INTRODUCTION

Description of Engineering Survey

The Commonwealth of Pennsylvania, Department of Mines and Mineral Industries, engaged Michael Baker, Jr. , Inc. in July, 1968 to conduct an engineering survey of the East Branch Clarion River Watershed under the "Operation Scarlift" land reclamation program. This survey was for the purpose of determining the extent of pollution within the watershed due to acid mine drainage and to recommend abatement measures. A one (1) year program of stream :sampling was performed to locate sources of pollution and to determine the acid loads from these sources.

This report contains the results of the survey conducted by Michael Baker, Jr. , Inc. together with conclusions as to the sources and extent of acid mine drainage pollution found within the watershed and recommendations on methods of abatement, Preliminary cost estimates for the recommended abatement methods are also included in the report.

Location

Most of the East Branch Clarion River Watershed lies within Sergeant Township, McKean County and Jones Township, Elk County, but the southern part of the watershed is in the northern parts of Ridgeway and Benzinger Townships, Elk County.

The East Branch Clarion River has its source in Sergeant Township, McKean County near the village of Clermont and flows generally in a south and southwesterly direction for,a distance of about 19 miles through Sergeant Township, McKean County, and Jones Township, Elk County, and joins the West Branch Clarion River to - become the Clarion River at Johnsonburg in the northern part of Ridgeway Township, Elk County.

