ABSTRACT

Hydrologic data were collected for the U.S. Geological Survey's Coal Hydrology Program from October 1978 through September 1982, at 1,499 stream sites in the Eastern Coal Province. The distribution of values above or below defined limits for four water-quality constituents and properties—total iron, total manganese, dissolved sulfate, and pH—were examined as possible indicators of acid mine drainage.

Values for all four characteristics at 25 stream sites in the Eastern Coal Province equaled or exceeded levels established by the U.S. Department of the Interior. These sites are in Pennsylvania and Ohio.

Total iron is the constituent that most commonly exceeded its limit. Sixty-two percent of 1,442 stream sites had median total-iron concentrations greater than 500 micrograms per liter. Twenty-eight sites in the northern part of the province had minimum total-iron concentrations greater than the Office of Surface Mining (OSM) maximum allowable effluent limit of 7,000 micrograms per liter.

Dissolved sulfate concentrations in the streams ranged from 0.0 to 6,300 milligrams per liter and 38 percent of 1,469 stream sites had median concentrations greater than 75 milligrams per liter.

The pH of sampled stream sites throughout the region ranged from 2.0 to 10.4. Only 418 sites (28 percent of 1,498 sites) had a minimum pH less than 6.0.

Only 329 sites (23 percent of 1,442 sites) had median concentrations of total manganese that exceeded 500 micrograms per liter.

INTRODUCTION

Background

The Surface Mining Control and Reclamation Act (Public Law 87, 1977) created a need to acquire water-quality data from potential coal-mining areas. This law requires that (1) each mining-permit applicant make an analysis of potential effects of the proposed mine on the hydrology of the mine site and surrounding area; (2) "an appropriate Federal or State agency" provide to each applicant hydrologic information on the general area prior to mining; and (3) measures be taken by mining permittees to control any adverse effects of mining or reclamation on the hydrologic balance.

The Eastern Coal Province is a long, narrow band extending from northern Pennsylvania to central Alabama and covers about 111,000 mi^2. Parts of nine States—Pennsylvania, Ohio, West Virginia, Maryland, Virginia, Kentucky, Tennessee, Alabama, and Georgia—are included in the Province. The Province has been subdivided into 24 specific reporting areas composed of hydrologic units (drainage basins) or parts of units (fig. 1).

Hydrologic data were collected during the 1979–82 water years at stream sites in the Eastern Coal Province as part of the U.S. Geological Survey Coal Hydrology Program. The sampling network of the Coal Hydrology Program was designed to provide broad areal coverage of the coal regions. The water-quality data collected were those considered pertinent to coal-bearing areas. Much of these data are presented in a series of coal area reports (Appendix).

PURPOSE AND SCOPE

This report summarizes values of pH, total iron, total manganese, and dissolved sulfate as possible water-quality indicators of acid mine drainage (AMD) throughout the Eastern Coal Province during 1979–82. These four water-quality characteristics were compared to limits established by the Office of Surface Mining (1979) and the Department of the Interior (1968). Two coal areas that have a large number of stream sites where limits for all four characteristics were equaled or exceeded were evaluated in greater detail and specific problem characteristics were discussed (pH in part of Area 1 and dissolved sulfate in Area 11). Net alkalinity—calculated as alkalinity minus acidity—also was used to further describe these areas.

PHYSIOGRAPHY

The Eastern Coal Province is an area of moderately high elevations surrounded by areas of coastal and central lowland. Most of the Eastern Coal Province lies in two physiographic provinces, the Valley and Ridge, and Appalachian Plateaus; both provinces are included in the Appalachian Mountain range. Beyond the Appalachian Mountains, the Eastern Coal Province also includes small parts of the Coastal Plain, Piedmont, Interior Low Plateau, and Central Lowland physiographic provinces (Fenneman, 1938) (fig. 2).

Parts of the Valley and Ridge Province that extend from West Virginia northeastward into central Pennsylvania have fairly rugged topography. West of the Valley and Ridge Province, the Appalachian Plateaus Province has a less rugged but more highly dissected terrain. The area from northern Pennsylvania to east-central West Virginia is higher and more mountainous than the rest of this province, but less so than the adjacent Valley and Ridge Province. The remaining provinces are gently rolling areas of low relief.

Only a small part of the region has been glaciated. All or parts of six counties in northwestern Pennsylvania were covered by glaciers during two ice ages, but bedrock generally is overlain by less than 10 ft of glacial drift.

Coal is the most valuable mineral resource in the Eastern Coal Province and underlies a large part of the area (fig. 3). Most of the coal occurs in rocks of Permian, Pennsylvanian, and Mississippian age. Bituminous coal fields in this province are among the most important in the world.

