long-term (36-yr) average discharge for Creek 2 below the reservoir is 25,200 L/s, while normal annual maximum and minimum discharges are about 1.13 x 10^5 L/s and 850 L/s respectively (U.S. Geological Survey, 1974a). The long-term average discharge for the Muskingum River near Coshocton, Ohio, is about 1.42 x 10^5 L/s. Discharge values for Creek 1 are not available.

Water quality data available for Creek 2 (U.S. Geological Survey, 1974b) suggest generally good quality water of moderate hardness. The available chemical information indicates that Creek 2 water would be suitable for domestic use and would probably meet water quality criteria for most industrial uses. It also appears likely that indigenous aquatic communities would not be seriously affected or restricted by ambient water quality. The range in sulfate concentrations (about 70-270 mg/L) suggests that Creek 2 is receiving mine drainage; however, average iron and manganese levels in the creek (about 0.1 and 0.2 mg/L, respectively) do not appear to be abnormally high. Coal mining in the basin apparently does not have a substantially adverse effect on Creek 2 water quality.

3.2 LOCATION AND FREQUENCY OF DATA COLLECTION

Locations of water quality monitoring stations at the mine site were chosen by ANL personnel and the consultant during an initial site visit. The locations of the four monitoring stations are shown in Fig. 6. Site 1 was approximately 660 ft (220 m) upstream of the point where the stream entered the main settling pond. Site 2 was in a channel that receives drainage from the coal storage pile, above a soda ash treatment structure. Site 4 was the outlet from the main settling pond. Sites 1 and 4 were sampled every two weeks from May, 1976, through July, 1977; sites 2 and 3 were sampled only during periods of surface water runoff. Flow rate at site 4 was measured using a 33.5 gal (128 L) tub and a stopwatch (Fig. 7). Three

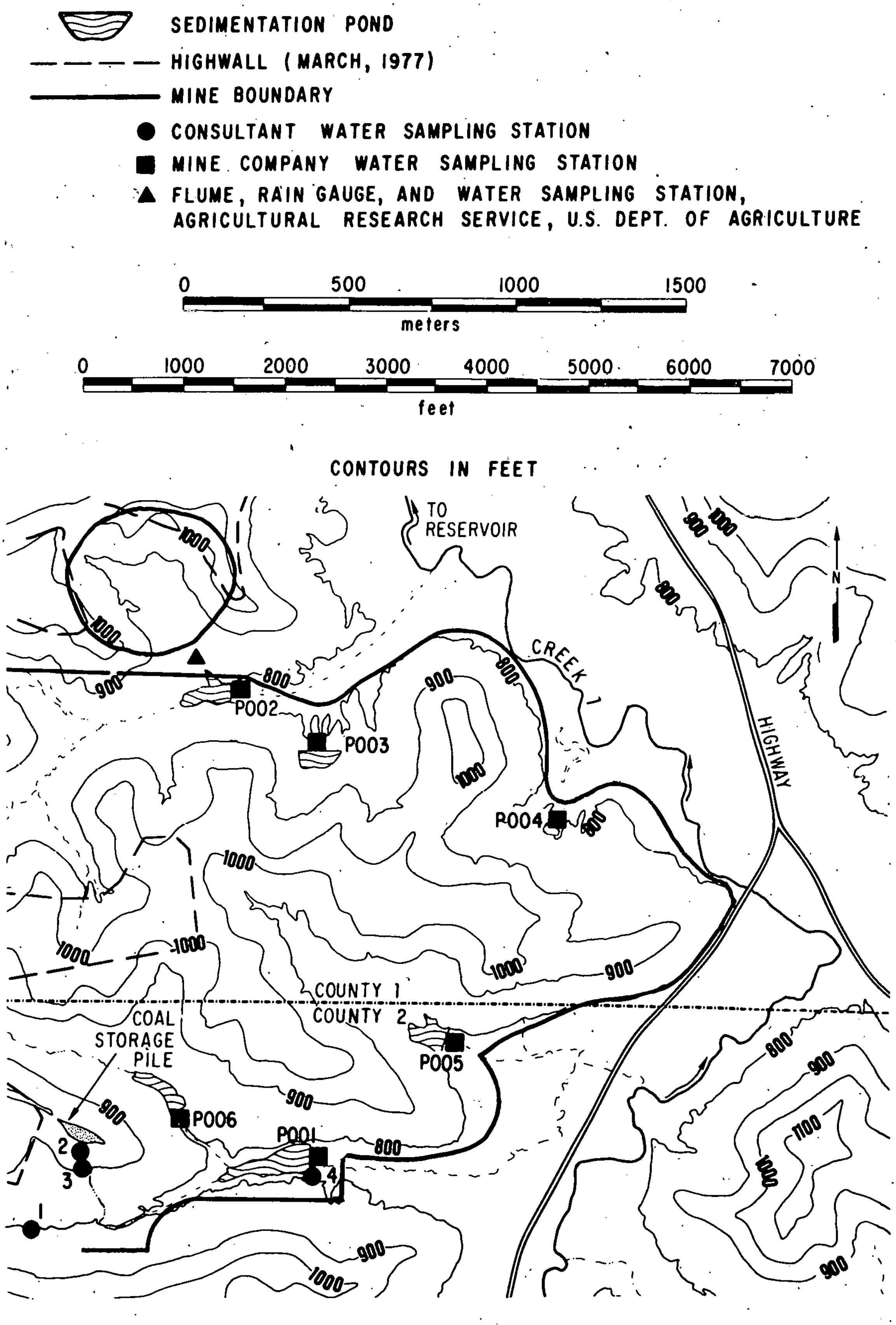

Fig. 6. Locations of Water Data Collection

Fig. 7. Measuring Flow Rate at Sampling Site 4

to five flow measurements were taken on each date and averaged. Water quality data and flow estimates, obtained from monthly sampling, were also provided by the mining company for discharges from the five settling ponds on the mine site. Data for the following time periods from four of these ponds were utilized for this report: Pond P001, 1/31/74 - 12/14/76; Pond P002, 4/05/76 - 12/14/76; Pond P003, 4/20/76 - 5/25/76; Pond P005, 4/20/76 - 12/14/76. Additional water quality data and surface water flow measurements were obtained from the Agricultural Research Service (A.R.S.), U.S. Dept. of Agriculture, for water flowing from unreclaimed spoil piles in the northwestern part of the mine site (Fig. 8).

3.3 HYDROLOGY OF THE MINE AREA

3.3.1 Precipitation

The average annual precipitation for southeastern Ohio is about 38.5 in. (98 cm). Precipitation is distributed fairly evenly throughout the year, with slightly higher amounts falling during May through July (see Table B-1 in Appendix B). Precipitation data were collected on a daily basis during the study period at a weather station on the mine site; the data were collected and provided by the Northern Appalachian Watershed District Research Service (Corbett and Manner, 1977). During the period

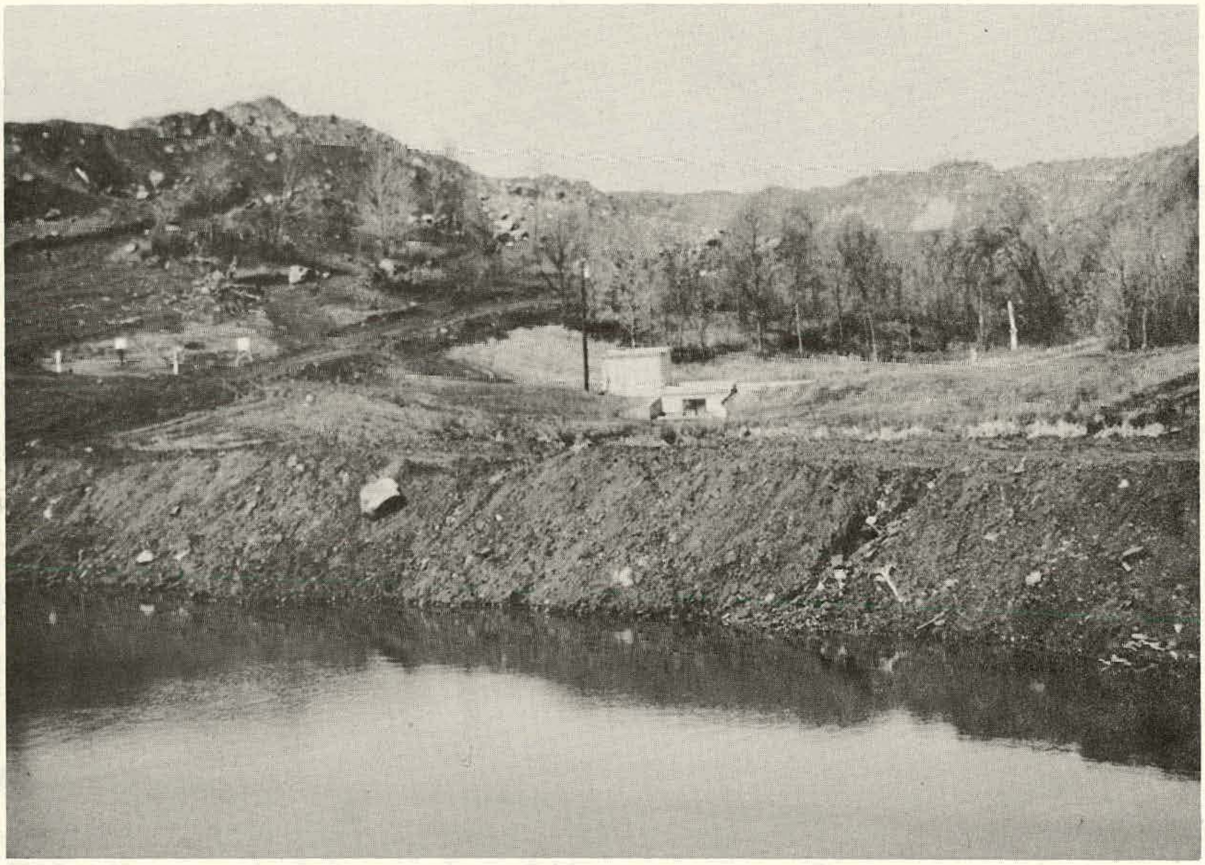

Fig. 8. Pond P002, Weir, and Rain Gauge

3/3/76 through 8/30/77, daily rainfall exceeded 1.0 in. (2.54 cm) 10 times. Two major rainstorms of 3.13 in./day (7.95 cm/day) occurred on 7/2/77 and 7/4/77.

3.3.2 Surface Water Runoff

Pumped mine discharges, as well as surface water runoff from spoil areas, are collected in five ponds around the perimeter of the mine operation. Table 8 shows the drainage areas and discharge rates of the mine ponds. Pond P001 has a considerably greater discharge rate because of the stream entering the pond from the unmined portion of the watershed. The flow rates of ponds P002-P005 are relatively small and intermittent.

Runoff rates were measured (A.R.S., 1977) in a small (approximately 51 ac or 21 ha) mined area that is located in the drainage basin of pond P002. No flow generally occurs from this area, and a maximum of only 16.9 L/s has been measured entering Pond P002 through the monitoring flume.

Runoff from the coal storage pile area occurs occasionally during rainstorms (Sites 2 and 3, Fig. 6). One flow measurement indicated a flow of 26 L/s from this area.

Table 8. Drainage Areas and Discharge Rates of Settling Ponds

Pond Number	Approximate Drainage Area Above Ponds (ac)[a]	Range of Flow Rate (L/s)
P001	694	0.536 - 48.8[b] (29)[c]
P002	576	0 - 8.76[d] (9)
P003	27	0 - 0.263[d] (9)
P004	7	0 - (8)
P005	104	0 - 1.97[d] (9)
P006	199	(0)
Weir	57	0 - 16.9[e] (5)

[a]1 acre = .4047 hectare.

[b]Flow data from Corbett and Manner (1977).

[c]Number in parentheses indicates number of flow measurements.

[d]Flow data from mining company.

[e]Flow data from A.R.S. et al. (1977).

3.3.3 Precipitation-Runoff Relationship

Surface water runoff during rainstorms and periods of significant snowmelt greatly increases the rate of water discharging from a mine, sometimes by many orders of magnitude. Runoff rate and amount during a storm are dependent on numerous variables, such as (1) rainfall intensity and duration, (2) antecedent soil moisture, (3) permeability of soils (disturbed and undisturbed), (4) soil cover, and (5) watershed topography. Using the daily precipitation data collected at the mine site and flow data from the main settling pond P001 (Corbett and Manner, 1977), attempts were made to establish an empirical relationship between rainfall and flow rate.

Flow rate was plotted vs. rainfall on day of flow measurement (P_o), rainfall on day of flow measurement plus previous day ($P_o + P_1$), etc. to a maximum of the sum of rainfall on day of flow measurement plus 13 previous days. Linear regression statistics are presented in Table 9. The Pearson r was calculated using the formula given in Section 2.4.3. The best correlation ($r^2 = 0.509$) appeared when flow rate was plotted vs. cumulative rainfall of the measurement date and eight previous days (Fig. 9). Flow rate was also plotted vs. rainfall on the previous day (P_1), rainfall on the previous two days ($P_1 + P_2$), etc., to a maximum of the sum of rainfall on 14 previous days. The results of these linear regression analyses indicated the best relationship ($r^2 = 0.494$) occurred when flow rate was correlated to cumulative rainfall of the previous nine days. This relationship suggests that the residence time of rainfall in the watershed of Pond P001 may be as much as nine days, and that flow rate and retention time in the pond may be dependent on several preceding storms, rather than only one.

Table 9. Precipitation-Runoff Relationships (Based on 29 Observations)

n	Significance	Flow rate vs. $\sum_{i=0}^{n} P_i$ r	r^2	Significance	Flow rate vs. $\sum_{i=1}^{n} P_i$ r	r^2
0	.334	.083	.007			
1	.423	.038	.001	.130	.216	.047
2	.067	.285	.081	.371	.064	.004
3	.005	.468	.219	.033	.346	.120
4	.001	.550	.303	.002	.528	.279
5	.001	.550	.303	<.001	.593	.351
6	<.001	.644	.414	<.001	.595	.354
7	<.001	.653	.426	<.001	.650	.423
8	<.001	.714	.509	<.001	.662	.439
9	.001	.560	.314	<.001	.703	.494
10	.001	.563	.316	.001	.547	.299
11	.004	.488	.238	.001	.549	.301
12	.008	.442	.196	.005	.475	.226
13	.063	.291	.085	.009	.437	.191
14				.062	.292	.086

NOTE: P_o = precipitation on day of flow measurement.
P_i = precipitation on ith day previous to flow measurement.
n = number of days prior to flow measurement.
r = Pearson correlation coefficient (Nie et al., 1975).

3.4 WATER QUALITY

3.4.1 Description of Water Sample Collection, Handling, Analytical Methods, and Analytical Reliability

Water samples were collected in new one-liter plastic containers. The containers were rinsed with sample and filled, and all air expelled before the cap was secured. As appropriate, one or two unacidified samples were taken at each site; an additional 250 mL sample at each site was acidified with 0.5 mL of concentrated nitric acid for metal analyses. Analytical methods and detection limits are summarized in Table B-2, Appendix B. The following quality control procedures were used by ANL to evaluate the contractor's analytical capabilities:

1. Three reference samples ("unknown") prepared by ANL were analyzed by the contractor during the study and results were compared to actual concentrations. The reference sample results for the University of Akron

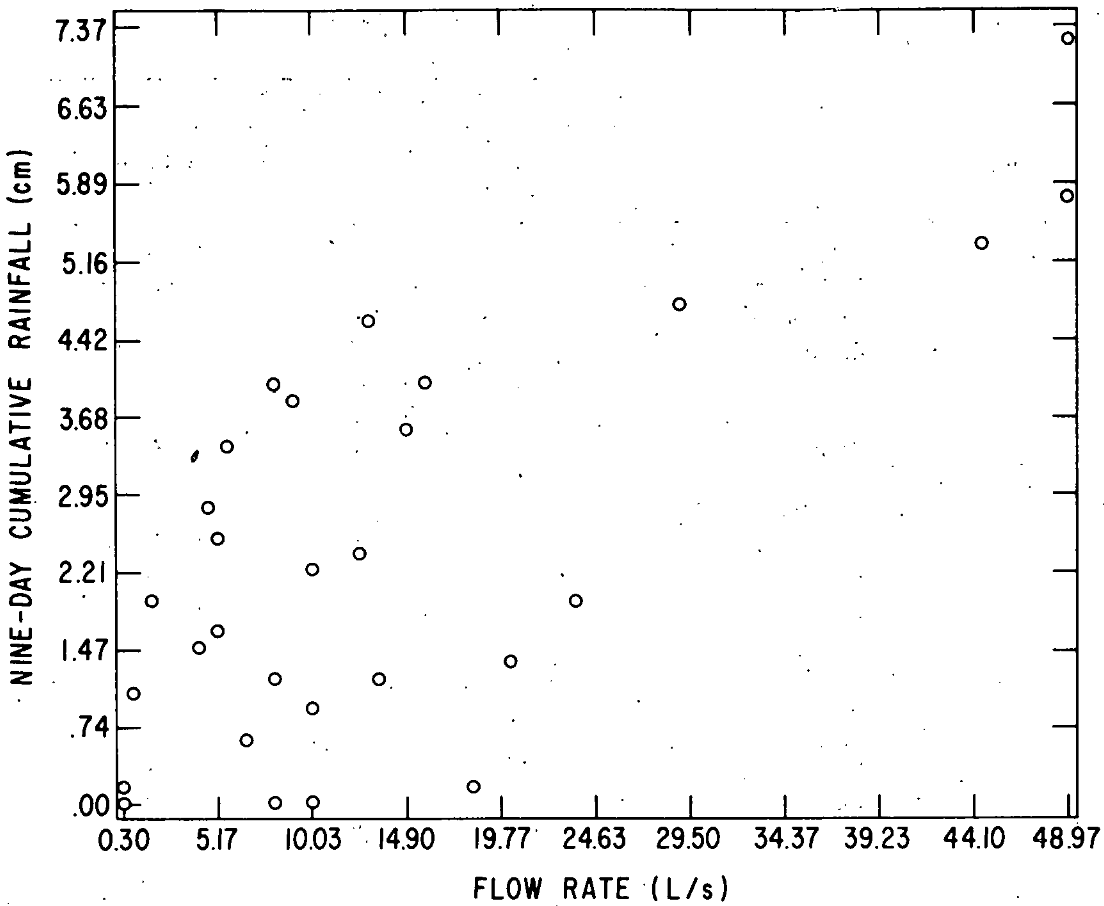

Fig. 9. Nine-Day Cumulative Rainfall vs. Flow Rate of Pond P001

contractor shown in Table 10. Results for reference sample 1 (trace metals) showed relatively poor accuracy. This was undoubtedly due to low concentrations in the sample, which in most cases were near or below the detection limit of the consultant's atomic absorption spectrophotometer. The element concentrations in sample 2 were in a more favorable analytical range and the consultant's analyses reflect this. Results for all sample 2 constituents are very good. The consultant's performance on sample 3 was generally acceptable, but better agreement would obviously be desirable.