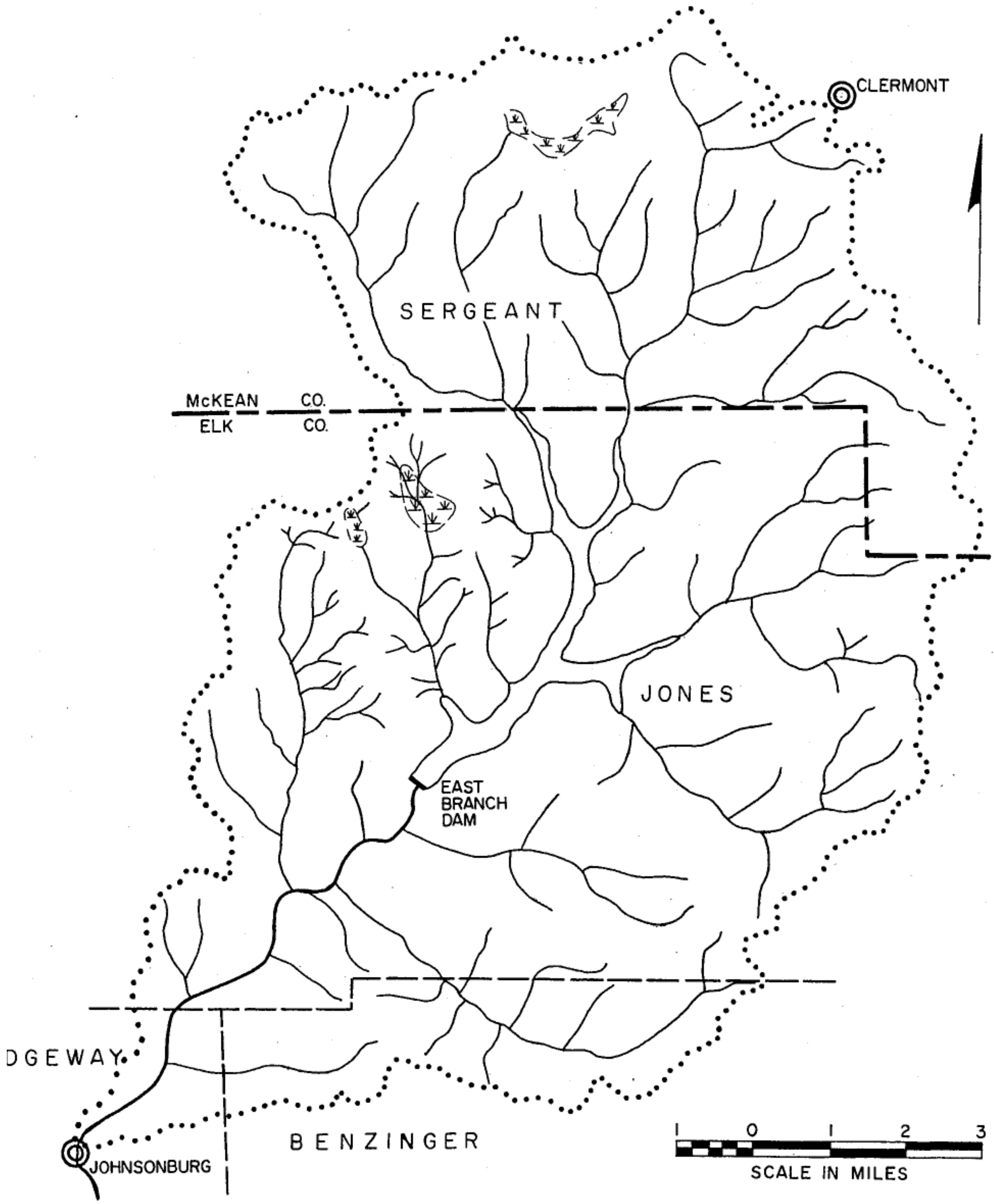

FIG. I

LOCATION MAP

EAST BRANCH CLARION RIVER DRAINAGE BASIN

Description of Drainage Basin

The East Branch Clarion River has a drainage area of approximately 69, 708 acres (109 square miles). The drainage basin is a maturely dissected plateau with a vast number of valleys, ravines and gullies. Twenty-six tributary streams with drainage areas ranging from 250 to 6, 775 acres enter the East Branch Clarion River between the headwaters and the mouth. These tributary streams account for about 57, 827 acres of drainage and the direct runoff into the East Branch Clarion River, including the East Branch Reservoir, comes from about 11,881 acres.

The larger tributary streams of the East Branch Clarion River having drainage areas of one thousand or more acres are: Straight Creek (6, 775 acres), Crooked Creek (6, 320 acres), South Fork Straight Creek (5, 721 acres), Johnson Run (5, 321 acres), Sevenmile Run (5, 185 acres), Fivemile Run (4,189 acres), Middle Fork (4, 065 acres), County Line Run (4, 025 acres), Swamp Creek (3, 275 acres), Smith Run (2, 130 acres), Indian Run (1, 863 acres), Martin Run (1, 320 acres) and Gum Boot Run (1, 188 acres).

Tributary Streams Polluted by Acid Mine Drainage

The sources of all the acid mine drainage pollution are in the drainage areas of seven of the tributary streams, but only five of the streams receive significant amounts of acid mine drainage and these streams are: Swamp Creek, Johnson Run, Yonkers Run, Gum Boot Run and Twomile Run.

Swamp Creek and Johnson Run, having a total drainage area of 8, 596 acres, are responsible for most of the acid mine drainage pollution and account for over 4, 800 pounds per day of the estimated average daily acid discharge of about 5, 600 lbs. per day in the East Branch
Clarion River Watershed.

An estimated average daily acid discharge of 3, 300 lbs. per day enters the East Branch Clarion River and reservoir above East Branch Dam. Johnson Run which has an estimated average daily acid discharge of 2, 000 lbs. per day enters the East Branch Clarion River about 2. 5 miles below the dam.

Cultural Features

The principal cultural feature on the East Branch Clarion River is the East Branch Dam which was completed by the Corps of Engineers in 1952. The dam is located approximately 7 miles upstream of Johnsonburg at a point where the drainage area of the East Branch Clarion River is 72.4 square miles. The primary purpose for constructing the dam was flood control and low flow augmentation. The reservoir has a gross storage capacity of 84, 300 acre-feet and an area of 1, 370 acres at Reservoir-full (El. 1685). The maxiumum summer discharge regulation pool (El. 1670) is 1, 160 acres with a storage capacity of 64, 300 acrefeet. The reservoir lies entirely within Jones Township, Elk County.