ACID MINE-DRAINAGE INDICATORS

The water-quality characteristics evaluated for acid mine-drainage indicators in this report are pH, total iron, total manganese, and dissolved sulfate. Values of these constituents in the stream above or below defined limits can indicate possible coal mining—both past and present. Site selection was based on the availability of a minimum of four analyses during 1979–82. Not every chemical analysis had data for all four constituents— for example, some may have determinations for total iron and total manganese, but not dissolved sulfate. The reports in Appendix were used for preliminary site selection but additional sites were added when available. A total of 1,499 sites in the Eastern Coal Province are shown by State in table 1.

The Permanent Regulatory Program of the Office of Surface Mining (1979) sets specific standards for quality of water leaving a mine site. Section 816.42 (a) (7) of the Permanent Regulatory Program sets certain specific effluent concentration limitations. These specific limits are for total iron, total manganese, and pH. Table 2 lists these concentration standards and the possible indicators of acid mine drainage set by the U.S. Department of the Interior (1968).

The effluent limits for total iron and manganese are considerably higher than those of 300 µg/L (micrograms per liter) for total iron and 50 µg/L for total manganese set for drinking water by the U.S. Environmental Protection Agency (US EPA, 1977).

Acid mine drainage can be associated with coal or coal mining. Many coal seams and adjacent rocks in the northern coal fields contain significant quantities of the iron-disulfide minerals, pyrite and marcasite, and mining activities expose these rocks and minerals to weathering processes. The oxidation of the disulfide minerals in the presence of water forms acidity and releases other substances, such as sulfate ions, iron, and manganese, to the water. Water contamination does not necessarily end when mining is discontinued. Acid may continue to form at inactive and abandoned mines and adversely affect nearby streams for years.

The most obvious effect of AMD on a stream may be aesthetic. When AMD is neutralized, the dissolved iron forms a ferric hydroxide precipitate. This ferric hydroxide forms a yellow-orange coating on stream beds, commonly called "yellow boy", and, when in suspension, imparts a reddish appearance to the stream.

The presence of AMD in the streams has a detrimental effect on the general welfare of the region. The corrosive acid water shortens the life of concrete and metal used in manmade structures. Water cannot be used for industrial or municipal use without extensive treatment. Acid streams are generally not suitable for recreational use. The pH of the water is generally below the tolerance level of most species of fish.

The absence of AMD indicators does not guarantee that acid mine drainage does not exist. Problem areas in the Eastern Coal Province may not be recognized because the sampling network used for the Coal Hydrology Program was not site specific enough or high concentrations of AMD indicators from very small drainage areas may have been diluted by other inflows before reaching the sampling sites downstream.

AREAL APPRAISAL OF ACID MINE DRAINAGE IN EASTERN COAL PROVINCE

Water quality at 25 of the 1,499 sites in the Eastern Coal Province equaled or exceeded levels established by the U.S. Department of the Interior (1968) for all four of the possible AMD indicators shown in table 2. These sites are in Pennsylvania (16 sites) and Ohio (9 sites). Two of the sites in Pennsylvania are in the Ohio River basin and the other 14 are in the West Branch Susquehanna River basin. Recommended levels for all four indicators may not have been exceeded in any one single analysis, but the median values of iron, manganese, and sulfate and the minimum value of pH at these 25 sites met or exceeded the standards during 1979–82. Figure 4 shows the areal distribution of the stream sites where four, three, two, one, or none of the standards are equaled or exceeded. The values used for the areal appraisal are published in a data report by Wetzel and Hoffman (1983).

Areas of possible acid mine-drainage problems in the Eastern Coal Province in Pennsylvania and Ohio are shown on figure 4. One such area is the drainage basin of the West Branch Susquehanna River in Coal Area 1 located in north-central Pennsylvania. A second area is Coal Area 11 (fig. 1), which comprises parts of Ohio, Kentucky, and West Virginia.

Total iron is the water-quality constituent that most commonly exceeded the limit for an AMD indicator. Figure 5 shows that 896 sites (62 percent of 1,442 sites) had median total-iron concentrations greater than 500 µg/L. Fifty-five sites had median total-iron concentrations greater than the OSM maximum allowable effluent limit of 7,000 µg/L. Twenty-eight sites in the northern part of the Province had minimum total-iron concentrations greater than 7,000 µg/L. Seventeen of these sites are in Pennsylvania.

The pH in the Eastern Coal Province ranged from 2.0 to 10.4. Only 2 percent of the total had a maximum pH of more than 9.0. Figure 5 shows that 418 sites, or 28 percent of the total number of 1,498 sites, had minimum pH values less than 6.0.