2. A second quality control procedure involved comparison of analytical results from two sets of samples collected concurrently at selected sites, one by the consultant and one by ANL. This procedure was designed primarily to detect gross analytical or sampling comparison are shown in Table 11. There is general agreement between the samples for most constituents, although sulfate variance in sample 2 might be considered excessive. The data do not suggest gross sampling or analytical problems.

Table 10. Results of Reference Sample Analyses

Sample No.	Parameter	Actual Conc. (mg/L unless otherwise noted)	Contractor Conc. (mg/L unless otherwise noted)
1	Aluminum	0.079	0.10
	Cadmium	0.005	<0.02
	Chromium	0.016	0.02
	Cobalt	0.017	<0.2
	Copper	0.016	0.02
	Iron	0.026	0.05
	Manganese	0.026	0.01
	Molybdenum	0	<0.1
	Nickel	0.026	0.03
	Lead	0.022	0.08
	Vanadium	0.052	<0.1
	Zinc	0.011	0.02
2	Calcium	50	49
	Magnesium	10	12
	Sodium	25	25
	Potassium	5	4.9
	Strontium	1.0	0.92
	Aluminum	0.2	0.20
	Iron	0.5	0.52
	Manganese	0.05	0.05
3	Chloride	50	38
	Fluoride	0.5	----
	Sulfate	490	550
	Specific conductance (μmhos/cm)	1110	----
	Total dissolved solids	808	761

3.4.2 Summary of Water Quality Data

The water quality of each pond discharge is very similar (Table 12). Ponds P003, P004, and P005 receive runoff water primarily from spoil materials. Most of the active pit discharges enter ponds P001 and P002. In addition, runoff from the coal storage pile enters pond P001. The highest averages for suspended and total dissolved solids and the highest concentrations of metals are generally found in the discharge of P001, the main settling pond. Ponds P002 and P003 had higher values of zinc, and pond P005 had higher values of manganese. Ponds P003 and P005 had lower values of alkalinity. Data were insufficient to determine the causes of variation of water chemistry between the ponds.

Water quality data collected by Corbett and Manner (1977) are summarized in Table B-3, Appendix B, and presented in their entirety in Table B-4,

Table 11. Comparison of Analyses on Concurrently Collected Samples[a]

Parameter	Sample 1 ANL	Sample 1 Consultant	Sample 2 ANL	Sample 2 Consultant
Total dissolved solids	150	160	318	364
Alkalinity	27	64	25	63
Chloride	<0.5	3.7	<0.5	5.4
Sulfate	71	70	173	330
Acidity	8.2	4.4	4.1	3.8
Calcium	26.1	18	69.3	51
Magnesium	10.5	12	32.5	34
Sodium	6.1	5	8.7	8
Potassium	1.9	1.2	3.2	2.3
Strontium	<0.5	0.09	<0.5	0.29

[a]All values are in mg/L.

Table 12. Comparison of Discharge Water Quality of Four Settling Ponds[a]

Parameter	P001	P002	P003	P004
pH, minimum	5.5 (36)[b]	6.1 (8)	6.3 (2)	5.5 (4)
pH, maximum	9.0 (36)	9.0 (8)	6.5 (2)	6.4 (4)
Total suspended solids, average	20.8 (36)	13.0 (8)	8.5 (2)	4.5 (4)
Alkalinity, average	64.0 (35)	81.6 (7)	46.0 (1)	37.0 (4)
Aluminum, average[c]	1.847 (13)	0.533 (8)	0.150 (2)	0.305 (4)
Cadmium, maximum	0.049 (28)	0.017 (8)	0.017 (2)	0.014 (4)
Total iron, average	1.748 (36)	0.872 (8)	0.340 (2)	0.185 (4)
Dissolved iron, average	0.227 (36)	0.066 (8)	0.080 (2)	0.050 (4)
Manganese, average	3.929 (13)	1.965 (8)	0.680 (2)	4.195 (4)
Nickel, average	0.146 (12)	0.070 (8)	0.060 (2)	0.077 (4)
Zinc, average	0.082 (13)	0.101 (8)	0.585 (2)	0.027 (4)

[a]All values except those for pH are in mg/L.

[b]Numbers in parentheses indicate number of analyses.

[c]All metal analyses are acid extractable except dissolved iron.

Appendix B. Pit discharges and runoff water from spoil material and the coal storage area evidently have a significant effect on water quality in the main settling pond. By comparing the average water quality of the inflowing stream to the average quality of the pond discharge, the following changes are apparent: specific conductance is raised by 74%, total dissolved solids are raised by 63%, alkalinity is reduced by 39%, and sulfate is raised by 114%. Concentrations of calcium, magnesium, potassium, copper, manganese, and zinc are raised by 39%, 73%, 53%, 183%, 193%, and 656%, respectively. Iron and aluminum concentrations, however, are reduced by 62% and 51%, respectively. The environmental implications of these water quality changes will be discussed in Section 5.

3.4.3 Flow-Dependent Relationships of Total Suspended Solids and Ion Concentrations

The major function of settling ponds is to provide storage capacity for heavy rains, thus reducing peak discharge rates, reducing flow velocity, and allowing sediment and/or precipitated material to be trapped. Concentrations of most chemical constituents are normally dependent on flow rates because rainfall and surface water runoff dilute the groundwater contributions to watershed discharge. As a first step in examining the flow-dependent nature of water quality from the main settling pond, Pearson correlation coefficients (r) of flow rate vs. concentration were determined for all parameters; results are presented in Table B-5, Appendix B. The formula utilized (Nie et al., 1975) has been given previously in this report. The only significant correlation for the main pond was a strong positive linear correlation between flow rate and total suspended solids (TSS) when all outflow data were combined ($n = 74$).

Although strong linear correlations are not apparent between flow rate and ion concentrations, a distinctly recognizable drop of most ion concentrations did occur during the period February 12 to May 7, 1977, when flow rates were high. This drop was seen for specific conductance, sulfate, total dissolved solids (TDS), calcium, magnesium, sodium, potassium, manganese, zinc, strontium, and nickel. Figure 10 shows the concentration of zinc at site 4 during the study period; the minimum values of zinc clearly occur during the spring months. Thus, an inverse relationship between flow rates and ion concentrations is suggested.

These data indicate that control and retention of water are necessary during storms and periods of high surface water flow rates in order to control suspended sediment. The data also imply that control of water quality (discussed in Section 4) is critical during low flow periods to minimize impacts to surface water resources.

3.4.4 pH-Ion Concentration Relationships

Concentrations of certain mine drainage constituents, particularly metals, are dependent on pH. Linear regression statistics may suggest where ion concentration-pH relationships are linear for a particular site. Pearson correlation coefficients (Nie et al., 1975) for pH vs. ion concentrations at sites 1, 4, P001, and all sites combined are summarized in Table

11. The pH of the stream entering the main settling pond and of water discharging from the main settling pond have the following ranges: Site 1, 6.31 to 8.30; Site 4, 6.42 to 8.12; and Site P001, 5.50 to 9.00. Most pH values ranged from 7.00 to 8.00. For these narrow ranges of pH, Table 13 shows no significant correlations ($r \geq |0.5|$) existing between pH and other water quality parameters at the two sites. However, when all data from the mine site were considered together (including samples from the coal storage area which had a pH < 3.0), some significant correlations did appear between pH and ion concentrations. Fourteen parameters had correlation coefficients $-1.0 < r < -0.5$; ten of the fourteen were metals that are more soluble in the lower pH range (< 6.0). The corresponding scattergrams for pH vs. ion concentrations (all data combined), however, show a serious tendency for data to be clustered either in a low pH range or the pH range 7.0 - 8.0.

The negative linear correlations between pH and iron, acidity, and sulfate are caused by their common process of formation, i.e., oxidation of pyrite. Only four samples had iron concentrations greater than 12 mg/L and these occurred where pH was below 5.0. Where pH ranged from 5.0 to 9.0, total iron was generally less than 4.0 mg/L with only three values between 4.0 and 12.0 mg/L.

The inverse relationships between pH and specific conductance and total dissolved solids are a general indication of higher concentrations of sulfate and soluble metals at lower pH values. The highest positive correlation shown in Table 13 (r = .424) occurred between pH vs. alkalinity.

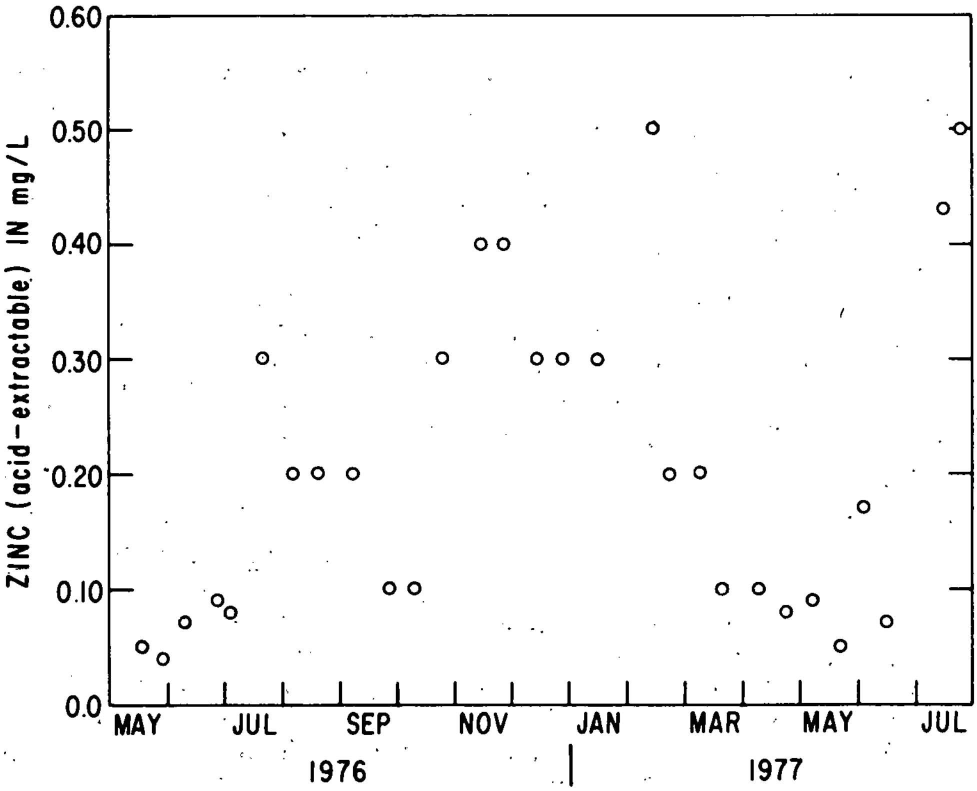

Fig. 10. Zinc Concentrations vs. Time at Site 4

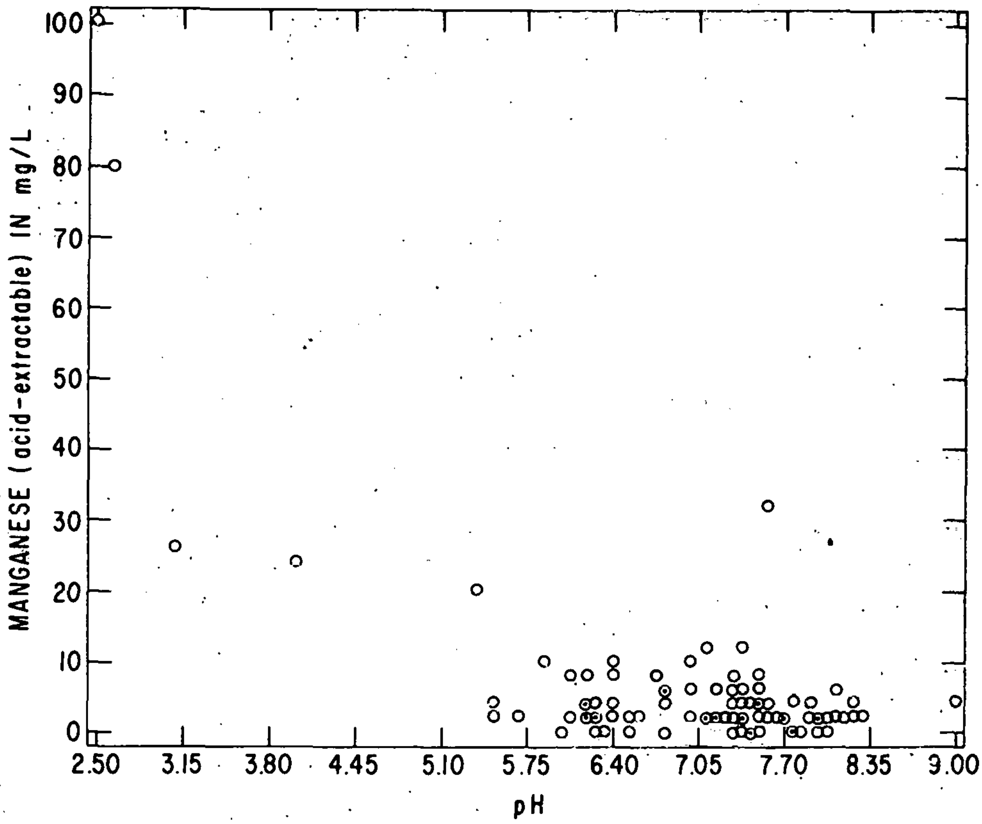

Fig. 11. Manganese Concentrations vs. pH

A scattergram plotting pH vs. total manganese is shown in Fig. 11. Five of six water samples having a manganese concentration greater than 15 mg/L also had a pH less than 5.5. The two highest manganese concentrations occurred when pH was below 3.0. When pH was in the range of 6.0 to 8.0, manganese concentrations were less than 12 mg/L with the exception of one value of 31 mg/L.

Of all water sampled, water draining from the coal storage area had the lowest pH. Because the soda ash treatment of water from the coal storage area was usually ineffective in raising the pH above 6.0, water with high concentrations of metals was reaching pond P006 and then flowing into pond P001. Therefore, the coal storage area may be a major source of the metals that enter pond P001.

3.4.5 Suspended Sediment-Ion Concentration Relationships

Because iron, manganese, and other metals may be transported while adsorbed on suspended sediment, the settling ponds may be effective in reducing metal contents if they retain suspended sediment. Linear regression statistics (Nie et al., 1974) for total suspended sediment vs. cation concentrations were run on all data collected from the mine site and are summarized in Table B-6, Appendix B. No significant linear relationships were determined between suspended sediment and cation concentrations. This suggests that more metals were being transported as dissolved constituents.

Table 13. Relationships Between pH and Water Quality Parameters

	Site 1				Site 4				Site P001				All Data			
pH vs.	n	r[a]	r^2	Signif.	n	r	r^2	Signif.	n	r	r^2	Signif.	n	r	r^2	Signif.
Chromium	28	.346	.120	.035	29	.042	.002	.414					62	-.844	.712	<.001
Magnesium	28	.118	.014	.275	29	-.021	.0004	.456					62	-.800	.637	<.001
Specific conductance	28	.176	.031	.185	29	-.187	.035	.166					68	-.770	.593	<.001
Total dissolved solids	28	-.229	.053	.120	29	-.208	.043	.140					68	-.744	.553	<.001
Acidity	28	.051	.003	.398	29	-.221	.049	.125					74	-.715	.511	<.001
Nickel	28	.124	.015	.265	29	-.161	.026	.202	11	-.251	.063	.228	88	-.704	.496	<.001
Sulfate	28	.050	.003	.400	29	-.080	.006	.339					71	-.690	.477	<.001
Manganese	28	.226	.051	.124	29	-.175	.031	.182	12	-.269	.072	.199	89	-.677	.458	<.001
Zinc	28	.588	.346	<.001	29	-.310	.096	.051					89	-.656	.430	<.001
Aluminum	28	.449	.201	.008	29	.031	.001	.437	13	-.163	.027	.297	89	-.632	.399	<.001
Iron	28	.188	.035	.169	29	-.087	.008	.326	36	.073	.005	.337	112	-.621	.386	<.001
Copper	28	-.004	.000	.492	28	.274	.075	.079					62	-.601	.361	<.001
Lead													62	-.578	.334	<.001
Cadmium	28	.065	.004	.370	29	-.170	.029	.188	27	-.338	.114	.042	104	-.575	.330	<.001
Alkalinity	28	-.148	.022	.220	29	.031	.001	.436	35	.384	.148	.011	118	.424	.180	<.001

[a]r = Pearson correlation coefficient (Nie et al., 1975).

[b]Metals were analyzed according to acid extraction method; samples were not filtered in the field.

NOTE: For other parameters, $r^2 < 0.30$ for all data.

3.4.6 Summary and Discussion of Potential Hydrologic Relationships

The Pearson correlation coefficients (r) suggest that positive linear relationships exist between flow rate and suspended solids for the main pond discharge and between pH and alkalinity (all water data combined). Also, significant negative linear correlations seem to exist between pH and dissolved metals, sulfate, and total dissolved solids for site 1 (all water data combined). These suggested linear relationships will be tested for other sites utilized for this project and, finally, for combinations of data from several sites or from all the sites. This is especially necessary for the pH relationships, in which data from mine OH-1 tend to cluster on the scattergrams.