An additional benefit of the East Branch Reservoir, because of the comparatively large summer pool and its scenic setting, is recreation. Approximately four-fifths of the reservoir area lies within Elk State Forest, which is under the jurisdiction of the Pennsylvania Department of Forests and Waters. Adjoining the Federal Reservation at the dam is State Game Land No. 25, which is administered by the Pennsylvania Game Commission. Sightseeing, boating, picnicking and fishing are the principal recreational activities for which the Corps of Engineers have provided and maintain facilities near the dam site. The Pennsylvania Department of Forests and Waters maintains picnicking, boating and fishing facilities in the upper part of the reservoir just south of where Yonkers Run enters the reservoir.

Much of the watershed is heavily forested with hardwoods and large tracts are owned by the forest products industries. The area is sparsely populated and the only city is Johnsonburg Borough with a population of 4, 239 (1970 census) at the mouth of the East Branch Clarion River. The Penn Tech Paper Mill, formerly owned by the New York and Pennsylvania Company, is the largest employer in Johnsonburg with about 800 employees. The only other settlement of consequence is the village of Clermont at the headwaters of the East Branch Clarion River where a field office of the United Natural Gas Company is located.

Physiography and Structural Geology

The East Branch Clarion River Watershed is within the Appalachian Plateau Province. The topography of the watershed is extremely varied and its main features have been determined by the geological structure. The highest surface elevations are located over anticlinal axes, which are the Fifth Anticlinal or Smethport Axis in the northwest, the Fourth Anticlinal or Norwich Axis in the southeast, and the Kinzua-Emporium Cross Anticlinal Axis which crosses' the watershed from northwest to southeast almost dividing it in half. The lowest elevations are, in general, along the East Branch Clarion River, the direction of which has been determined by the Fifth Synclinal Axis. The principal features of the topography and structure are shown on the Coal Structure Contour Map (Plate II, in pocket).

The Fifth Synclinal Axis which in Elk County is called the Johnson Run Coal Basin and in McKean County the Clermont Coal Basin is the dominent structural feature and the central and greater part of the watershed is confined within its limits. In general, the Fifth Synclinal Axis is a long, broad, symmetrical trough plunging to the southwest. The main structural trend is northeast to southwest and the strata, for the most part, have gentle dips amounting to about 2 to 4 feet per 100 feet.

Stratigraphy

The total thickness of the stratigraphic sequence exposed above stream level probably does not exceed 900 feet in the East Branch Clarion River Watershed. The formations range in age from Mississippian to the Pottsville and Allegheny Groups of the Pennsylvania System. The Mississippian formations are predominently sandstones and conglomerates whereas the Pennsylvanian formations consist mostly of shales, sandstones and interbedded shales and sandstones. The workable coal beds are in the Pottsville and Allegheny Groups and consist of the Lower and Upper Mercer Coals, Clarion Coal, and Lower and Middle Kittanning Coals.

Most of the East Branch Clarion River Watershed is covered by alluvial and residual soil deposits. Geological mapping of the structure and stratigraphy of Elk and McKean Counties is very difficult because natural exposures are very scarce and widely separated, and the lithology of different formations are similar. The Second Geological Survey of Pennsylvania (1874-1887) noted in their reports the great difficulty they had in mapping the s stratigraphy of these Counties.

If one can have an advantage in mapping an area in which there are few outcrops and the region is heavily forested, then possibly the Second Geological Survey had an advantage that was not available to the geologists during this investigation. At the time the Second Geological Survey made their investigation, a great number of openings were being made for coal and a number of holes were drilled near the village of Clermont and in the drainage area of Lukes Run. Almost all of the openings were obliterated with passage of time. This investigation relied heavily on the interpretations of the geologists of the Second Geological Survey, but had one advantage that they did not have, besides using their reports, and that is that strip-mining operations gave a clue to the stratigraphy and structure of a broad area. -

Typical Stratigraphic Section in the Johnson Run Coal Basin

The following stratigraphic section is based on the work of the Second Geological Survey of Pennsylvania in Jones Township, Elk County (Report RR, 1885) and the typical section is located in the vicinity of the Bucktail Mines starting at the top of the hill above the mines. The Bucktail Mines are in the Johnson Run drainage area. They are east of Township Road 363 and encompassed by strip-mines.