The dissolved-sulfate concentrations ranged from 0.0 to 6,300 mg/L (milligrams per liter) within the Province. The maximum concentration of 6,300 mg/L was measured in Coal Area 23. About 38 percent of the 1,469 sites had median sulfate concentrations greater than the AMD indicator of 75 mg/L (fig. 5).

Total-manganese concentrations do not appear to be a major problem in the Eastern Coal Province. Figure 5 shows that only 329 sites (23 percent of 1,442 sites) had median concentrations greater than the AMD indicator of 500 µg/L.

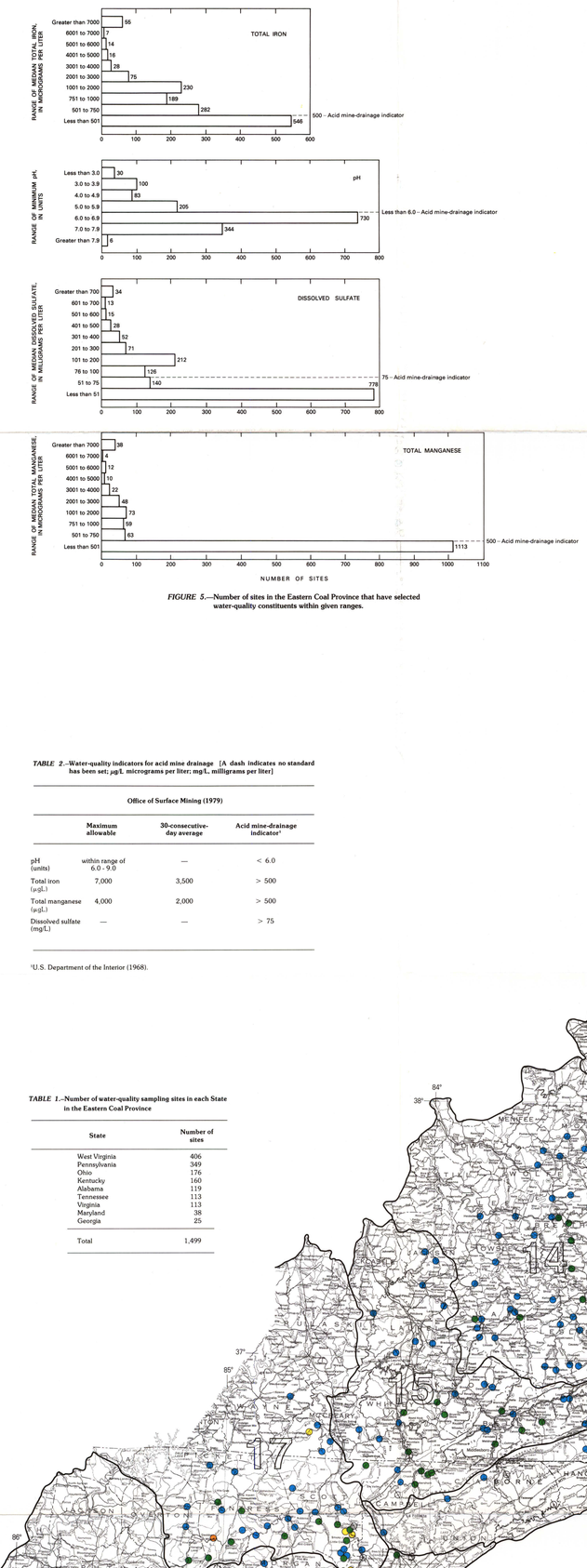

FIGURE 5.—**Number of sites in the Eastern Coal Province that have selected water-quality constituents within given ranges.**

TABLE 2.—**Water-quality indicators for acid mine drainage [A dash indicates no standard has been set; µg/L micrograms per liter; mg/L, milligrams per liter]**

	Office of Surface Mining (1979)		
	Maximum allowable	30-consecutive-day average	Acid mine-drainage indicator[1]
pH (units)	within range of 6.0 - 9.0	—	< 6.0
Total iron (µg/L)	7,000	3,500	> 500
Total manganese (µg/L)	4,000	2,000	> 500
Dissolved sulfate (mg/L)	—	—	> 75

[1]U.S. Department of the Interior (1968).