Obviously, the goal is to suggest which parameters are key indicators and predictors of effluent water quality at surface mines. The parameters tested here were chosen partly on the basis of theoretical considerations that may or may not be valid in a dynamic open system such as a surface mine. The other primary consideration was observed seasonal variations in parameter concentrations; these seasonal variations suggest dependence upon flow rates and suspended solids content.

The linear relationships tested here were chosen as a first step in examining the water data from one surface mine. The larger sample size gained by combining data from several sites may increase the significance of the observed relationships at mine OH-1, or it may suggest other relationships (linear and nonlinear) not considered in this report that may have regional significance.

4 DISCUSSION OF CONTROL TECHNOLOGY EFFECTIVENESS

4.1 SUCCESS OF TREATMENT THROUGH SAMPLING PERIOD IN REDUCING IRON, MANGANESE, AND TOTAL SUSPENDED SOLIDS, AND IN INCREASING pH

Figures 12 through 15 indicate changes during the sampling period in the mine effluent parameters regulated by the U.S. Environmental Protection Agency (EPA) and by the Office of Surface Mining Reclamation and Enforcement (OSM), Department of Interior -- namely, pH, iron, manganese and total suspended solids. At this writing the latest pertinent regulations consist of the final regulations made available for public comment on Sept. 18, 1978, by OSM (Federal Register, 1978). Because the federal regulations regarding surface mine effluents are not finalized, this discussion will consider a strict interpretation of the Sept. 18, 1978 OSM regulations which impose the following effluent limitations (in mg/L, except for pH):

Effluent Characteristics[a]	Maximum Allowable[b]	Average of Daily Values for 30 Consecutive Discharge Days
Iron, total	7.0	3.5
Manganese, total[c]	4.0	2.0
Total suspended solids[d]	70.0	35.0
pH	Within the range 6.0 to 9.0	

[a]To be determined according to collection and analytical procedures adopted by the EPA's regulations for waste water analyses (40 CFR 136).

[b]Based on representative sampling.

[c]The manganese limitation shall not apply to discharges that are alkaline as defined by the Environmental Protection Agency (40 CFR 434). Where the application of neutralization and sedimentation treatment technology results inability to comply with the manganese limitations set forth, the regulatory authority may allow the pH level in the discharge to exceed to a small extent the upper limit of 9.0 in order that the manganese limitations will be achieved.

[d]In Arizona, Colorado, Montana, New Mexico, North Dakota, South Dakota, Utah, and Wyoming, total suspended solids limitations will be determined on a case-by-case basis, but they must not be greater than 45 mg/L (maximum allowable) and 30 mg/L (average of daily value for 30 consecutive discharge days) based on a representative sampling.

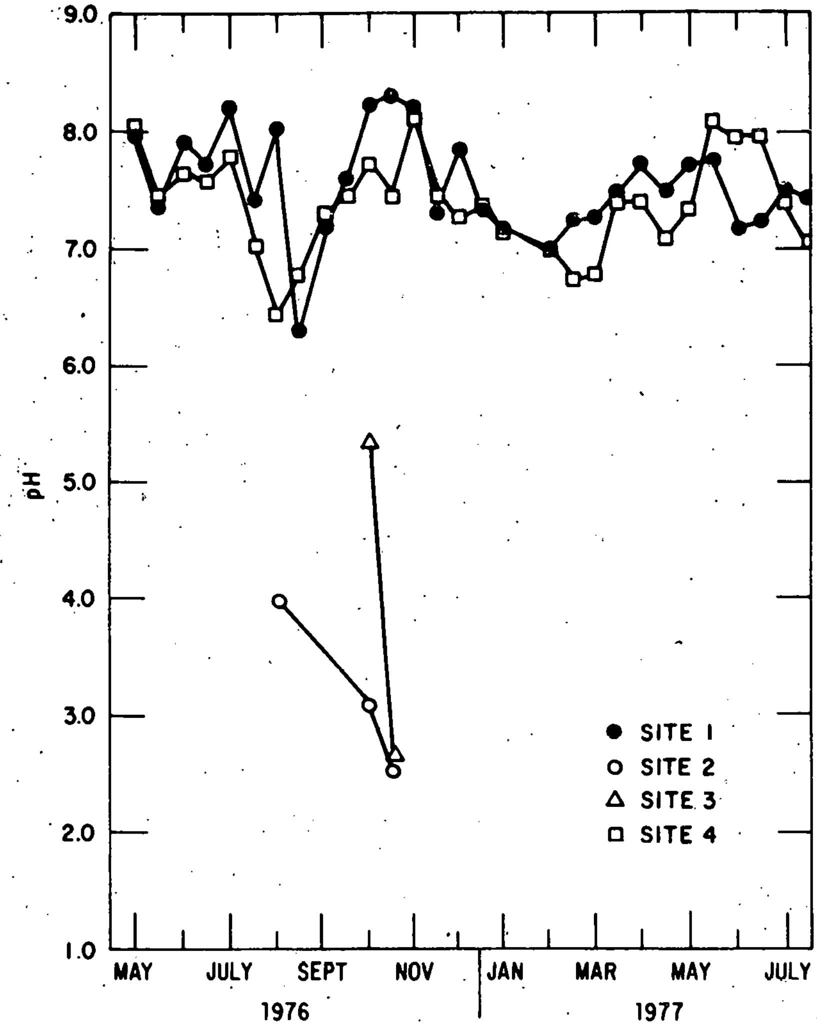

Fig. 12. Variations in pH Through Sampling Period

There is confusion regarding the EPA definition of "alkaline discharge," i.e., it is uncertain whether the effluent pH, which must be above 6.0 to be considered "alkaline," is measured before treatment or after treatment. This is an important distinction since, as noted above, the manganese restriction does not apply to "alkaline" effluents. For purposes of this discussion, the OH-1 effluent will be considered as subject to the manganese restriction, even though the pH of both sites 1 and 4 was above 6.0 through the sampling period.

The only chemical treatment at this mine consists of a soda ash dispenser between sites 2 and 3 to treat runoff from the coal storage site. It is difficult to evaluate quantitatively the effectiveness of the treatment since data for sites 2 and 3 are very limited. Qualitatively, storage pile runoff between sites 2 and 3 was seen to circumvent the soda ash treatment, so perhaps these data would not be particularly meaningful even if available.

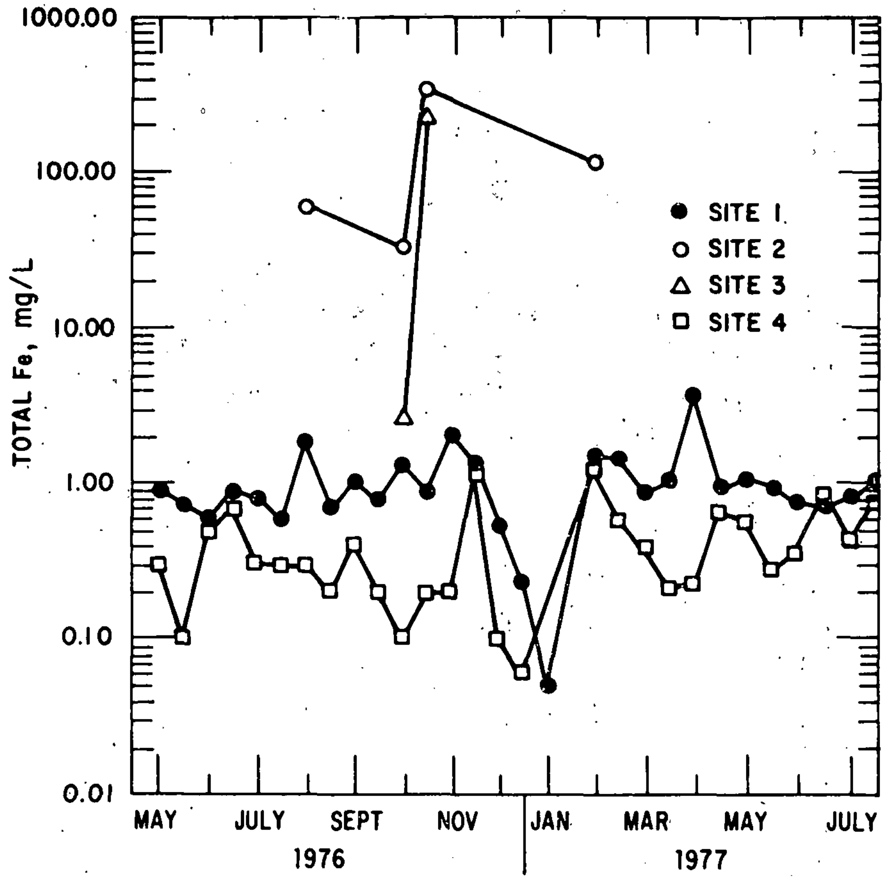

Fig. 13. Variations in Total Iron (Fe) Through Sampling Period

A comparison of the data from site 1 (which includes drainage from an unmined area as well as some mine drainage) and site 4 (the final effluent from the large settling pond) shows that concentrations of manganese frequently exceed the 4 mg/L daily maximum permitted by OSM. Manganese removal by direct oxidation is difficult at near-neutral pH. Iron concentrations at sites 1 and 4 were both below the daily maximum permitted by OSM (7 mg/ L). The TSS concentrations from the final pond (site 4) were under the OSM maximum of 70 mg/L on all but one of the sampling dates, indicating that the pond is effectively reducing suspended solids. The pond is well-engineered so that retention time is probably several days, which promotes removal of suspended solids. Values of pH at both sites 1 and 4 vary between 6.5 to 8.0, well within the OSM limits of 6.0 to 9.0. Note that the pH values for the coal pile runoff (sites 2 and 3) are well below 5.5. It is interesting to observe that on 9 October 1976 the pH for site 2 (before soda ash treatment) is well above 5.0; however, values for both sites 2 and 3 for 24 October 1976 hover around 2.7, suggesting that treatment is sporadically ineffective in raising pH. Since drainage to the pond consists of relatively large discharges draining both mined and unmined areas, dilution is significant in keeping relatively low concentrations of dissolved solids in the final effluent (site 4), despite contributions of relatively high concentrations from the storage pile runoff. Note that the iron, manganese, and TSS values for sites 2 and 3 generally far exceed the values for sites 1 and 4.

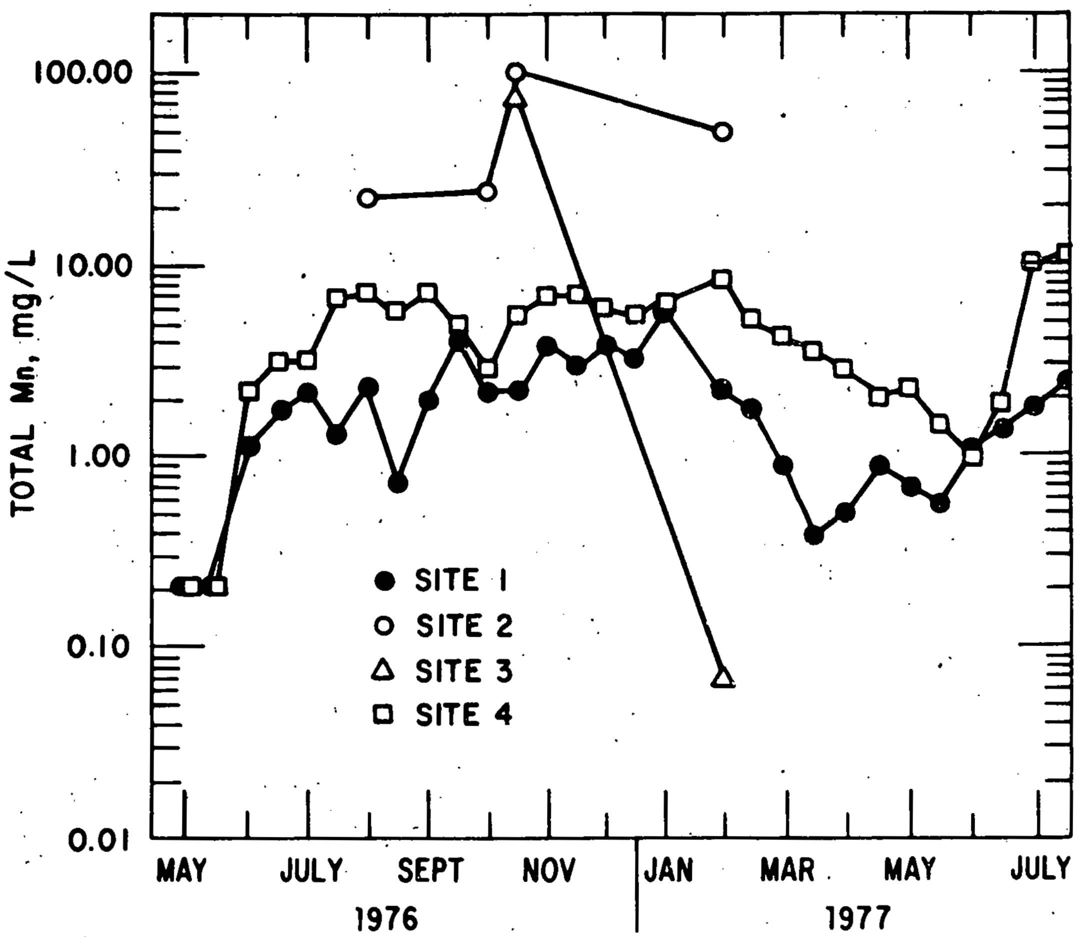

Fig. 14. Variations in Total Manganese (Mn) through Sampling Period

Obviously, seasonal variations in flow and concentrations (as shown in Fig. 12-15) are great. There is a general tendency for concentrations of dissolved metals and sulfate in mine drainage to be high during times of low flow during warm months and to peak after the first major precipitation event at the end of a dry period. Conversely, concentrations of suspended solids tend to be highest immediately after major precipitation events. Calculated loading rates for site 4 (the final effluent at mine OH-1) have the following broad ranges due to seasonal variations:

Total Iron	0.6 - 290 kg/day
Total Manganese	2.8 - 1500 kg/day
Total Suspended Solids	0.0 - 100,000 kg/day

4.2. CALCULATIONS OF TREATMENT EFFICIENCY

In order to quantify the observations derived from Fig. 12-15, a set of simple efficiency calculations were performed on the water data for the parameters regulated by OSM. Table 14 presents efficiency calculations (by date) for H^+ (calculated from pH), total suspended solids, total iron,

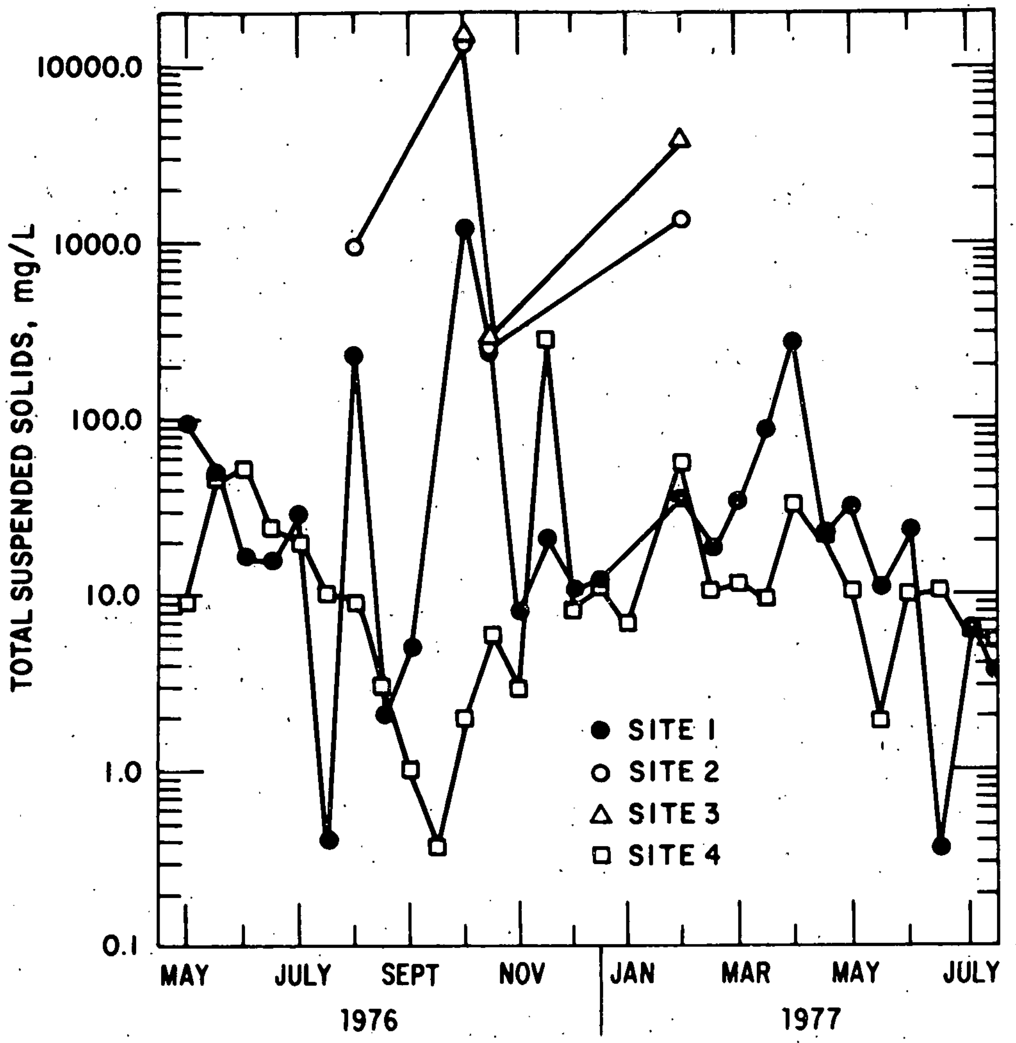

Fig. 15. Variations in Total Suspended Solids Through Sampling Period

and total manganese where there was a reduction in the parameter concentration from site 1 to site 4. The formula used was:

$$\frac{(\text{before} - \text{after})}{\text{before}} \times 100\%$$

where before > after.