STRATIGRAPHIC SECTION - VICINITY OF BUCKTAIL MINES

	60'	Shales and Sandstone, shaly
	2' ±	Coal - Middle Kittanning Coal Bed
	50'	Shales and Sandstone, shaly
	2'-3"	Coal - Lower Kittanning Coal Bed
	40'	Slate and Shale
Allegheny	3'	Limestone
	8'	Shale, gray
	1'	Iron Ore
	7'-11"	Limestone
	1'-4"	Coal - Vanport (Ferriferous) Coal Bed
	30'	Shales
→	2'-6"	Coal - Clarion Coal Bed
	75'	Sandstone, massive, with occasional shale beds
	3'	Coal - Upper Mercer Coal Bed
	18'	Sandstone, Shales and Fire Clay
	3'-6"	Coal - Lower Mercer Coal Bed
Pottsville	100' to 115'	Sandstone and Conglomerate, coal horizon near center - Quakertown Coal Bed
	415' ±	TOTAL

Typical Stratigraphic Section in the Clermont Coal Basin

The following stratigraphic section is based on the work of the Second Geological Survey of Pennsylvania in Sergeant Township, McKean County (Report R, 1880) and the typical section is located in the vicinity of the village of Clermont and was compiled from the records of borings made in the 1870's

STRATIGRAPHIC SECTION - VICINITY OF CLERMONT

ALLEGHENY	20'	Slate, gray and black
	1'	Coal - Middle Kittanning Coal Bed
	40'	Sandstone, gray and brown, hard, fine grained
	2'-9"	Coal - Lower Kittanning Coal Bed
	2'	Fire Clay
	10'	Sandstone and Slate
	8'	Limestone
	31'-6"	Sandstone and Slate
	2'-11"	Coal - Clarion Coal Bed
	2'	Fire Clay
POTTSVILLE →	46'	Sandstone
	2'-3"	Coal - Upper Mercer Coal Bed
	2'-6"	Fire Clay
	11'	Slate, blue and black
	3'-6"	Coal - Lower Mercer Coal Bed
	2'	Fire Clay
	45'	Sandstone
	5'	Coal and Slate - Quakertown Coal Bed?
	45'	Conglomerate
	5' to 10'	Slate, black and Coal - Sharon Coal Bed?
	290' ±	TOTAL

History of Coal Mining Operations

In the period between 1850 and 1880 large tracts of Elk and McKean Counties were purchased as coal lands as it was believed the area would someday become the center of a valuable coal and iron region Almost everyone who owned a large tract had professional reports made by geologists and mining engineers and numerous openings and prospects were made for coal during this period. The area is underlain to a considerable extent by coal beds, but most of the coal beds are highly irregular, of poor quality, and not of sufficient thickness to be mined profitably.

A number of mines were opened in the East Branch Clarion River Watershed in the 1870's and 1880's, the most important of which were the Bucktail Mines in the Johnson Run sub-basin, the Instantur Mines on Twomile Run, and the Gum Boot Mines on Gum Boot Run. These mines were all shut down within a few years after the 20th century began, but the Bucktail Mines were reopened for a few years in the 1920's. During the 20th century, up to about 1948, there were occasional spurts of mining activity, such as the aforementioned Bucktail Mines, the H. C. Quinn Mines on Yonkers Run in the 1920's and 1930's, and the Anderson Mine on Smith Run in the 1930's, but for the most part, the mining was sporadic and consisted of small one or two man operations that were worked at irregular intervals.

In 1947 and 1948, the Pennsylvania Department of Mines and Mineral Industries, as part of a mine sealing program, sealed all the mines that were discharging acid water into the waters of the Commonwealth, but shortly thereafter strip-mining operations began in the East Branch Clarion River Watershed.

The strip-mining was confined to the drainage areas of Swamp Creek, Johnson Run, Yonkers Run, and Borgardy Run, and these operations continued to about 1960. Most of the strip-mining was in areas where deep mines had closed down because underground mining had become unprofitable.

By far, most of the coal produced in the East Branch Clarion River Watershed has come from strip-mining operations between 1948 and 1960.