TABLE 1.—**Number of water-quality sampling sites in each State in the Eastern Coal Province**

State	Number of sites
West Virginia	406
Pennsylvania	349
Ohio	176
Kentucky	160
Alabama	119
Tennessee	113
Virginia	113
Maryland	38
Georgia	25
Total	1,499

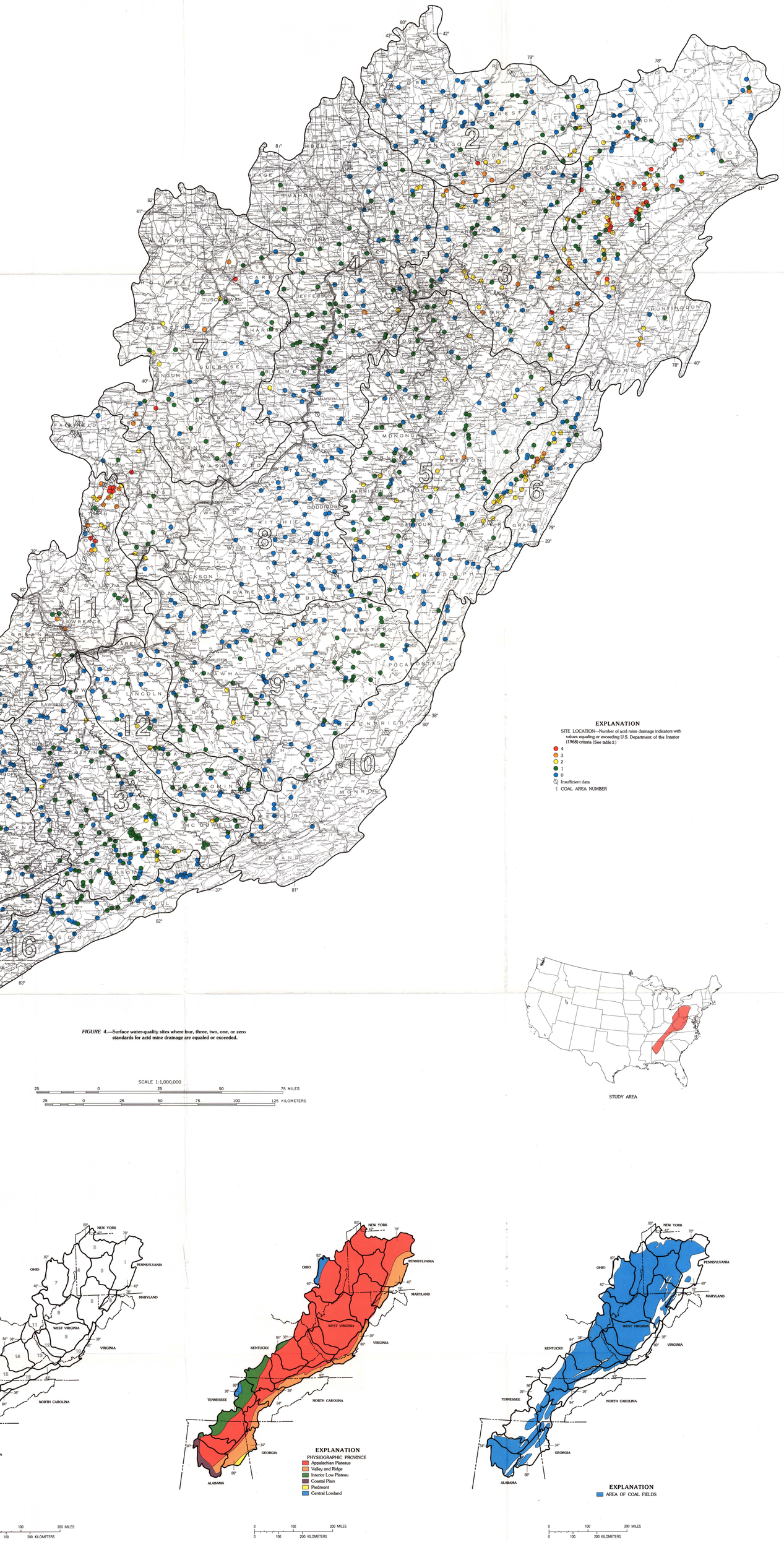

FIGURE 4.—**Surface water-quality sites where four, three, two, one, or zero standards for acid mine drainage are equaled or exceeded.**

FIGURE 1.—**The 24 coal areas in the Eastern Coal Province.**

FIGURE 2.—**The physiographic provinces of the Eastern Coal Province.**

FIGURE 3.—**Location of the coal fields in the Eastern Coal Province.**

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Base from U.S. Geological Survey
State Base Maps

DISTRIBUTION OF WATER-QUALITY CHARACTERISTICS THAT MAY INDICATE THE PRESENCE OF ACID MINE DRAINAGE IN THE EASTERN COAL PROVINCE OF THE UNITED STATES

By
Kim L. Wetzel and Scott A. Hoffman

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