In general, significant reductions in total iron and, to a lesser extent, total suspended solids, were observed, coupled with sparse reductions in H^+ and essentially no reduction in total manganese. Table 15 presents equivalent calculations for the same parameters and the same sites where there was an increase in the observed concentrations from site 1 to site 45. The formula used was:

$$\frac{|\text{before} - \text{after}|}{\text{after}} \times 100\%$$

where after > before.

The most striking increase is in total manganese. The increase in H^+ is less significant because the raw data indicate that, during the entire sampling period, pH ranged from a low of 6.3 to a high of 8.3, all values thus being within the range of 6.0 to 9.0 designated by OSM.

Efficiency calculations were not performed for sites 2 and 3, before and after the soda ash treatment, due to the sparse data. As suggested by the previous graphs (Figures 12-15), the soda ash treatment appears to be sporadically ineffective at raising the pH and reducing concentrations of dissolved solids. However, the coal storage pile runoff is considerably dilted by the great volume of water entering the large settling pond and thus forms a relatively small contribution to the total inflow to the pond. The pond itself, due to adequate retention times, is generally effective in reducing suspended solids concentrations to meet the OSM regulations. In summary, the main problem at this site pertains to total manganese concentrations, which are frequently increased from site 1 to site 4.

4.3 COMPLIANCE RATING FOR CONTROL TECHNOLOGY

4.3.1 Compliance Rating Concept

In order to compare various mine effluents with respect to regulated parameters, the concept of compliance rating (CR) was developed. The purpose of the compliance rating is to provide an order-of-magnitude indication of compliance to OSM effluent regulations. Basically, any final effluent that meets the OSM regulations receives a compliance rating of 100. Compliance ratings for effluents that do not conform to effluent guidelines receive ratings according to a declining log scale (Appendix C). That is, a compliance rating of 10 implies an order of magnitude increase over the acceptable standard. Formulas used for calculating compliance ratings are:

(1) where $pH \geq 9$: $\log pH = -.0436 \log CR + \log 11$,

(2) where $pH \leq 6$: $\log pH = .088 \log CR + \log 4$,

(3) Manganese: $\log [Mn] = -\log CR + \log 400$,

(4) Iron: $\log [Fe] = -\log CR + \log 700$, and

(5) Total suspended solids: $\log [TSS] = -\log CR + \log 7000$.

4.3.2 Compliance Ratings for Mine OH-1

In general, compliance ratings for the final effluent (site 4) at Mine OH-1 were high. Throughout the sampling period, both pH and iron rating values were 100. Except for one sample, total suspended solids ratings

Table 14. Percent Reduction in Selected Effluent Parameters after Treatment, Using Formula (B - A) x 100%/B

Date	H+ From pH	Total Suspended Solids	Total Iron	Total Manganese
05/18/76	13	90	67	0
05/29/76	13	19	86	0
06/09/76	--[a]	--	17	-
06/26/76	--	--	22	-
07/03/76	--	31	63	-
07/21/76	--	--	50	-
08/06/76	--	96	85	-
08/19/76	67	--	71	-
09/07/76	21	80	64	-
09/25/76	--	100	75	-
10/09/76	--	100	93	-
10/24/76	--	97	78	-
11/13/76	--	63	90	-
11/27/76	29	--	13	-
12/14/76	--	27	75	-
12/28/76	2	15	74	-
02/12/77	--	62	19	-
02/21/77	--	42	62	-
03/05/77	--	65	56	-
03/21/77	7	89	80	-
04/09/77	--	89	94	-
04/23/77	--	--	30	-
05/07/77	--	67	48	-
05/22/77	50	83	72	-
06/04/77	83	59	50	17
06/15/77	81	--[b]	--	--
07/16/77	--	14	47	--
07/25/77	--	--	27	--

Statistics for Table 14:

Statistic	H+ From pH	Total Suspended Solids	Total Iron	Total Manganese
Count	10	20	27	3
Minimum	2	14	13	0
Maximum	83	100	94	17
Mean	37	64	59	6
Standard Deviation	30	29	24	8

[a]Value can be found in Table 15.

[b]Divisor in calculation is zero.

Table 15. Percent Increase in Selected Effluent Parameters after Treatment, Using Formula (B - A) x 100%/B

Date	H+ From pH	Total Suspended Solids	Total Iron	Total Manganese
05/18/76	--[a]	--	--	0
05/29/76	--	--	--	0
06/09/76	44	67	--	50
06/26/76	24	29	--	94
07/03/76	60	--	--	32
07/21/76	59	96	--	79
08/06/76	98	--	--	67
08/19/76	--	33	--	87
09/07/76	--	--	--	74
09/25/76	22	--	--	16
10/09/76	70	--	--	25
10/24/76	85	--	--	63
11/13/76	22	--	--	43
11/27/76	--	92	--	58
12/14/76	74	--	--	35
12/28/76	--	--	--	42
02/12/77	5	--	--	76
02/21/77	68	--	--	65
03/05/77	68	--	--	80
03/21/77	--	--	--	89
04/09/77	55	--	--	83
04/23/77	61	4	--	57
05/07/77	56	--	--	71
05/22/77	--	--	--	62
06/04/77	--	--	--	--
06/15/77	--	100	16	21
07/16/77	28	--	--	83
07/25/77	59	33	--	78

Statistics for Table 15:

Statistic	H+ From pH	Total Suspended Solids	Total Iron	Total Manganese
Count	18	8	1	27
Minimum	5	4	16	0
Maximum	98	100	16	94
Mean	53	57	16	5
Standard Deviation	24	34	0	27

[a]Value can be found in Table 14.

Statistics for Tables 14 and 15:

Statistic	H+ From pH	Total Suspended Solids	Total Iron	Total Manganese
Count	28	28	28	28
Minimum	-98*	-100	-16	-94
Maximum	83	100	94	17
Mean	-21	30	57	-54
Standard Deviation	50	63	28	30

*Negative values indicate increases.

were also 100; the exception was one value of 22. For manganese, however, compliance ratings ranged from 33 to 100; the average value was 79 during the sampling period. Thus, compliance ratings for regulated parameters generally indicate that the mine effluent consistently met OSM standards for pH, iron, and total suspended solids but was not generally able to meet the manganese standard.

4.4 COST OF TREATMENT

4.4.1 Chemical Treatment Costs

The soda ash treatment facility on the coal storage pile is supplied and maintained by the Ohio Mining and Reclamation Association (OMRA). The OMRA indicated that 1978 delivered costs for soda ash (from a Georgia supplier) would be approximately $187.00 per ton (910 kg) in 100 lb bags (45 kg); this figure includes $140.00 basic cost and $47.00 cost to haul from Georgia. The OMRA charges $45.00 to $50.00 for the dispenser box (Tostenson, personal communication). The dispenser box is filled as needed; neither the OMRA nor the mine company could indicate how much soda ash is used in a given year or how much was used during the ECT sampling period at this site.

4.4.2 Economic Analysis of Sedimentation Ponds

In order to comply with the OSM regulations of September 18, 1978, for sedimentation ponds (Federal Register, 1978), a mine is required to have a sediment storage volume of 0.1 acre ft for every disturbed upstream acre. By planimeter, the total area of mine OH-1 was determined to be 1060 acres (424 ha); the total area of the seven sedimentation ponds was calculated to be 10 acres (4 ha). Assuming the total acreage as the "disturbed area" to determine a worst case condition, approximately 106 acre ft of storage is required. Assuming a nominal depth of 20 ft for existing ponds, they provide 200 acre ft of storage -- almost twice the amount required (assuming the total acreage as the disturbed area). In reality, the actual area disturbed by mining at any one time will be much less than the total acreage owned.

Excavation costs for these sediment ponds can be estimated using Means' Building Construction Cost Data (1977). This estimating guide indicates that unit costs for excavation using a wheel-mounted front end loader with a 1.5 yd^3 capacity would be \$0.42 yd^3 (1 yd^3 = 0.76 m^3). This figure includes the cost of labor and equipment to the coal mining company but does not include overhead or profit. Mining company personnel indicated that the cost of excavating the large 3.9 acre (1.6 hectare) settling pond near the southern end of the mine operation (Fig. 5) was approximately \$30,000 (1976). If an average depth of 20 ft (6 m) is assumed for this pond, the total volume is approximately 20,000 yd^3 (15,200 m^3). The unit cost for excavation is then about \$0.25/yd^3; this approximates the labor costs for excavation listed in the Means manual.

5 ENVIRONMENTAL EFFECTS

5.1 IMPACTS TO SURFACE WATER SYSTEMS

During the study period, the flow rate of the main settling pond discharge (site 4) averaged 14.4 L/s. As shown in Table 16, the pond effluent was slightly alkaline (average pH of 7.4) and somewhat mineralized in comparison to nearby Creek 1 (the average effluent TDS of 748 mg/L was nearly three times that of Creek 1). The elevated TDS in the pond effluent was due primarily to higher concentrations of sulfate and, to a lesser extent, calcium and magnesium. The average total iron concentration in the effluent (0.42 mg/L) was approximately four times that observed in Creek 1, while the average total manganese level (5.7 mg/L) was more than 20 times that measured in Creek 1. The manganese concentrations in the final effluent exceeded the OSM maximum of 4.0 mg/L (Federal Register, 1978) in 17 of 29 samples collected during that study.

Concentrations of total aluminum, nickel, and zinc in the final effluent were often anomalously high. Total aluminum averaged 0.35 mg/L, with a maximum of 3.2 mg/L; total nickel averaged 0.05 mg/L, with a maximum of 0.18 mg/L; and total zinc averaged 0.2 mg/L, with a maximum of 0.5 mg/L. One exceptionally high copper value (2.4 mg/L vs. the average of 0.29 mg/L) was also measured, but is suspected to be erroneous. Suspended solids in the effluent were generally low, but a few high values (up to 300 mg/L) were recorded. The average TSS was about 23 mg/L.

As discussed previously, comparison of the quality of the settling pond effluent (Site 4) with that of the unnamed tributary above the mine (Site 1) gives a qualitative indication of the effects of mine drainage on water quality in the small unnamed stream. Values for specific conductance, dissolved solids, sulfate, calcium, magnesium, and manganese in the pond effluent are significantly higher than those in the stream, which suggests a contribution from the mine area (Table 16). Iron and aluminum, on the other hand, were higher in the stream above the mine than in the pond effluent. This suggests that the high iron and aluminum in the pond effluent may not originate in the active mine area.

In order to assess the potential effects of the mine effluent on the main receiving stream (Creek 1), materials-balance calculations were undertaken for mixing of the mine effluent with Creek 1 at two Creek 1 discharge rates: the average discharge of 25,202 L/s, and a representative low discharge of 850 L/s (U.S. Geological Survey, 1974a). The following equation was used:

$$C_a = \frac{C_r D_r + C_e D_e}{D_r + D_e}$$

where:

C_a = concentration of given parameter in Creek 1 after complete mixing,

C_r = ambient Creek 1 concentration of the given parameter before addition of effluent,

C_e = concentration of the parameter in effluent,

D_r = Creek 1 flow rate, and

D_e = effluent flow rate.

Table 16. Summary of Effluent and Stream Quality, Including Materials-Balance Calculations for Mine Effluent

Parameter[a]	Tributary Above Mine[b]	Pond Effluent[c]	Creek 1[d]	Materials-Balance Calculations[e]	
Flow (L/s)	---	14.4	32,564	25,202	850
Dissolved Oxygen	9.2	9.6	9.4	---	---
pH	7.6	7.4	7.3	---	--
Spec. Cond. (μmhos/cm)	516	897	415	416	451
Chloride	5.7	7.3	7.4	7.4	7.3
Sulfate	233	498	130	132	157
Total dissolved solids	459	748	268	269	304
Total suspended solids	90.2	22.9	---	---	---
Alkalinity	86.9	54.3	---	---	---
Acidity	8.1	7.5	---	---	---
Calcium	53.7	74.6	51	51	52
Magnesium	26.4	44.6	16	17	19
Sodium	13.6	13.3	8	8	8
Potassium	2.6	3.9	2	2	2
Total Iron	1.1	0.42	0.1	0.1	0.12
Total Manganese	1.8	5.7	0.2	0.21	0.61
Total Aluminum	0.7	0.4	---	---	---

[a]Values are mg/L unless otherwise noted.

[b]Average of 28 samples collected at site 1 (tributary stream above mine).

[c]Average of 29 samples collected at site 4 (outlet of main settling pond).

[d]Results of sampling 9/26/74 below reservoir (U.S. Geological Survey, 1974a, 1974b.

[e]Results of materials-balance calculations simulating mixing of pond effluent with Creek 1 at indicated quality and river flow rates of 25,202 (long-term average) and 850 L/s (representative minimum). Flow rates measured at downstream station below reservoir (U.S. Geological Survey, 1974a.

Results of the calculations indicate that at or above the average river flow of 25,202 L/sec, no measurable increase in any of the constituents considered in Table 16 will occur in Creek 1 as a result of discharge of the mine effluent. However, at low river flow rates, sizeable increases in TDS, sulfate, and manganese could occur. It is unlikely that these increases would affect the indigenous aquatic biota of Creek 1, since the toxicities of these constituents are relatively low. Likewise, other potentially toxic trace elements in the effluent would be reduced to safe levels after mixing with the river. The environmental consequences of the increases would primarily affect domestic consumers. The indicated increases in TDS would not be of concern, but an increase in sulfate could induce laxative reactions in consumers if a sulfate level of ≃ 250 mg/L is exceeded (U.S. EPA, 1976). Consumer complaints might also arise if manganese concentration reaches about 0.2-0.5 mg/L in water supplies. These complaints would primarily involve the staining of laundry and porcelain fixtures and the imparting of objectionable tastes to drinking water (U.S. EPA, 1976; McKee and Wolf, 1963). The U.S. Public Health Service (1962) recommends that manganese concentrations be less than 0.05 mg/L in drinking water supplies for these reasons. Therefore, periodic increases of manganese, sulfate, and TDS concentrations in the watershed could be due in part to effluents from mine OH-1.

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6 SUMMARY AND CONCLUSIONS

This study, one of a series of case-study reports, has addressed two goals of the Program, namely, the environmental impact of the mine operation and an evaluation of the control technology efficacy.

The following conclusions can be drawn from this study regarding site OH-1:

1. Comparison of water quality of the final mine effluent with an unnamed tributary above the mine suggests that elevated values for specific conductance, total dissolved solids (TDS), sulfate, calcium, magnesium, manganese, and zinc can be attributed to the mine operation. Materials-balance calculations based on high and low flow rates for the stream receiving the mine effluent indicate that sulfate and manganese concentrations in the stream during periods of low flow may be objectionable if the stream is used as a public water supply.

2. The final effluent generally met standards of the U.S. Department of Interior Office of Surface Mining for iron, pH, and total suspended solids (TSS). Manganese concentrations, however, exceeded the OSM daily maximum of 4.0 mg/L in 17 of the 29 samples collected, and averaged 5.7 mg/L.

3. In general, seasonal variations in flow rates correlated positively to TSS concentrations and negatively to concentrations of dissolved constituents for the discharge from the main settling pond.

4. Limited data on drainage from the coal storage pile before and after treatment with Na_2CO_3 (soda ash) briquettes indicate that the treatment was generally ineffective. More frequent maintenance of the soda ash dispenser and proper channeling of storage pile drainage to the dispenser would promote more effective treatment.

5. Drainage from the coal storage pile is characterized by elevated levels of acid and dissolved metals, but is significantly diluted by the large volumes of alkaline water in the large settling pond.

6. Calculated Pearson correlation coefficients (r) between precipitation and flow, between ion concentrations and flow, and between ion concentrations and pH for individual sampling points were generally $< |0.5|$ where $n \geq 11$. In the case of pH vs. various metal ion concentrations (all sampling points combined), several showed strong negative correlations with pH ($-1 < r < -0.5$ where $n \geq 14$).

7. Overburden and coal chemical data indicated that the major impacts to the mine drainage are from the Middle Kittanning Coal (mainly the storage pile drainage) and the Lower Freeport Shale that overlies the coal. However, the presence of a calcite-cemented section of the Upper Freeport Sandstone mitigates the net acid-producing potential of the coal and shale units.