Previous Water Quality Surveys

With the exception of mine sealing, which was part of a statewide program to improve the quality of the waters of the Commonwealth, no concern was expressed for the water quality of the East Branch Clarion

River until after strip-mining operations started. Based on the few water quality records available before strip-mining began, it appears there was no need for concern because the records indicate the water quality of the East Branch Clarion River was good.

In 1948, the Pennsylvania Department of Health began sampling the discharges from strip-mines and deep mines. Some of the mine seals were destroyed by stripping operations. The change in the water quality of some of the tributary streams such as Swamp Creek, Yonkers Run, Borgardy Run and Johnson Run was obvious.

Between 1953 and 1966, at least 15 water quality surveys were made by the Pennsylvania Department of Health, the Pennsylvania Fish Commission and the Federal Water Quality Administration. As a result of the earlier surveys, various pollution control methods were instituted during the period of strip-mining activity. Several sections of mine refuse covered roads were reclaimed, the operators were made to backfill the strippings in accordance with the limited requirements of the mining laws of the time, lime was added at the discharge points of active operations, and the inspection of mining operations was increased.

In spite of the control measures, the water quality of the East Branch Clarion River did not improve significantly, and it appears that the poor water quality is a direct result of the strip-mining operations between 1948 and 1960.

Present Water Quality Survey

Michael Baker, Jr., Inc., in September and October, 1968, made surveys of the East Branch Clarion River Watershed to obtain information necessary for the planning of a years study of the water quality and sources of acid mine drainage pollution. At this time, over one hundred water samples were taken and, based on water quality test results, a proposed program of water quality sampling and testing was submitted to and discussed with representatives of the Pennsylvania Department of Mines and Mineral Industries. The program was approved and sampling and testing was started in November, 1968 and continued to December, 1969. Eightytwo sampling stations were established throughout the watershed and over 1, 200 water samples were taken and water quality tests made on them during the years study.

A block of STORET code numbers was assigned by the Federal Water Quality Administration, Upper Ohio Basin Office, Wheeling, West Virginia, and these numbers were used to designate the sampling stations.
See "Water Quality Sampling Stations" (Plate III, in pocket).

In order to obtain accurate flow data so as to be able to compute the pounds of acid being discharged by the various sources of acid mine drainage, weirs were constructed at many points in the watershed. Preference was given to the rectangular weir because the flows in tributary streams vary so greatly that other types of weirs would be submerged frequently.

An alternate method of measuring flow was established at each weir location which consisted of measuring the height of water at a nearby pipe, culvert or existing earth channel. Correlation of this second measurement with the flow determined at the weir resulted in the development of head-flow curves for the alternate methods, thus flows could be determined if the weir was destroyed or if the flow was so great that the weir was submerged. The second method had to be used on occasion when weirs were destroyed by road maintenance crews and vandalism, and a few times when there were very high flows.

In some locations, such as mine seal outlets, a bucket and stop watch were used to measure flow.

An IBM System 360/30 65K Computer was used in making a statistical evaluation of water quality test results and stream flow data. Comparisons were made of test and flow data between sampling stations within individual sub-basins and between sub-basins. The computer was programmed to compare the average monthly stream flow with the average monthly acid discharge at each sampling station and to obtain the average daily acid discharge for each station based on the years sampling.

The entire East Branch Clarion River Watershed was flown by the Photogrammetry Division of Michael Baker, Jr. , Inc. , in order to obtain air photo, coverage suitable for a detailed investigation. The photogrammetry was used to construct topographic maps on scale of 1" = 200' with a contour interval of five feet of areas affected by acid mine drainage pollution. These topographic maps were used in the field along with the aerial photographs.

Information pertinent to the pollution study,, such as, the delineation of mine drainage sources, the type and origin of the acid material, the locations of deep mines, highwalls, sampling stations, drainage divides, etc. , are shown on the new topographic maps. Copies of these maps on a scale of 1" = 500' (23 sheet's) are in Appendix A of the report. Plate I (in pocket) is an index map showing the locations of acid mine drainage sources and areas covered by 1" = 200' topography.

Water Quality Analysis Methods

Water samples were collected in polyethlene plastic containers. Where iron concentrations were known to be high, or if precipitation of iron occurred previously, a second sample was collected and acidified with a small portion of hydrochloric acid in order to prevent hydrolysis and precipitation of iron.