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APPENDIXES

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ABBREVIATIONS USED IN APPENDIXES

Al	aluminum
Ammonia-N	nitrogen as ammonia
Ca	calcium
$CaCO_3$	calcium carbonate
Cd	cadmium
Co	cobalt
Cond.	specific conductance (μmhos/cm)
Cr	chromium
Cu	copper
Diss. Oxygen or Diss. O_2	dissolved oxygen
Fe	iron
gpm	gallons/minute
Hg	mercury
HNO_3	nitric acid
K	potassium
Mg	magnesium
Mn	manganese
Mo	molybdenum
Na	sodium
Ni	nickel
Pb	lead
PO_4	phosphate
Si	silicon
Sr	strontium
TDS or TD Solids	total dissolved solids
Ti	titanium
TSS or TS Solids	total suspended solids
V	vanadium
Zn	zinc

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APPENDIX A

OVERBURDEN AND COAL CHEMISTRY DATA

Table A-1. Elemental Analyses of Overburden and Coal (ppm)

Sample No.	(Munsell) Color	Lithology	Si (x 10^4)	Al (x 10^4)	Ca (x 10^4)	Mg (x 10^4)	Fe (x 10^4)	Mn (x 10^4)	Na (x 10^4)	K (x 10^4)	PO^4 (x 10^4)	Ti (x 10^4)	Zn	Sr	Cd	Co	Cu	Pb	Mo	V	Ni	Cr
17	2.5YR8/4	Sandstone	80.4	11.3	0.04	0.47	1.21	0.06	1.38	2.66	0.02	0.66	105	50	20	35	25	125	100	50	75	25
16	2.5YR7/4	Sandstone	68.9	15.2	<0.02	0.70	5.22	0.28	1.77	4.03	0.14	1.93	200	50	20	60	20	80	100	150	80	35
15	2.5YR7/4	Sandstone	76.0	10.3	0.02	0.55	3.05	0.28	1.93	3.48	0.04	1.18	105	<50	25	30	15	135	50	150	90	35
14	10YR8/1	Sandstone	45.6	9.02	27.4	1.58	3.44	0.39	1.47	2.52	0.00	1.24	185	150	25	50	25	130	100	100	95	25
13	10YR8/1	Sandstone	48.7	9.07	29.9	1.70	3.80	0.19	1.32	2.36	0.09	1.27	500	150	20	60	30	30	150	100	90	20
12	No Sample																					
11	2.5YR8/2	Sandstone	68.5	15.8	0.02	1.13	4.37	0.12	2.11	4.05	0.04	1.53	190	50	15	500	25	150	<50	200	500	35
10	5YR7/1	Sandstone	72.5	14.1	0.02	1.12	3.33	0.28	2.07	3.31	0.00	1.31	110	<50	15	50	15	110	50	200	90	35
9	5YR6/1	Shale	57.2	17.2	0.02	1.76	7.99	0.21	1.70	6.01	0.10	2.19	225	50	15	70	45	65	50	100	75	60
8	5YR7/1	Shale	58.4	17.5	0.02	1.92	6.23	0.17	1.38	6.76	0.04	2.19	80	50	15	60	40	95	100	100	100	75
7	5YR5/1	Shale	52.0	17.9	0.02	2.30	6.99	0.25	0.69	7.41	0.21	2.46	350	50	20	75	50	125	50	150	125	85
6	5YR7/1	Shale	53.8	18.1	0.02	2.28	8.41	0.27	0.59	7.58	0.13	2.39	345	<50	20	80	45	145	<50	150	115	70
5	5YR6/1	Shale	50.6	18.0	0.02	2.08	7.72	0.27	0.59	7.57	0.17	2.56	255	50	20	55	45	65	50	300	120	60
4	5YR6/1	Shale	50.5	17.7	0.02	2.65	11.39	0.49	0.72	6.07	0.21	3.66	240	50	20	30	50	105	50	300	70	55
3	5YR6/1	Shale	53.9	18.1	0.02	2.17	7.92	0.29	0.58	7.42	0.15	2.63	275	50	20	55	50	120	100	300	120	55
2	5YR6/2	Shale	54.3	18.3	0.02	2.04	7.53	0.17	0.48	7.22	0.19	2.89	265	50	25	60	50	110	<50	300	120	65
1	5YR7/2	Shale	53.7	18.0	0.02	1.81	6.38	0.21	0.56	7.50	.004	2.45	380	50	20	65	45	90	100	300	135	80
-1C	7.5YR2/0	Upper Coal	16.0	14.2	0.17	0.95	29.39	0.07	1.06	1.01	0.12	9.36	645	100	25	600	236	155	150	200	85	85
-2C	7.5YR4/0	Clay	45.3	17.4	0.02	1.12	10.46	0.04	0.48	5.04	0.00	5.21	120	50	20	35	60	145	100	300	125	85
-3C	7.5YR2/0	Lower Coal	18.96	13.5	0.12	0.69	44.01	0.05	0.55	1.43	0.08	9.50	600	100	40	110	195	185	200	250	175	60
DC-7		Surface Sandy Shale	67.6	16.3	0.00	1.00	6.36	0.20	1.14	2.90	0.15	2.30	55	---	2.5	19.0	3.5	6.5	<5.0	10.0	13.0	10.0
DC-6		Sand Rock-base	84.8	9.16	0.00	0.54	3.25	0.09	1.01	1.80	0.06	1.19	42	---	3.0	12.5	2.5	5.5	<5.0	5.0	10.0	5.5
DC-5		Sand Rock-base	55.2	17.7	1.22	1.99	9.06	0.40	1.09	4.33	0.28	3.42	55	---	1.5	15.5	3.0	4.5	<5.0	15.0	8.0	8.5
DC-4		Hard Sandy Gray Shale	48.7	18.8	1.12	2.89	6.92	0.25	0.45	6.48	0.28	2.69	75	---	1.5	10.0	4.5	5.0	<5.0	20.0	13.0	11.5
DC-3		Dark Shale Slate, Coal	25.6	16.5	2.46	1.37	7.14	0.19	0.21	2.94	0.67	2.62	17.5	---	2.5	9.0	4.0	4.5	<5.0	15.0	11.0	9.5

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APPENDIX B
MISCELLANEOUS SUPPORTING DATA

Table B-1. Average Monthly and Annual Rainfall in Southeastern Ohio

Month	Amount cm	Amount in.
January	7.26	2.86
February	6.53	2.57
March	9.47	3.73
April	9.25	3.64
May	10.16	4.00
June	10.08	3.97
July	11.10	4.37
August	7.90	3.11
September	6.93	2.73
October	5.66	2.23
November	6.93	2.73
December	6.48	2.55
Annual	97.75	38.49

Table B-2. Summary of Analytical Methods and Detection Limits

Parameter[a]	Analytical Method	Method Reference	Lower Detection Limit
Diss. Oxygen	polarographic O_2 probe	--	---
pH (field) (standard units)	--	--	---
Specific Conductance (μmhos/cm)	Wheatstone Bridge	--	0.0
Chloride	Mohr Method	b	0.0
Sulfate	Turbidimetric	c	0
TDS	Residue on evaporation	b	0.0
TSS[e]	Filtration	b	0.4
Alkalinity, Acidity (as $CaCO_3$)	Electrometric titration	b	0.0
Al[f]	Atomic absorption	d	0.01
Ca	Atomic absorption	d	0.01
Co	Atomic absorption	d	0.02
Cr	Atomic absorption	d	0.1
Cu	Atomic absorption	d	0.02
Fe	Atomic absorption	d	0.01
K	Atomic absorption	d	0.01

Table B-2. (Contd.)

Parameter[a]	Analytical Method	Method Reference	Lower Detection Limit
Mg	Atomic absorption	d	0.01
Mo	Atomic absorption	d	0.1
Na	Atomic absorption	d	0.01
Ni	Atomic absorption	d	0.02
Pb	Atomic absorption	d	0.1
Sr	Atomic absorption	d	0.01
V	Atomic absorption	d	0.1
Zn	Atomic absorption	d	0.02

[a]All parameters reported as mg/L except where noted.

[b]Methods for Collection and Analysis of Water Samples for Dissolved Minerals and Gases, U.S. Geological Survey, 1974.

[c]Water and Wastewater Analytical Procedures, Hach Chemical Co., Ames, Iowa, Cat. No. 10, Second Revised Addition, July 1969.

[d]Methods for Collection and Analysis of Water Samples for Dissolved Minerals and Gases, U.S. Geological Survey, 1974; and/or Analytical Methods for Atomic Absorption Spectrophotometry, Perkin-Elmer Corp., Norwalk, Conn., September 1976.

[e]Filtration by a 0.45 μm Millipore system.

[f]All metals were analyzed from unfiltered, acidified (10 drops Conc. HNO_3) samples.

Table B-3. Summary of Water Quality Data Collected by Corbett and Manner (1977)

Parameter[b]:	minimum / maximum / average	Consultant Sampling Sites[a] 1		2		3		4	
Flow (L/s)	min.	----		0		0		0.536	
	max.	----		----		0.435		48.8	
	avg.	----		----		----		14.4	(29)[d]
Field pH (pH units)		6.31		2.53		2.65		6.42	
		8.30		3.98		5.35		8.12	
		7.59		3.20	(3)	4.00	(2)	7.40	(29)
Water Temp (^oC)		-0.3		0.2		0.0		0.0	
		26.6		24.2		9.5		30.6	
		----		----		----		----	
Dissolved O_2		6.0		7.2		10.6		6.0	
		14.2		14.1		12.3		14.0	
		9.2	(28)	10.3	(4)	11.4	(2)	9.6	(29)
Specific Conductance (µmhos/cm)		220		2200		3000		450	
		1610		8000		7800		1800	
		516		4125	(4)	4800	(3)	897	(29)
TDS		52		2032		2960		93	
		1540		14900		10800		1501	
		459	(28)	5695	(4)	6103	(3)	748	(29)
TSS		<0.4		266		283		<0.4	
		1115		15400		17500		298	
		90	(28)	4544	(4)	7338	(3)	23	(29)
Alkalinity (as $CaCO_3$)		20		0		0		1	
		135		0		720		127	
		87	(28)	0	(4)	263	(3)	54	(29)
Acidity (as $CaCO_3$)		2		3		0		1	
		23		5043		7165		20	
		8	(28)	1460	(4)	2412	(3)	7	(29)

Table B-3 (Contd.)

Parameter[b]:	minimum maximum average	Consultant Sampling Sites[a] 1		2		3		4	
Chloride		1.1 15.0 5.7	 (28)	7.8 2500 649	 (4)	3.9 18.0 11.3	 (3)	1.5 19.0 7.3	 (29)
Sulfate		16 750 233	 (28)	150 5200 2200	 (4)	200 5000 2333	 (3)	52 1000 498	 (29)
Calcium[c]		9.5 130 53.7		36.0 140 90.2		18.0 470 176		30.0 155 74.6	 (29)
Magnesium		9 71 26	 (28)	80 340 182	 (4)	69 270 143	 (3)	22 71 45	 (29)
Sodium		5 60 14	 (28)	10 31 17	 (4)	21 1300 557	 (3)	5 25 13	 (29)
Potassium		1.10 8.10 2.55	 (28)	0.30 10.0 4.1	 (4)	0.70 7.0 4.5	 (3)	2.1 7.9 3.9	 (29)
Iron		0.23 3.90 1.12	 (28)	34 350 144	 (4)	0.10 240 81	 (3)	0.05 1.30 .42	 (29)
Manganese		0.20 4.10 1.76	 (28)	23.0 100 49.5	 (4)	0.07 80.0 33.4	 (3)	0.20 31.0 5.72	 (29)
Aluminum		0.1 4.4 0.7	 (28)	21 300 108	 (4)	0.3 220 73	 (3)	<0.01 3.2 0.4	 (29)
Cadmium		<0.02 0.03 <0.02	 (28)	<0.01 0.08 0.03	 (4)	0.02 0.04 0.02	 (3)	<0.02 0.02 <0.02	 (29)

Table B-3 (Contd.)

Parameter[b]:	minimum maximum average	Consultant Sampling Sites[a] 1		2		3		4	
Cobalt		<0.1		0.4		<0.1		<0.1	
		<0.1		1.89		1.53		<0.1	
		<0.1	(28)	0.91	(4)	0.58	(3)	<0.1	
Chromium[c]		<0.02		0.02		<0.02		<0.02	
		0.03		0.17		0.14		0.04	
		<0.02		0.08	(4)	0.07	(3)	<0.02	(29)
Copper		<0.01		0.10		<0.01		<0.01	
		0.70		2.60		1.90		2.40	
		0.029	(28)	0.95	(4)	0.64	(3)	0.085	(29)
Nickel		<0.02		0.52		<0.02		<0.02	
		0.07		4.10		3.30		0.18	
		<0.02		1.79	(4)	1.27	(3)	0.05	(29)
Strontium		0.07		0.10		0.04		0.07	
		2.10		0.58		0.82		0.92	
		0.33	(28)	0.42	(4)	0.32	(3)	0.49	(29)
Zinc		<0.02		1.90		0.02		0.04	
		0.10		23.0		16.0		0.50	
		0.03	(28)	9.4	(4)	5.6	(3)	0.20	(29)

[a]Sampling station 1 -- upstream of main settling pond.
Sampling station 2 -- coal storage pile drainage upstream from soda ash treatment.
Sampling station 3 -- coal storage pile drainage downstream from soda ash treatment.
Sampling station 4 -- outlet of main settling pond.

[b]All parameters reported as mg/L except where noted.

[c]All metals were analyzed from unfiltered, acidified samples (acid extraction method).

[d]Number in parentheses refers to number of measurements.

KEY TO WATER DATA IN TABLE B-4

OH1 = Mine OH-1

05/18/1976, etc. = Date of samples (SAMP DATE)

CSUL STATION = consultant station

ANL STATION = Argonne station

STATION DESC & LOCATION = Station description and location

DO = dissolved oxygen (mg/L)

PHF = field pH

WTEMP = water temp. (°C)

CONDF = field conductivity (micromhos/cm)

$N-NH_4$ = nitrogen as ammonia (mg/L)

CL = chloride (mg/L)

F = fluoride (mg/L)

SO_4 = sulfate (mg/L)

CO_3 = carbonate (mg/L)

HCO_3 = bicarbonate (mg/L)

TDS = total dissolved solids (mg/L)

TSS = total suspended solids (mg/L)

ALK = alkalinity (mg/L)

ACID = acidity (mg/L)

D + symbol for chemical element = dissolved concentration of element (mg/L)

T + symbol for chemical element = total concentration of element (mg/L)

DFET = total dissolved iron (mg/L)

TFET = total iron (mg/L)

DISC = discharge (liters/minute)

Table B-4. Water Quality Data

ANL MINE CODE OH1 CSUL STATION 1

SAMP DATE					
05/18/1976					
STATION DESC & LOC		WTEMP			
UPSTREAM FROM SETTLING POND		13.5			
CONDF	PHF	ALK	ACID	CO3	HCO3
380.000000	7.970000	75.000000	5.000000		
CL	F	SO4	N-NH4	DAL	DCA
6.500000		160.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.900000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.010000
TFET	THG	TMN	TNI	TPB	TSB
.900000		.200000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.030000		

SAMP DATE					
05/29/1976					
STATION DESC & LOC		WTEMP			
UPSTREAM FROM SETTLING POND		20.2			
CONDF	PHF	ALK	ACID	CO3	HCO3
380.000000	7.350000	71.000000	5.000000		
CL	F	SO4	N-NH4	DAL	DCA
2.500000		380.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					1.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.020000
TFET	THG	TMN	TNI	TPB	TSB
.700000		.200000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.040000		

ANL MINE CODE OH1 CSUL STATION 1

SAMP DATE
06/09/1976

STATION DESC & LOC		WTEMP			
UPSTREAM FROM SETTLING POND		23.6			
CONDF	PHF	ALK	ACID	CO3	HCO3
400.000000	7.900000	73.000000	5.000000		
CL	F	SO4	N-NH4	DAL	DCA
5.310000		180.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.500000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.020000
TFET	THG	TMN	TNI	TPB	TSB
.600000		1.100000	.040000	.000000	
TSE	TTL	TV	TZN		
		.000000	.000000		

SAMP DATE
06/26/1976

STATION DESC & LOC		WTEMP			
UPSTREAM FROM SETTLING POND		23.8			
CONDF	PHF	ALK	ACID	CO3	HCO3
470.000000	7.700000	92.000000	2.000000		
CL	F	SO4	N-NH4	DAL	DCA
5.600000		180.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.400000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.900000		1.800000	.030000	.000000	
TSE	TTL	TV	TZN		
		.100000	.020000		

ANL MINE CODE OH1 CSUL STATION 1

SAMP DATE
07/03/1976
STATION DESC & LOC
UPSTREAM FROM SETTLING POND

		WTEMP			
		18.9			
CONDF	PHF	ALK	ACID	CO3	HCO3
620.000000	8.180000	93.000000	5.000000		
CL	F	SO4	N-NH4	DAL	DCA
3.800000		280.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.300000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.800000		2.100000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.020000		

SAMP DATE
07/21/1976
STATION DESC & LOC
UPSTREAM FROM SETTLING POND

		WTEMP			
		21.5			
CONDF	PHF	ALK	ACID	CO3	HCO3
480.000000	7.400000	80.000000	13.000000		
CL	F	SO4	N-NH4	DAL	DCA
2.400000		160.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.100000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.600000		1.400000	.050000	.000000	
TSE	TTL	TV	TZN		
		.000000	.000000		

ANL MINE CODE OH1 — CSUL STATION 1

SAMP DATE
08/06/1976

STATION DESC & LOC		WTEMP			
UPSTREAM FROM SETTLING POND		21.0			
CONDF	PHF	ALK	ACID	CO3	HCO3
660.000000	8.030000	62.000000	6.000000		
CL	F	SO4	N-NH4	DAL	DCA
1.800000		380.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					1.100000
TAS	TBA	TBE	TCD	TCR	TCU
			.010000	.010000	.010000
TFET	THG	TMN	TNI	TPB	TSB
1.900000		2.300000	.030000	.000000	
TSE	TTL	TV	TZN		
		.000000	.040000		

SAMP DATE
08/19/1976

STATION DESC & LOC		WTEMP			
UPSTREAM FROM SETTLING POND		18.1			
CONDF	PHF	ALK	ACID	CO3	HCO3
250.000000	6.310000	65.000000	10.000000		
CL	F	SO4	N-NH4	DAL	DCA
3.300000		120.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.700000		.720000	.020000	.000000	
TSE	TTL	TV	TZN		
		.000000	.000000		

ANL MINE CODE OH1 CSUL STATION 1

SAMP DATE
09/07/1976
STATION DESC & LOC — WTEMP
UPSTREAM FROM SETTLING POND — 16.2

CONDF	PHF	ALK	ACID	CO3	HCO3
470.000000	7.200000	82.000000	19.000000		
CL	F	SO4	N-NH4	DAL	DCA
13.000000		160.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
1.100000		1.900000	.020000	.000000	
TSE	TTL	TV	TZN		
		.000000	.000000		

SAMP DATE
09/25/1976
STATION DESC & LOC — WTEMP
UPSTREAM FROM SETTLING POND — 13.7

CONDF	PHF	ALK	ACID	CO3	HCO3
1610.000000	7.590000	89.000000	23.000000		
CL	F	SO4	N-NH4	DAL	DCA
10.000000		750.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.600000
TAS	TBA	TBE	TCD	TCR	TCU
			.030000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.800000		4.100000	.030000	.000000	
TSE	TTL	TV	TZN		
		.000000	.020000		

ANL MINE CODE OH1 CSUL STATION 1

SAMP DATE
10/09/1976
STATION DESC & LOC — WTEMP
UPSTREAM FROM SETTLING POND — 9.9

CONDF	PHF	ALK	ACID	CO3	HCO3
520.000000	8.240000	77.000000	15.000000		
CL	F	SO4	N-NH4	DAL	DCA
1.900000		16.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					2.500000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.030000	.020000
TFET	THG	TMN	TNI	TPB	TSB
1.400000		2.100000	.070000	.000000	
TSE	TTL	TV	TZN		
		.000000	.100000		

SAMP DATE
10/24/1976
STATION DESC & LOC — WTEMP
UPSTREAM FROM SETTLING POND — 7.7

CONDF	PHF	ALK	ACID	CO3	HCO3
420.000000	8.300000	48.000000	19.000000		
CL	F	SO4	N-NH4	DAL	DCA
9.200000		50.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					4.400000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.010000
TFET	THG	TMN	TNI	TPB	TSB
.900000		2.100000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.100000		

ANL MINE CODE OH1 CSUL STATION 1

SAMP DATE
11/13/76
STATION DESC & LOC
UPSTREAM FROM SETTLING POND

		WTEMP			
		1.8			
CONDF	PHF	ALK	ACID	CO3	HCO3
880.000000	8.230000	87.000000	2.000000		
CL	F	SO4	N-NH4	DAL	DCA
3.800000		550.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
2.100000		3.900000	.070000	.000000	
TSE	TTL	TV	TZN		
		.000000	.070000		

SAMP DATE
11/27/1976
STATION DESC & LOC
UPSTREAM FROM SETTLING POND

		WTEMP			
		9.9			
CONDF	PHF	ALK	ACID	CO3	HCO3
580.000000	7.340000	93.000000	4.700000		
CL	F	SO4	N-NH4	DAL	DCA
3.100000		260.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.300000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
1.500000		3.000000	.030000	.000000	
TSE	TTL	TV	TZN		
		.100000	.030000		

ANL MINE CODE OH1 CSUL STATION 1

SAMP DATE
12/14/1976
STATION DESC & LOC WTEMP
UPSTREAM FROM SETTLING POND .0

CONDF	PHF	ALK	ACID	CO3	HCO3
520.000000	7.890000	100.000000	19.000000		
CL	F	SO4	N-NH4	DAL	DCA
1.100000		220.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.400000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.400000		3.900000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.030000		

SAMP DATE
12/28/1976
STATION DESC & LOC WTEMP
UPSTREAM FROM SETTLING POND .0

CONDF	PHF	ALK	ACID	CO3	HCO3
620.000000	7.390000	92.000000	2.300000		
CL	F	SO4	N-NH4	DAL	DCA
3.800000		300.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.230000		3.300000	.040000	.000000	
TSE	TTL	TV	TZN		
		.000000	.030000		

ANL MINE CODE OH1 CSUL STATION 1

SAMP DATE
02/12/1977
STATION DESC & LOC
UPSTREAM FROM SETTLING POND

WTEMP
.0

CONDF	PHF	ALK	ACID	CO3	HCO3
420.000000	7.010000	71.000000	9.800000		
CL	F	SO4	N-NH4	DAL	DCA
4.000000		170.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					1.100000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
1.600000		2.200000	.020000	.000000	
TSE	TTL	TV	TZN		
		.000000	.020000		

SAMP DATE
02/21/1977
STATION DESC & LOC
UPSTREAM FROM SETTLING POND

WTEMP
.0

CONDF	PHF	ALK	ACID	CO3	HCO3
430.000000	7.280000	135.000000	3.600000		
CL	F	SO4	N-NH4	DAL	DCA
5.700000		160.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
1.600000		1.800000	.040000	.000000	
TSE	TTL	TV	TZN		
		.100000	.030000		

ANL MINE CODE OH1 CSUL STATION 1

SAMP DATE					
03/05/1977					
STATION DESC & LOC		WTEMP			
UPSTREAM FROM SETTLING POND		4.2			
CONDF	PHF	ALK	ACID	CO3	HCO3
310.000000	7.300000	83.000000	6.100000		
CL	F	SO4	N-NH4	DAL	DCA
7.800000		80.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.500000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.900000		.900000	.040000	.000000	
TSE	TTL	TV	TZN		
		.000000	.020000		

SAMP DATE					
03/21/1977					
STATION DESC & LOC		WTEMP			
UPSTREAM FROM SETTLING POND		12.3			
CONDF	PHF	ALK	ACID	CO3	HCO3
220.000000	7.450000	64.000000	4.400000		
CL	F	SO4	N-NH4	DAL	DCA
3.700000		70.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.800000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
1.080000		.400000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.020000		

ANL MINE CODE OH1 CSUL STATION 1

SAMP DATE
04/09/1977
STATION DESC & LOC — WTEMP
UPSTREAM FROM SETTLING POND — 13.0

CONDF	PHF	ALK	ACID	CO3	HCO3
220.000000	7.770000	20.000000	8.400000		
CL	F	SO4	N-NH4	DAL	DCA
6.500000		90.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					1.300000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.010000
TFET	THG	TMN	TNI	TPB	TSB
3.900000		.500000	.030000	.000000	
TSE	TTL	TV	TZN		
		.000000	.080000		

SAMP DATE
04/23/1977
STATION DESC & LOC — WTEMP
UPSTREAM FROM SETTLING POND — 17.7

CONDF	PHF	ALK	ACID	CO3	HCO3
300.000000	7.530000	134.000000	5.600000		
CL	F	SO4	N-NH4	DAL	DCA
3.600000		115.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.400000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.700000
TFET	THG	TMN	TNI	TPB	TSB
1.000000		.900000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.000000		

SAMP DATE
05/07/1977

STATION DESC & LOC		WTEMP			
UPSTREAM FROM SETTLING POND		16.7			
CONDF	PHF	ALK	ACID	CO3	HCO3
270.000000	7.750000	100.000000	6.000000		
CL	F	SO4	N-NH4	DAL	DCA
4.100000		85.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.500000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
1.150000		.700000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.000000		

SAMP DATE
06/04/1977

STATION DESC & LOC		WTEMP			
UPSTREAM FROM SETTLING POND		16.3			
CONDF	PHF	ALK	ACID	CO3	HCO3
640.000000	7.210000	94.000000	7.000000		
CL	F	SO4	N-NH4	DAL	DCA
6.800000		270.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.300000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.780000		1.200000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.000000		

ANL MINE CODE OH1 CSUL STATION 1

SAMP DATE
06/15/1977

STATION DESC & LOC	WTEMP
UPSTREAM FROM SETTLING POND	17.9

CONDF	PHF	ALK	ACID	CO3	HCO3
570.000000	7.270000	108.000000	4.100000		
CL	F	SO4	N-NH4	DAL	DCA
11.000000		310.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.780000		1.500000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.000000		

SAMP DATE
07/16/1977

STATION DESC & LOC	WTEMP
UPSTREAM FROM SETTLING POND	23.7

CONDF	PHF	ALK	ACID	CO3	HCO3
680.000000	7.540000	134.000000	7.600000		
CL	F	SO4	N-NH4	DAL	DCA
9.900000		390.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.870000		1.900000	.020000	.000000	
TSE	TTL	TV	TZN		
		.000000	.030000		

ANL MINE CODE OH1 CSUL STATION 1

07/25/1977

STATION DESC & LOC ATEMP WTEMP

UPSTREAM FROM SETTLING POND 22.3

CONDF	PHF	ALK	ACID	CO3	HCO3
700.000000	7.490000	133.000000	5.900000		
CL	F	SO4	N-NH4	DAL	DCA
15.000000		480.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.700000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.010000
TFET	THG	TMN	TNI	TPB	TSB
1.130000		2.700000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.000000		

ANL MINE CODE OH1 CSUL STATION APTK

SAMP DATE

03/21/1977

STATION DESC & LOC ATEMP WTEMP

UPSTREAM FROM SETTLING POND

CONDF	PHF	ALK	ACID	CO3	HCO3
125.000000	6.300000	2706.000000	8.160000	.000000	33.000000
CL	F	SO4	N-NH4	DAL	DCA
.000000	.160000	71.000000	.350000		26.100000
DCD	DCO	DCR	DCU	DFET	DHG
					.000000
DK	DMG	DMN	DMO	DNA	DNI
1.900000	10.500000			6.100000	
DPB	DSR	DV	DZN	TAG	TAL
	.500000			.000000	1.060000
TAS	TBA	TBE	TCD	TCR	TCU
1.000000	.000000	.000000	.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
1.740000	.000000	.680000	.020000	.000000	.000000
TSE	TTL	TV	TZN		
.470000	.040000	.000000	.020000		

ANL MINE CODE OH1 CSUL STATION 2

SAMP DATE
08/06/1976

STATION DESC & LOC		WTEMP			
COAL PILE DRAINAGE ABOVE TMT		24.2			
CONDF	PHF	ALK	ACID	CO3	HCO3
2200.000000	3.980000	.000000	293.000000		
CL	F	SO4	N-NH4	DAL	DCA
16.000000		1350.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					21.000000
TAS	TBA	TBE	TCD	TCR	TCU
			.020000	.020000	.100000
TFET	THG	TMN	TNI	TPB	TSB
64.000000		23.000000	.520000	.040000	
TSE	TTL	TV	TZN		
		.000000	1.900000		

SAMP DATE
10/09/1976

STATION DESC & LOC	ATEMP	WTEMP			
COAL PILE DRAINAGE ABOVE TMT		9.8			
CONDF	PHF	ALK	ACID	CO3	HCO3
2500.000000	3.100000	.000000	500.000000		
CL	F	SO4	N-NH4	DAL	DCA
71.000000		150.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					36.000000
TAS	TBA	TBE	TCD	TCR	TCU
			.010000	.100000	.400000
TFET	THG	TMN	TNI	TPB	TSB
34.000000		25.000000	.940000	.000000	
TSE	TTL	TV	TZN		
		.100000	4.500000		

ANL MINE CODE OH1 CSUL STATION 2

SAMP DATE
10/24/1976

STATION DESC & LOC		WTEMP			
COAL PILE DRAINAGE ABOVE TMT		9.3			
CONDF	PHF	ALK	ACID	CO3	HCO3
8000.000000	2.530000	.000000	5043.000000		
CL	F	SO4	N-NH4	DAL	DCA
2500.000000		5200.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					300.000000
TAS	TBA	TBE	TCD	TCR	TCU
			.080000	.170000	2.600000
TFET	THG	TMN	TNI	TPB	TSB
350.000000		100.000000	4.100000	.150000	
TSE	TTL	TV	TZN		
		.200000	23.000000		

SAMP DATE
02/12/1977

STATION DESC & LOC		WTEMP			
COAL PILE DRAINAGE ABOVE TMT		.2			
CONDF	PHF	ALK	ACID	CO3	HCO3
380.000000		.000000	3.000000		
CL	F	SO4	N-NH4	DAL	DCA
7.800000		2100.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					75.000000
TAS	TBA	TBE	TCD	TCR	TCU
			.030000	.030000	.700000
TFET	THG	TMN	TNI	TPB	TSB
130.000000		50.000000	1.600000	.000000	
TSE	TTL	TV	TZN		
		.200000	8.100000		

ANL MINE CODE OH1 — CSUL STATION ACSB

SAMP DATE
03/21/1977
STATION DESC & LOC — WTEMP
COAL PILE DRAINAGE ABOVE TMT

CONDF	PHF	ALK	ACID	CO3	HCO3
2790.000000	2.300000	.000000	10400.000000	.000000	.000000
CL	F	SO4	N-NH4	DAL	DCA
		2900.000000	1.750000	810.000000	340.000000
DCD	DCO	DCR	DCU	DFET	DHG
.200000	4.450000	.000000	3.050000	2460.000000	.000000
DK	DMG	DMN	DMO	DNA	DNI
1.000000	419.000000	168.000000	.040000	11.900000	7.950000
DPB	DSR	DV	DZN	TAG	TAL
.000000	.500000	.000000	21.050000	.000000	454.000000
TAS	TBA	TBE	TCD	TCR	TCU
4.500000	.300000	.060000	.090000	.000000	2.400000
TFET	THG	TMN	TNI	TPB	TSB
2855.000000	.000750	148.100000	4.600000	1.150000	.480000
TSE	TTL	TV	TZN		
.720000	.500000	.250000	14.700000		

ANL MINE CODE OH1 — CSUL STATION 3

SAMP DATE
10/09/1976
STATION DESC & LOC — ATEMP — WTEMP
COAL PILE BELOW DRAINAGE TMT

CONDF	PHF	ALK	ACID	CO3	HCO3
3000.000000	5.350000	70.000000	70.000000		
CL	F	SO4	N-NH4	DAL	DCA
3.900000		200.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.400000
TAS	TBA	TBE	TCD	TCR	TCU
			.010000	.070000	.010000
TFET	THG	TMN	TNI	TPB	TSB
2.700000		20.000000	.500000	.000000	
TSE	TTL	TV	TZN		
		.000000	.700000		

ANL MINE CODE OH1 CSUL STATION 3

SAMP DATE
10/24/1976
STATION DESC & LOC WTEMP
COAL PILE BELOW DRAINAGE TMT 9.5

CONDF	PHF	ALK	ACID	CO3	HCO3
7800.000000	2.650000	.00000			
					TSB
2.700000		20.000000	.500000	.000000	
TSE	TTL	TV	TZN		
		.000000	.700000		

SAMP DATE
10/24/1976
STATION DESC & LOC WTEMP
COAL PILE BELOW DRAINAGE TMT 9.5

CONDF	PHF	ALK	ACID	CO3	HCO3
7800.000000	2.650000	.000000	7165.000000		
CL	F	SO4	N-NH4	DAL	DCA
18.000000		5000.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					220.000000
TAS	TBA	TBE	TCD	TCR	TCU
			.040000	.140000	1.900000
TFET	THG	TMN	TNI	TPB	TSB
240.000000		80.000000	3.300000	.000000	
TSE	TTL	TV	TZN		
		.200000	16.000000		

ANL MINE CODE OH1 — CSUL STATION 3

SAMP DATE
02/12/1977
STATION DESC & LOC — WTEMP
COAL PILE BELOW DRAINAGE TMT — .0

CONDF	PHF	ALK	ACID	CO3	HCO3
360.000000		720.000000	.000000		
CL	F	SO4	N-NH4	DAL	DCA
12.000000		1800.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.300000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.100000		.070000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.020000		

ANL MINE CODE OH1 — CSUL STATION 4

SAMP DATE
05/18/1976
STATION DESC & LOC — WTEMP
SETTLING POND EFFLUENT — 16.2

CONDF	PHF	ALK	ACID	CO3	HCO3
450.000000	8.030000	65.000000	1.000000		
CL	F	SO4	N-NH4	DAL	DCA
9.200000		350.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.000000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.010000
TFET	THG	TMN	TNI	TPB	TSB
.300000		.200000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.050000		

ANL MINE CODE OH1 CSUL STATION 4

05/29/1976

STATION DESC & LOC — WTEMP

SETTLING POND EFFLUENT — 21.8

CONDF	PHF	ALK	ACID	CO3	HCO3
700.000000	7.410000	79.000000	2.000000		
CL	F	SO4	N-NH4	DAL	DCA
1.500000		460.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.000000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.010000
TFET	THG	TMN	TNI	TPB	TSB
.100000		.200000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.040000		

SAMP DATE

06/09/1976

STATION DESC & LOC — WTEMP

SETTLING POND EFFLUENT — 27.5

CONDF	PHF	ALK	ACID	CO3	HCO3
620.000000	7.650000	63.000000	7.000000		
CL	F	SO4	N-NH4	DAL	DCA
9.850000		550.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.600000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.020000
TFET	THG	TMN	TNI	TPB	TSB
.500000		2.200000	.040000	.000000	
TSE	TTL	TV	TZN		
		.200000	.070000		

ANL MINE CODE OH1 CSUL STATION 4

SAMP DATE
06/26/1976
STATION DESC & LOC
SETTLING POND EFFLUENT

		WTEMP			
		27.5			
CONDF	PHF	ALK	ACID	CO3	HCO3
860.000000	7.580000	60.000000	2.000000		
CL	F	SO4	N-NH4	DAL	DCA
7.800000		580.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.100000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.700000		31.000000	.020000	.000000	
TSE	TTL	TV	TZN		
		.200000	.090000		

SAMP DATE
07/03/1976
STATION DESC & LOC
SETTLING POND EFFLUENT

		WTEMP			
		24.5			
CONDF	PHF	ALK	ACID	CO3	HCO3
880.000000	7.780000	63.000000	10.000000		
CL	F	SO4	N-NH4	DAL	DCA
9.200000		620.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.100000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.300000		3.100000	.030000	.000000	
TSE	TTL	TV	TZN		
		.000000	.080000		

ANL MINE CODE OH1 CSUL STATION 4

SAMP DATE
07/21/1976
STATION DESC & LOC WTEMP
SETTLING POND EFFLUENT 27.8

CONDF	PHF	ALK	ACID	CO3	HCO3
950.000000	7.010000	20.000000	6.000000		
CL	F	SO4	N-NH4	DAL	DCA
6.900000		650.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.100000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TSB	
.300000		6.700000	.050000	.000000	
TSE	TTL	TV	TZN		
		.100000	.300000		

SAMP DATE
08/06/1976
STATION DESC & LOC WTEMP
SETTLING POND EFFLUENT 24.6

CONDF	PHF	ALK	ACID	CO3	HCO3
1100.000000	6.420000	20.000000	5.000000		
CL	F	SO4	N-NH4	DAL	DCA
2.700000		450.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.100000
TAS	TBA	TBE	TCD	TCR	TCU
			.010000	.010000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.300000		7.000000	.130000	.030000	
TSE	TTL	TV	TZN		
		.000000	.200000		

ANL MINE CODE OH1 CSUL STATION 4

09/07/1976
STATION DESC & LOC
SETTLING POND EFFLUENT

		WTEMP			
		24.0			
CONDF	PHF	ALK	ACID	CO3	HCO3
920.000000	7.300000	23.000000	13.000000		
CL	F	SO4	N-NH4	DAL	DCA
16.000000		550.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.100000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.400000		7.400000	.100000	.000000	
TSE	TTL	TV	TZN		
		.000000	.200000		

SAMP DATE
09/25/1976
STATION DESC & LOC
SETTLING POND EFFLUENT

		WTEMP			
		18.2			
CONDF	PHF	ALK	ACID	CO3	HCO3
1220.000000	7.480000	38.000000	11.000000		
CL	F	SO4	N-NH4	DAL	DCA
14.000000		550.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.020000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.200000		4.900000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.100000		