Samples were analyzed for pH, total acidity, free acidity, total alkalinity, total iron and sulfate. Some samples were analyzed for ferrous iron, manganese, aluminum and arsenic content as well as calcium and magnesium hardness.

The pH is a measurement of the hydrogen ion concentration. It is not a measurement of the total acid content. In analytical chemistry, a pH of 7. 0 is neutral and below 7. 0 is acidic. For practical purposes in water chemistry, a stream is not considered acidic unless the pH is below a chosen value, usually 4. 5. Within the East Branch Clarion River Watershed, streams with a pH of from 4. 8 to 5. 1 are being considered neutral provided that they contain no mineral salts which could lower the pH further downstream. Streams with a pH in the above range have very little ability to neutralize acid mine drainage. The pH measurements were made using a Hach model 1975 pH meter.

The total acidity test is a measurement of the total amount of acid producing mineral salts present, such as iron and aluminum sulfate in addition to weak acids, such as carbon dioxide and organic acids. The total acidities were determined by hot titration (90^0- 100^0 C) using 0. 020 N sodium hydroxide standard solution to the pink phenolphthalein endpoint. Hot titration has the advantages of speeding the titration and yielding more reproducible results. Although boiling the sample for a minimum of two minutes has the effect of dispelling any dissolved carbon dioxide, this had negligible effects with acid mine drainage samples. In a few cases, with samples not polluted by acid mine drainage, the loss of carbon dioxide had the effect of raising the pH to about 8. 3 producing the pink color. These samples were then back-titrated to the faint pink endpoint resulting in a few negative total acidities. Technically the phenophthalein endpoint at this temperature occurs at a pH slightly lower than 8. 3. Acidity and alkalinity results are in equivalent milligrams per liter (mg/l) of calcium carbonate. Because of the high pH endpoint, even unpolluted water will commonly have a total acidity of a few milligrams per liter. Although the high pH endpoint usually results in overestimating the amount of neutralization needed under natural conditions, it is necessary at times in order to precipitate all ferrous iron.

The free acidity was determined by titrating with 0, 020 N sodium hydroxide solution to pH 4. 8 using Bromm Cresol Green Methyl Red Indicator at room temperature. This test measures the amount of free mineral acids present. The results may indicate the amount of treatment necessary to bring the water to a barely acceptable quality. Free acidity titrations, however, may be misleading or appear too low due to incomplete precipitation of acid producing ferrous iron or aluminum ions.

The total alkalinity of a stream not polluted by acid mine drainage was tested by titrating down to pH 5. 1, the equivalence point for low alkalinities, with 0. 020 N standard sulfuric acid solution. Brom Cresol Green Methyl Red Indicator was used at room temperature. Generally, the higher the alkalinity the greater the ability of a stream to neutralize acid mine drainage when mixing occurs, but unfortunately most of the streams in the East Branch Clarion River Watershed, which have not been polluted by acid mine drainage, have marginal alkalinities.

Iron, sulfate, manganese and aluminum were tested using the photoelectric colorimeter supplied with a Hach model DR-EL Portable Engineers Laboratory. Samples to be tested were diluted with deionized water when necessary in order to obtain ion concentrations suitable for measurement. When large dilutions were needed, micropipets and volumetric flasks were employed.

Iron occurs as one of the main constituents of acid mine drainage. In the project area it is present is solution as ferrous and ferric sulfate which are in part responsible for the acidic nature of the affected waters. Attempts always were made to collect clear samples. If turbidity existed when samples were collected, these samples were allowed to settle and then decanted before testing or filtered through Whatman fine #42 filter paper.

Total iron (ferrous, ferric, collodial and nonfilterable or nonsettleable) was determined by the 1-10 phenathroline method using Hach FerroVer reagent powder pillows. These pillow reagents contain a reducing agent which dissolves precipitated iron and reduces ferric iron in solution to the ferrous state for measurement. The intensity of the resulting orange complex is measured colorimetrically. Reagent blanks were run with the tests to compensate for any slight color or turbidity produced by the chemical alone. With some samples, dilutions of several hundred fold were needed prior to testing.