ANL MINE CODE OH1 CSUL STATION 4

SAMP DATE
10/09/1976
STATION DESC & LOC — WTEMP
SETTLING POND EFFLUENT — 13.7

CONDF	PHF	ALK	ACID	CO3	HCO3
1220.000000	7.710000	48.000000	15.000000		
CL	F	SO4	N-NH4	DAL	DCA
4.400000		52.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.100000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.040000	.010000
TFET	THG	TMN	TNI	TPB	TSB
.100000		2.800000	.010000	.000000	
TSE	TTL	TV	TZN		
		.000000	.100000		

SAMP DATE
10/24/1976
STATION DESC & LOC — WTEMP
SETTLING POND EFFLUENT — 8.2

CONDF	PHF	ALK	ACID	CO3	HCO3
1200.000000	7.480000	24.000000	12.000000		
CL	F	SO4	N-NH4	DAL	DCA
11.000000		550.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.800000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.200000		5.600000	.130000	.000000	
TSE	TTL	TV	TZN		
		.000000	.300000		

ANL MINE CODE OH1 CSUL STATION 4

SAMP DATE
11/13/1976
STATION DESC & LOC
SETTLING POND EFFLUENT

WTEMP
3.8

CONDF	PHF	ALK	ACID	CO3	HCO3
1100.000000	8.120000	25.000000	4.000000		
CL	F	SO4	N-NH4	DAL	DCA
4.400000		620.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.200000		6.900000	.170000	.000000	
TSE	TTL	TV	TZN		
		.000000	.400000		

SAMP DATE
11/27/1976
STATION DESC & LOC
SETTLING POND EFFLUENT

WTEMP
6.7

CONDF	PHF	ALK	ACID	CO3	HCO3
1180.000000	7.490000	40.000000	3.500000		
CL	F	SO4	N-NH4	DAL	DCA
5.200000		1000.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					3.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.020000	.000000
TFET	THG	TMN	TNI	TPB	TSB
1.300000		7.100000	.150000	.000000	
TSE	TTL	TV	TZN		
		.000000	.400000		

ANL MINE CODE OH1 — CSUL STATION 4

SAMP DATE
12/14/1976
STATION DESC & LOC — SETTLING POND EFFLUENT
WTEMP 2.7

CONDF	PHF	ALK	ACID	CO3	HCO3
970.000000	7.300000	67.000000	14.000000		
CL	F	SO4	N-NH4	DAL	DCA
5.300000		700.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.100000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.100000		6.000000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.300000		

SAMP DATE
01/15/1977
STATION DESC & LOC — SETTLING POND EFFLUENT
WTEMP .5

CONDF	PHF	ALK	ACID	CO3	HCO3
1800.000000	7.180000	77.000000	8.800000		
CL	F	SO4	N-NH4	DAL	DCA
3.900000		700.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.050000		6.100000	.120000	.000000	
TSE	TTL	TV	TZN		
		.000000	.300000		

ANL MINE CODE OH1 CSUL STATION 4

SAMP DATE
02/12/1977

STATION DESC & LOC		WTEMP			
SETTLING POND EFFLUENT		.8			
CONDF	PHF	ALK	ACID	CO3	HCO3
1050.000000	6.990000	85.000000	20.000000		
CL	F	SO4	N-NH4	DAL	DCA
11.000000		430.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.300000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
1.300000		9.000000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.500000		

SAMP DATE
02/21/1977

STATION DESC & LOC		WTEMP			
SETTLING POND EFFLUENT		.0			
CONDF	PHF	ALK	ACID	CO3	HCO3
700.000000	6.790000	127.000000	5.800000		
CL	F	SO4	N-NH4	DAL	DCA
6.300000		300.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.300000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.600000		5.100000	.050000	.000000	
TSE	TTL	TV	TZN		
		.000000	.200000		

ANL MINE CODE OH1 CSUL STATION 4

SAMP DATE
03/05/1977

STATION DESC & LOC		WTEMP			
SETTLING POND EFFLUENT		4.2			
CONDF	PHF	ALK	ACID	CO3	HCO3
810.000000	6.810000	69.000000	7.600000		
CL	F	SO4	N-NH4	DAL	DCA
4.800000		420.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.300000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.400000		4.400000	.060000	.000000	
TSE	TTL	TV	TZN		
		.000000	.200000		

SAMP DATE
03/21/1977

STATION DESC & LOC		WTEMP			
SETTLING POND EFFLUENT		8.4			
CONDF	PHF	ALK	ACID	CO3	HCO3
620.000000	7.480000	63.000000	3.800000		
CL	F	SO4	N-NH4	DAL	DCA
5.400000		330.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
	.000000				.400000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.220000		3.800000	.040000	.000000	
TSE	TTL	TV	TZN		
		.000000	.010000		

ANL MINE CODE OH1 CSUL STATION 4

SAMP DATE
04/09/1977
STATION DESC & LOC
SETTLING POND EFFLUENT

WTEMP
11.2

CONDF	PHF	ALK	ACID	CO3	HCO3
520.000000	7.420000	21.000000	7.100000		
CL	F	SO4	N-NH4	DAL	DCA
4.500000		240.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.300000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.240000		3.000000	.020000	.000000	
TSE	TTL	TV	TZN		
		.000000	.100000		

SAMP DATE
04/23/1977
STATION DESC & LOC
SETTLING POND EFFLUENT

WTEMP
19.9

CONDF	PHF	ALK	ACID	CO3	HCO3
500.000000	7.120000	85.000000	4.900000		
CL	F	SO4	N-NH4	DAL	DCA
2.400000		175.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.300000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	2.400000
TFET	THG	TMN	TNI	TPB	TSB
.700000		2.100000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.080000		

ANL MINE CODE OHI — CSUL STATION 4

SAMP DATE
05/07/1977
STATION DESC & LOC
SETTLING POND EFFLUENT

		WTEMP			
		20.3			
CONDF	PHF	ALK	ACID	CO3	HCO3
520.000000	7.390000	93.000000	1.000000		
CL	F	SO4	N-NH4	DAL	DCA
7.600000		215.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.600000		2.400000	.040000	.000000	
TSE	TTL	TV	TZN		
		.000000	.090000		

SAMP DATE
05/22/1977
STATION DESC & LOC
SETTLING POND EFFLUENT

		WTEMP			
		27.0			
CONDF	PHF	ALK	ACID	CO3	HCO3
520.000000	8.100000	64.000000	6.600000		
CL	F	SO4	N-NH4	DAL	DCA
7.300000		245.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.300000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.280000		1.600000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.050000		

ANL MINE CODE OH1 CSUL STATION 4

SAMP DATE
06/04/1977
STATION DESC & LOC
SETTLING POND EFFLUENT

WTEMP
22.0

CONDF	PHF	ALK	ACID	CO3	HCO3
670.000000	7.980000	74.000000	5.000000		
CL	F	SO4	N-NH4	DAL	DCA
6.300000		290.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.100000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.390000		1.000000	.000000	.000000	
TSE	TTL	TV	TZN		
		.000000	.170000		

SAMP DATE
06/15/1977
STATION DESC & LOC
SETTLING POND EFFLUENT

WTEMP
23.5

CONDF	PHF	ALK	ACID	CO3	HCO3
810.000000	7.990000	62.000000	5.400000		
CL	F	SO4	N-NH4	DAL	DCA
11.000000		460.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.500000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.010000
TFET	THG	TMN	TNI	TPB	TSB
.930000		1.900000	.020000	.000000	
TSE	TTL	TV	TZN		
		.000000	.070000		

ANL MINE CODE OH1 CSUL STATION 4

SAMP DATE
07/16/1977

STATION DESC & LOC		WTEMP			
SETTLING POND EFFLUENT		30.6			
CONDF	PHF	ALK	ACID	CO3	HCO3
1100.000000	7.400000	16.000000	4.700000		
CL	F	SO4	N-NH4	DAL	DCA
4.200000		880.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.400000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.460000		11.000000	.180000	.000000	
TSE	TTL	TV	TZN		
		.000000	.430000		

SAMP DATE
07/25/1977

STATION DESC & LOC		WTEMP			
SETTLING POND EFFLUENT		28.2			
CONDF	PHF	ALK	ACID	CO3	HCO3
1150.000000	7.100000	12.000000	6.500000		
CL	F	SO4	N-NH4	DAL	DCA
19.000000		930.000000			
DCD	DCO	DCR	DCU	DFET	DHG
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.500000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000	.000000	.010000
TFET	THG	TMN	TNI	TPB	TSB
.820000		12.000000	.020000	.000000	
TSE	TTL	TV	TZN		
		.000000	.500000		

ANL MINE CODE OH1 CSUL STATION APTE1

SAMP DATE
03/21/1977
STATION DESC & LOC WTEMP
SETTLING POND EFFLUENT

CONDF	PHF	ALK	ACID	CO3	HCO3
261.000000	6.400000	25.420000	4.080000	.000000	31.000000
CL	F	SO4	N-NH4	DAL	DCA
.000000	.228000	172.500000	.500000	.000000	69.300000
DCD	DCO	DCR	DCU	DFET	DHG
.000000	.000000	.000000	.000000	.000000	.000000
DK	DMG	DMN	DMO	DNA	DNI
3.200000	32.500000	3.900000	.000000	8.700000	.050000
DPB	DSR	DV	DZN	TAG	TAL
.000000	.000000	.000000	.050000	.000000	.400000
TAS	TBA	TBE	TCD	TCR	TCU
.000000	.000000	.000000	.000000	.000000	.000000
TFET	THG	TMN	TNI	TPB	TSB
.560000	.000270	3.270000	.040000	.000000	.130000
TSE	TTL	TV	TZN		
.650000	.000000	.000000	.050000		

ANL MINE CODE OH1 CSUL STATION P1

SAMP DATE
01/31/1974
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	7.000000	76.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.300000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
TFET	THG	TMN	TNI	TPB	TSB
7.950000					
TSE	TTL	TV	TZN		

ANL MINE CODE OH1 | CSUL STATION P1

SAMP DATE
02/26/1974
STATION DESC & LOC | WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	7.200000	70.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
.012000				.705000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
			.017000		
TFET	THG	TMN	TNI	TPB	TSB
3.060000					
TSE	TTL	TV	TZN		

SAMP DATE
03/28/1974
STATION DESC & LOC | WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	7.200000	90.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.145000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
TFET	THG	TMN	TNI	TPB	TSB
2.030000					
TSE	TTL	TV	TZN		

ANL MINE CODE OH1 CSUL STATION P1

SAMP DATE
04/27/1974
STATION DESC & LOC
MAIN SP EFFLUENT (001 PEABODY)

		WTEMP			
CONDF	PHF	ALK	ACID	CO3	HCO3
	7.500000	88.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
.049000				.040000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
			.049000		
TFET	THG	TMN	TNI	TPB	TSB
.730000					
TSE	TTL	TV	TZN		

SAMP DATE
05/30/1974
STATION DESC & LOC
MAIN SP EFFLUENT (001 PEABODY)

		WTEMP			
CONDF	PHF	ALK	ACID	CO3	HCO3
	7.500000	106.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.270000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
TFET	THG	TMN	TNI	TPB	TSB
3.770000					
TSE	TTL	TV	TZN		

ANL MINE CODE OH1 CSUL STATION P1

SAMP DATE
08/29/1974
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	7.600000	125.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.000000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
TFET	THG	TMN	TNI	TPB	TSB
.790000					
TSE	TTL	TV	TZN		

SAMP DATE
09/24/1974
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	7.500000	69.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.155000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
TFET	THG	TMN	TNI	TPB	TSB
.095500					
TSE	TTL	TV	TZN		

ANL MINE CODE OH1 — CSUL STATION P1

SAMP DATE
10/29/1974
STATION DESC & LOC — WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	7.500000	91.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.000000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
TFET	THG	TMN	TNI	TPB	TSB
.202000					
TSE	TTL	TV	TZN		

SAMP DATE
11/27/1974
STATION DESC & LOC — WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	7.000000	72.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.250000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
.620000	.000000				
TSE	TTL	TV	TZN		

ANL MINE CODE OH1

CSUL STATION P1

SAMP DATE
12/18/1974
STATION DESC & LOC
MAIN SP EFFLUENT (001 PEABODY)

		WTEMP			
CONDF	PHF	ALK	ACID	CO3	HCO3
	8.000000	42.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.220000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
2.240000	.000120				
TSE	TTL	TV	TZN		

SAMP DATE
01/28/1975
STATION DESC & LOC
MAIN SP EFFLUENT (001 PEABODY)

		WTEMP			
CONDF	PHF	ALK	ACID	CO3	HCO3
	6.700000	46.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.530000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
2.490000	.000000				
TSE	TTL	TV	TZN		

ANL MINE CODE OH1 CSUL STATION P1

SAMP DATE
02/26/1975
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	7.000000	32.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.400000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
7.400000	.000040				
TSE	TTL	TV	TZN		

SAMP DATE
03/27/1975
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	9.000000	45.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.140000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
.880000	.000000				
TSE	TTL	TV	TZN		

ANL MINE CODE OH1 CSUL STATION P1

SAMP DATE
04/29/1975
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	7.200000	47.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.270000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
1.380000	.000000				
TSE	TTL	TV	TZN		

SAMP DATE
05/22/1975
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	7.300000	60.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.170000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
1.250000	.000000				
TSE	TTL	TV	TZN		

ANL MINE CODE OH1 CSUL STATION P1

SAMP DATE
06/17/1975
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.200000	40.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.030000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
.640000	.000000				
TSE	TTL	TV	TZN		

SAMP DATE
07/25/1975
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	7.000000	74.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.000000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
.210000	.000000				
TSE	TTL	TV	TZN		

ANL MINE CODE OH1 CSUL STATION P5

SAMP DATE
07/28/1976
STATION DESC & LOC WTEMP
MINOR SP (005 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
1120.000000	6.300000	26.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.060000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.610000
TAS	TBA	TBE	TCD	TCR	TCU
			.012000		
TFET	THG	TMN	TNI	TPB	TSB
.320000	.000140	4.330000	.060000		
TSE	TTL	TV	TZN		
			.020000		

SAMP DATE
08/31/1976
STATION DESC & LOC WTEMP
MINOR SP (005 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.000000	31.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.030000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.400000
TAS	TBA	TBE	TCD	TCR	TCU
			.014000		
TFET	THG	TMN	TNI	TPB	TSB
.100000	.000060	.370000	.070000		
TSE	TTL	TV	TZN		
			.030000		

ANL MINE CODE OH1 CSUL STATION P5

SAMP DATE
12/14/1976
STATION DESC & LOC WTEMP
MINOR SP (005 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	5.500000	43.000000	.080000		
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.080000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.010000		
TFET	THG	TMN	TNI	TPB	TSB
.120000	.000060	2.420000	.070000		
TSE	TTL	TV	TZN		
			.010000		

ANL MINE CODE OH1 CSUL STATION WBL

SAMP DATE
06/01/1976
STATION DESC & LOC WTEMP
WEIR, LOW BASEFLOW (ARS DATA)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.200000	5.300000	4.500000		6.400000
CL	F	SO4	N-NH4	DAL	DCA
1.200000	.060000	37.000000	.040000	.017000	11.200000
DCD	DCO	DCR	DCU	DFET	DHG
.000000		.000000	.004000	.028000	.000000
DK	DMG	DMN	DMO	DNA	DNI
	4.400000	.160000		1.700000	.000000
DPB	DSR	DV	DZN	TAG	TAL
.000000	.035000		.008000		
TAS	TBA	TBE	TCD	TCR	TCU
TFET	THG	TMN	TNI	TPB	TSB
TSE	TTL	TV	TZN		

ANL MINE CODE OH1 CSUL STATION WBA

SAMP DATE
06/01/1976
STATION DESC & LOC WTEMP
WEIR, AVG BASEFLOW (ARS DATA)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.500000	9.200000	5.000000		11.200000
CL	F	SO4	N-NH4	DAL	DCA
1.600000	.060000	38.000000	.080000	.054000	12.600000
DCD	DCO	DCR	DCU	DFET	DHG
.000000		.000000	.005000	.066000	.000000
DK	DMG	DMN	DMO	DNA	DNI
	4.800000	.278000		1.800000	.000000
DPB	DSR	DV	DZN	TAG	TAL
.000000	.040000		.010000		
TAS	TBA	TBE	TCD	TCR	TCU
TFET	THG	TMN	TNI	TPB	TSB
TSE	TTL	TV	TZN		

ANL MINE CODE OH1 CSUL STATION WRL

SAMP DATE
06/01/1976
STATION DESC & LOC WTEMP
WEIR, LOW RUNNOFF (ARS DATA)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.100000	3.000000	5.500000		4.000000
CL	F	SO4	N-NH4	DAL	DCA
.900000	.003000	53.000000	.010000	.014000	13.500000
DCD	DCO	DCR	DCU	DFET	DHG
.000000		.000000	.000000	.007000	.000000
DK	DMG	DMN	DMO	DNA	DNI
	4.400000	.414000		1.200000	.000000
DPB	DSR	DV	DZN	TAG	TAL
.000000	.037000		.002000		
TAS	TBA	TBE	TCD	TCR	TCU
TFET	THG	TMN	TNI	TPB	TSB
TSE	TTL	TV	TZN		

ANL MINE CODE OH1 CSUL STATION P1

SAMP DATE
08/20/1975
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	8.500000	57.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.030000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
.320000	.000040				
TSE	TTL	TV	TZN		

SAMP DATE
09/22/1975
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	8.000000	50.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.030000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
.490000	.000000				
TSE	TTL	TV	TZN		

ANL MINE CODE OH1 CSUL STATION P1

SAMP DATE
10/20/1975
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	8.000000	42.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.130000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
1.270000	.000000				
TSE	TTL	TV	TZN		

SAMP DATE
11/17/1975
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.500000	56.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.060000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
.530000	.000000				
TSE	TTL	TV	TZN		

ANL MINE CODE OH1 CSUL STATION P1

SAMP DATE
02/26/1976
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.300000	36.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.130000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
.900000	.000000	1.990000	.040000		
TSE	TTL	TV	TZN		
			.030000		

SAMP DATE
03/22/1976
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.200000	50.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.060000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.800000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
1.040000	.000000	3.230000	.060000		
TSE	TTL	TV	TZN		
			.050000		

ANL MINE CODE OH1   CSUL STATION P1

SAMP DATE
04/05/1976
STATION DESC & LOC   WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.600000	50.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.050000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
.560000	.000000	2.260000	.100000		
TSE	TTL	TV	TZN		
			.030000		

SAMP DATE
05/25/1976
STATION DESC & LOC   WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.500000				
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.070000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					20.000000
TAS	TBA	TBE	TCD	TCR	TCU
			.017000		
TFET	THG	TMN	TNI	TPB	TSB
.360000	.000090	1.150000	.070000		
TSE	TTL	TV	TZN		
			.030000		

ANL MINE CODE OH1 CSUL STATION P1

SAMP DATE
06/28/1976
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.200000	58.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.030000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.300000
TAS	TBA	TBE	TCD	TCR	TCU
			.013000		
TFET	THG	TMN	TNI	TPB	TSB
1.220000	.000070	3.200000	.060000		
TSE	TTL	TV	TZN		
			.040000		

SAMP DATE
07/28/1976
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
950.000000	6.200000	28.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.060000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.610000
TFET	THG	TMN	TNI	TPB	TSB
.440000	.000140	7.230000	.090000		
TSE	TTL	TV	TZN		
			.150000		

ANL MINE CODE OH1 | CSUL STATION P1

SAMP DATE
08/31/1976
STATION DESC & LOC | WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	5.900000	27.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.030000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.500000
TAS	TBA	TBE	TCD	TCR	TCU
			.014000		
TFET	THG	TMN	TNI	TPB	TSB
.260000	.000060	9.030000	.100000		
TSE	TTL	TV	TZN		
			.150000		

SAMP DATE
09/29/1976
STATION DESC & LOC | WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	5.500000	48.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.030000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.100000
TAS	TBA	TBE	TCD	TCR	TCU
			.006000		
TFET	THG	TMN	TNI	TPB	TSB
.140000	.000040	4.290000	.060000		
TSE	TTL	TV	TZN		
			.040000		

ANL MINE CODE OH1 CSUL STATION P1

SAMP DATE
10/22/1976
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	7.100000	123.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.050000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.100000
TAS	TBA	TBE	TCD	TCR	TCU
			.014000		
TFET	THG	TMN	TNI	TPB	TSB
.840000	.000070	1.410000	.070000		
TSE	TTL	TV	TZN		
			.140000		

SAMP DATE
11/13/1976
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.700000	34.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.050000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.011000		
TFET	THG	TMN	TNI	TPB	TSB
.350000	.000070	8.330000	.170000		
TSE	TTL	TV	TZN		
			.180000		

ANL MINE CODE OH1 CSUL STATION P1

SAMP DATE
12/18/1975
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	5.700000	53.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.090000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.300000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
1.400000	.000000	1.980000			
TSE	TTL	TV	TZN		
			.060000		

SAMP DATE
01/26/1976
STATION DESC & LOC WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.400000	36.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.080000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.500000
TAS	TBA	TBE	TCD	TCR	TCU
			.019000		
TFET	THG	TMN	TNI	TPB	TSB
2.370000	.000040	1.860000	.040000		
TSE	TTL	TV	TZN		
			.070000		

ANL MINE CODE OH1 — CSUL STATION P1

SAMP DATE
12/14/1976
STATION DESC & LOC — WTEMP
MAIN SP EFFLUENT (001 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.100000	62.000000	1.210000		
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				1.210000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.010000		
TFET	THG	TMN	TNI	TPB	TSB
3.000000	.000060	7.100000	.890000		
TSE	TTL	TV	TZN		
			.160000		

ANL MINE CODE OH1 — CSUL STATION P2

SAMP DATE
04/05/1976
STATION DESC & LOC — WTEMP
WEIR SP EFFLUENT (002 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
2080.000000	6.800000	59.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.090000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					1.600000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
2.540000	.000000	.560000	.100000		
TSE	TTL	TV	TZN		
			.040000		

ANL MINE CODE OH1 CSUL STATION P2

SAMP DATE
05/25/1976
STATION DESC & LOC WTEMP
WEIR SP EFFLUENT (002 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.300000				
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.070000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.300000
TAS	TBA	TBE	TCD	TCR	TCU
			.017000		
TFET	THG	TMN	TNI	TPB	TSB
.460000	.000090	1.170000	.070000		
TSE	TTL	TV	TZN		
			.190000		

SAMP DATE
06/28/1976
STATION DESC & LOC WTEMP
WEIR SP EFFLUENT (002 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.200000	103.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.060000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.500000
TAS	TBA	TBE	TCD	TCR	TCU
			.013000		
TFET	THG	TMN	TNI	TPB	TSB
1.190000	.000070	1.480000	.060000		
TSE	TTL	TV	TZN		
			.110000		

ANL MINE CODE OH1 — CSUL STATION P2

SAMP DATE
07/28/1976
STATION DESC & LOC — WTEMP
WEIR SP EFFLUENT (002 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
490.000000	6.400000	38.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.060000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					1.067000
TAS	TBA	TBE	TCD	TCR	TCU
			.012000		
TFET	THG	TMN	TNI	TPB	TSB
1.390000	.000140	3.800000	.060000		
TSE	TTL	TV	TZN		
			.180000		

SAMP DATE
08/31/1976
STATION DESC & LOC — WTEMP
WEIR SP EFFLUENT (002 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.100000	114.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.030000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.400000
TAS	TBA	TBE	TCD	TCR	TCU
			.014000		
TFET	THG	TMN	TNI	TPB	TSB
.200000	.000060	2.800000	.070000		
TSE	TTL	TV	TZN		
			.060000		

ANL MINE CODE OH1 CSUL STATION P2

SAMP DATE
09/29/1976
STATION DESC & LOC WTEMP
WEIR SP EFFLUENT (002 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.200000	122.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.030000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.100000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
.190000	.000040	1.480000	.060000		
TSE	TTL	TV	TZN		
			.060000		

SAMP DATE
10/22/1976
STATION DESC & LOC WTEMP
WEIR SP EFFLUENT (002 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	7.100000	123.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.050000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.100000
TAS	TBA	TBE	TCD	TCR	TCU
			.014000		
TFET	THG	TMN	TNI	TPB	TSB
.840000	.000060	1.410000	.070000		
TSE	TTL	TV	TZN		
			.140000		

ANL MINE CODE OH1 — CSUL STATION P2

SAMP DATE
12/14/1976
STATION DESC & LOC
WEIR SP EFFLUENT (002 PEABODY)

		WTEMP			
CONDF	PHF	ALK	ACID	CO3	HCO3
	9.000000	12.000000	.140000		
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.140000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.010000		
TFET	THG	TMN	TNI	TPB	TSB
.170000	.000060	3.020000	.070000		
TSE	TTL	TV	TZN		
			.030000		

ANL MINE CODE OHL — CSUL STATION P3

SAMP DATE
04/20/1976
STATION DESC & LOC
MINOR SP (003 PEABODY)

		WTEMP			
CONDF	PHF	ALK	ACID	CO3	HCO3
	6.500000	46.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.030000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.200000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
.480000	.000000	.980000	.050000		
TSE	TTL	TV	TZN		
			.510000		

ANL MINE CODE OH1 — CSUL STATION P3

SAMP DATE
05/25/1976
STATION DESC & LOC — WTEMP
MINOR SP (003 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.300000				
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.130000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.100000
TAS	TBA	TBE	TCD	TCR	TCU
			.017000		
TFET	THG	TMN	TNI	TPB	TSB
.200000	.000090	.380000	.070000		
TSE	TTL	TV	TZN		
			.660000		

ANL MINE CODE OH1 — CSUL STATION P5

SAMP DATE
04/20/1976
STATION DESC & LOC — WTEMP
MINOR SP (005 PEABODY)

CONDF	PHF	ALK	ACID	CO3	HCO3
	6.400000	48.000000			
CL	F	SO4	N-NH4	DAL	DCA
DCD	DCO	DCR	DCU	DFET	DHG
				.030000	
DK	DMG	DMN	DMO	DNA	DNI
DPB	DSR	DV	DZN	TAG	TAL
					.010000
TAS	TBA	TBE	TCD	TCR	TCU
			.000000		
TFET	THG	TMN	TNI	TPB	TSB
.200000	.000000	9.660000	.110000		
TSE	TTL	TV	TZN		
			.050000		

Table B-5. Relationships Between Flow Rate and Water Quality Parameters

Flow Rate vs.	Site 4				P001				Combined Data			
	n[a]	r[b]	r^2	Signif.[c]	n	r	r^2	Signif.	n	r	r^2	Signif.
Total Suspended Solids	29	-.068	.005	.362	25	.127	.016	.273	74	.949	.901	<.001
Potassium[d]	29	-.435	.189	.009					29	-.435	.189	.009
Sulfate	29	-.428	.183	.010					35	-.415	.172	.007
Total dissolved Solids	29	-.086	.007	.328					35	-.393	.155	.010
Sodium[d]	29	-.355	.126	.030					32	.362	.131	.021
Magnesium[d]	29	-.349	.122	.032					29	-.355	.126	.030
Chloride	29	-.233	.054	.112					29	-.349	.122	.032
Calcium[d]	29	-.318	.101	.046					35	-.328	.107	.027
Manganese[d]	29	-.130	.017	.251	10	.433	.188	.106	53	.046	.002	.373
Iron[d]	29	-.107	.011	.291	25	.011	<.011	.480	66	-.028	.001	.412

[a]n = number of values.

[b]r = Pearson correlation coefficient (Nie et al., 1975).

[c]Signif. = significance (Nie et al., 1975). Significance is computed from Student's t test with N - 2 degrees of freedom from:

$$r\left[\frac{N - 2}{1 - r^2}\right]^{1/2}$$

[d]All metals analyzed from unfiltered, acidified samples.

Table B-6. Suspended Sediment-Cation Concentration Relationships

TSS vs.	n[a]	r[b]	r^2
Aluminum	66	.151	.023
Calcium	55	.063	.004
Cadmium	14	-.091	.008
Copper	17	-.128	.016
Iron	90	.155	.024
Potassium	55	.259	.067
Magnesium	55	-.143	.020
Manganese	68	-.093	.009
Sodium	55	-.090	.008
Nickel	49	-.023	.001
Strontium	55	-.089	.008
Zinc	60	-.039	.002

[a]n = number of analyses.

[b]r = Pearson correlation coefficient (Nie et al., 1975).

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APPENDIX C
COMPLIANCE RATING SCALES

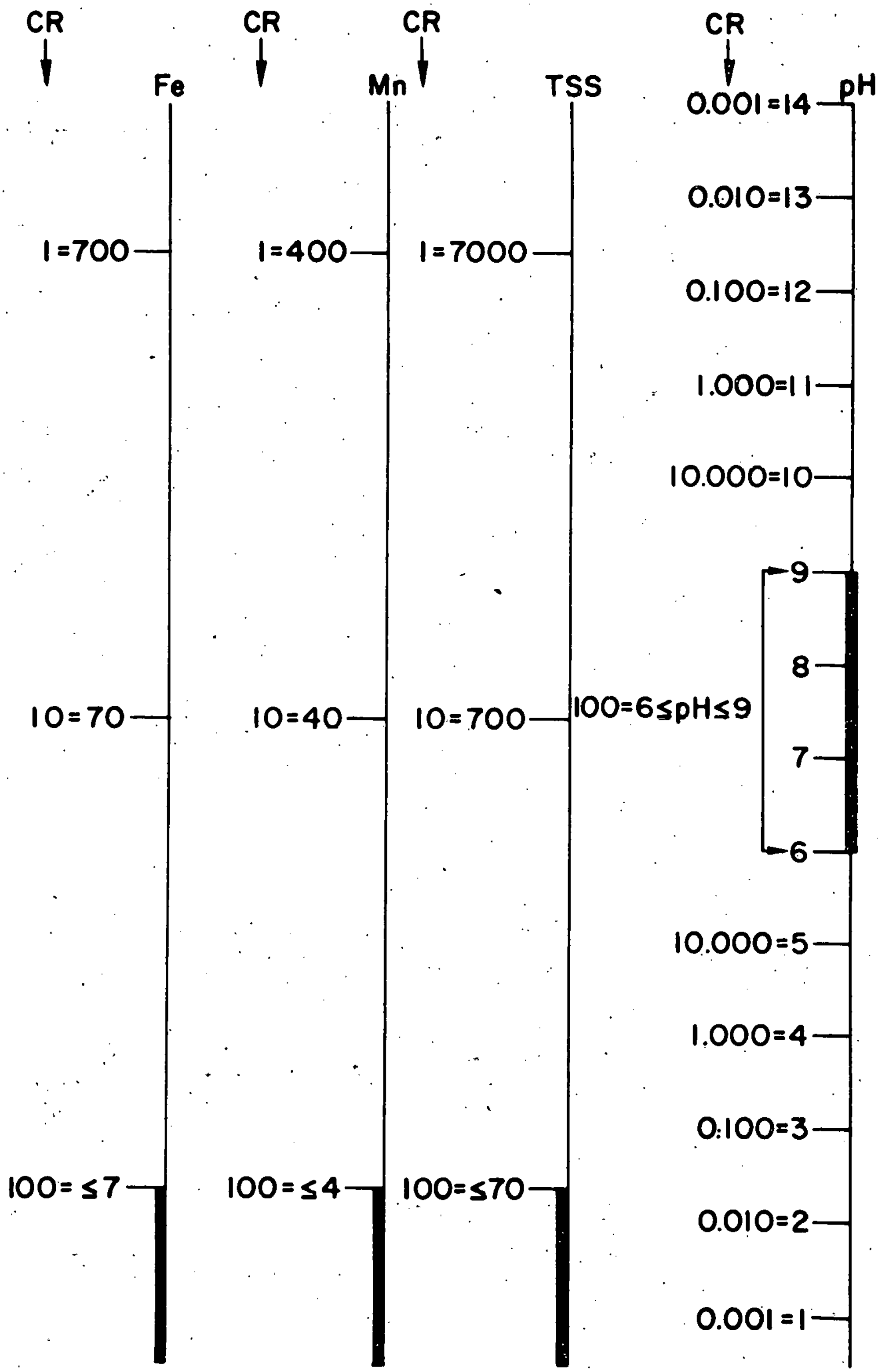

Fig. C-1. Graphic Representation of Compliance Rating

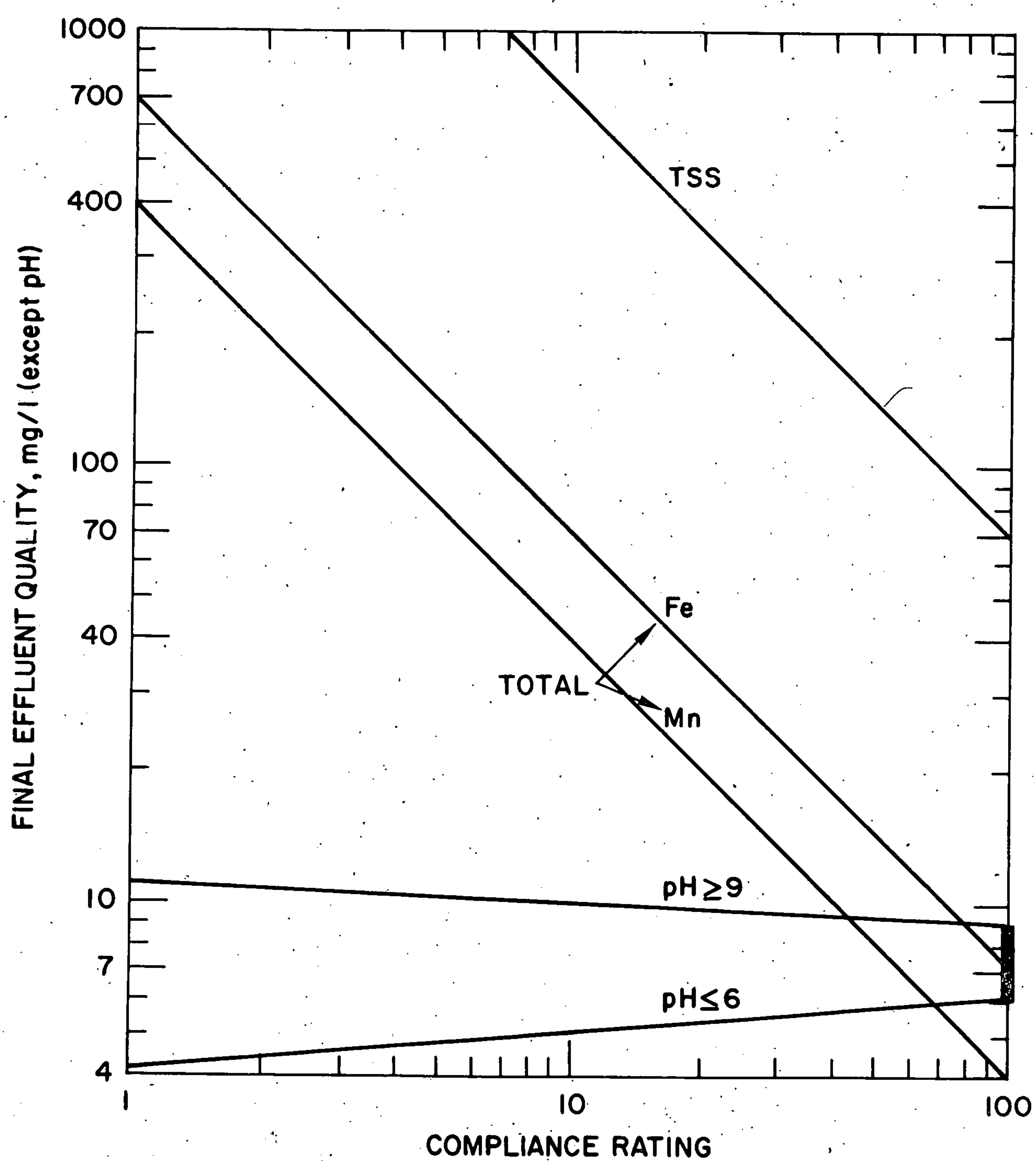

Fig. C-2. Calculation of Compliance Ratings

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