Sulfate is the principle anion occurring in streams polluted by acid mine drainage and originates, as does iron, from the oxidation of pyrite associated with the coal seams. The sulfate ion concentration in water quality samples was determined by the turbidimetric method using Hach SulfaVer III reagent pillows. A calibration curve was prepared testing sulfate solutions of known concentrations. In the transmittance range commonly used for the sulfate test, the results varied from 12. 8 to 15. 1 percent above the actual ion concentration using the Hach Calibrated standard. An average correction factor of 0. 86 was employed to reduce the sulfate test results to a correct value. Reagent blanks were used where possible. Results are represented in milligrams per liter of sulfate ion.

The occurrence of manganese in acid mine drainage, although not responsible for the acidic nature of the water nor toxic in small to moderate amounts, is undesirable. Its removal is difficult for water treatment plants and can cause serious staining. The U. S. Public Health Service recommends a limit of 0. 05 mg/l for a potable water supply. The source of the manganese is near or at the site of pyrite oxidation resulting from the action of sulfuric acid on manganesian minerals. Tests for soluble manganese, probably the manganous II ion, were performed using the cold periodate oxidation method. A few samples have shown over 100 mg/l.

Aluminum is similar to ferric iron in that it causes' an intense acid condition of the affected stream. Any free sulfuric acid produced in the oxidation reactions and not neutralized because of insufficient calcium or magnesium carbonate, will react with clay minerals to yield aluminum ion. An increase of aluminum in a stream may occur as a result of ferrous iron oxidizing to ferric, the ferric iron precipitating as "yellowboy" yielding free hydrogen ions which then dissolve aluminum. The high content of aluminum and manganese compared to iron in drainage from the Bucktail Mines and H. C. Quinn Mines tends to indicate that 1) a large amount or rapid renewal of oxygen in the mines exists, or 2) that seepage from adjacent strip-mines is entering the drift mines. Aluminum was tested by the aluminum (Tricarboxylic acid) method using Hach equipment and chemicals. Results are in mg /l of aluminum ion.

At a meeting with the Federal Water Quality Administration, Ohio River Basin Office, in Wheeling, West Virginia, it was suggested that occasionally water quality tests be run for arsenic content. None of the samples, tested by the silver diethyldithiocarbamate method as found in Standard Methods, showed a content of arsenic greater than 0. 1 mg/l. According to the U. S. Public Heath Service drinking water standards,
.a potable water supply is rejected when the arsenic concentration exceeds 0. 05 mg /l.

Hardness tests were also performed occasionally using the E. D. T. A. (ethylenediamine tetracetic acid) titrametric method after removal of interferring metal ions.

Copies of computer printouts of the water quality test data are in Appendix B of the report.

Discussion of Recommended Abatement Measures

In making recommendations for abatement of acid mine drainage from the various pollution sources the following factors were considered:

I. The pollution sources are on private property.

2. Most of the acid mine drainage pollution is due to stripmining operations and the water quality of the East Branch Clarion River Watershed appears to have been good prior to strip-mining.

3. Some of the strip-mines were graded, but there was no attempt to revegetate the spoil banks.

4. An attempt was made by strip-mine operators at some of the pollution sources to partially reclaim the land. Although the strip-mines were not graded to present day standards, the depressions were backfilled and a vegetation cover of trees was established. Tree growth in these areas has reached a point where a canopy is developing which is becoming effective in intercepting part of the precipitation and evapotranspiration during the growing season reduces the amount of runoff.

5. A few of the property owners have planted seedlings at various times in attempt to improve the property and there has been some natural seeding of trees native the the region.

6. Since all of the pollution sources are on private property, the recommended abatement methods should not require periodic maintenance by the Commonwealth and the objective should be to obtain the most pollution abatement possible while cost of abatement is kept to a minimum.

7. It is preferable to abate pollution at the source by effectively reclaiming the land and preventing seepage from deep mines. Therefore, other than for a temporary mined drainage treatment plant on Johnson Run, no consideration was given to mine drainage treatment.

8. The East Branch Dam is the center of a recreational area. Therefore, improvement of the water quality
of the East Branch Clarion River would have significant benefits to the Commonwealth.

9. Most of the clean streams have very little residual alkalinity and at best can be called marginally alkaline.

The following is a general discussion of the recommended abatement measures.

Strip-Mine Reclamation - This work will include backfilling, grading, soil treatment and revegetation. Since all the strip-mined areas are at or near the topographic highs, no diversion ditches or slope drain flumes are needed. A combination of terrace and contour grading is recommended for the larger strip-mined areas because of economy. The emphasis was on improving drainage, soil treatment and the establishment of a ground cover of vegetation as this will considerably reduce the infiltration of surface water into the spoil material. Figure 2 shows the proposed grading for part of a large strip-mine.

Burial of Coal Mine Waste - It is proposed to bury most of the acidic coal mine waste from other sources in a pit in the northeastern end of the Area 11 Strip-Mine. This location was chosen because there is good access to the strip-pit, it is convenient to most of the pollution sources, and the abatement measures for Area 11 call for backfilling the strip pit. Figure 3 shows the method recommended for backfilling the pit and how it will look after the coal mine waste removed from the pollution sources in the Swamp Creek Sub-Basin is dumped and covered with three feet of soil.

Mine Sealing - It is recommended that double bulkhead grout seals be used in sealing deep mines because the mines are caved at the portal and because this method has proved to be very effective at Moraine State Park. Prior to the installation of mine seals, a study should be made of the hydrogeologic conditions at each mine site. A drilling program has been proposed for investigating the hydrologic conditions and feasibility of sealing the deep mines. Figure 4 is an isometric drawing showing a double bulkhead grout seal.

Mine Waste on Pumpkin Hill Road - It is recommended that the acidic mine waste mixed with soil and aggregate on Pumpkin Hill Road (Township Road 363) be covered and that the mine waste to the sides of of the road be removed. The abatement measures call for widening of the roadway to cover the most objectionable acidic material. After grading and shaping of the roadway, the mine waste material shall be covered with a 4 inch layer of crushed limestone aggregate which shall then be treated with a bituminous surface coating. Crushed limestone aggregate shall also be placed in the bottom of the roadway ditches. Figure 5 is a generalized cross-section showing the reconstruction and soil treatment of a section of Pumpkin Hill Road.

Sources of Information

We wish to express our appreciation to all who have contributed to this study. The information pertinent to the engineering survey of the East Branch Clarion River, for the purpose of determining the extent of acid mine drainage pollution within the watershed, was obtained from a number of sources.

.The areal extent of the drainage basin and sub-basin was measured from existing U. S. Geological Survey topographic maps or, in sub-basins where there were sources of acid mine drainage pollution, from topographic maps made during this investigation.

Information on stream flow was obtained from the U.S. Geological Survey, Water Resources Division, the U.S. Army Corps of Engineers, and from measurements made at weirs constructed for the study.

The information dealing with climatology and precipitation was obtained from publications of the U. S. Department of Commerce, Environmental Science Services Administration, and from the files of the State Climatologist of the Commonwealth of Pennsylvania.

The geological description of the area was found in publications of the U. S. Geological Survey and the Topographic and Geologic Survey of the Commonwealth of Pennsylvania.

An extensive search for information on deep mining in the East Branch Clarion River Watershed revealed that there were no deep mine maps available for the mining operations. Most of the coal mining information was obtained from reports of the U. S. Geological Survey, publications of the Topographic and Geologic Survey of the Commonwealth of Pennsylvania, and from local residents who had been employed in the mining operations.

The United Natural Gas Company, Oil City, Pennsylvania, is now the owner of the properties in the Two mile Run and Gum Boot Run areas where deep mining took place. The geologist was allowed to make notes on maps and reports in their files concerning the geology and mining of the Instantur and Gum Boot Mines, but copies of the maps could not be made because they contained classified information dealing with coal reserves and oil and gas tests.

The Pennsylvania Department of Mines and Mineral Industries supplied what information they had available on coal production from deep mines within the watershed. However, most of the deep mine coal production estimates used in this report are assumptions based on the interpretation of field data and the recorded history of mining operations.

Most of the data dealing with acid mine drainage pollution of the East Branch Clarion River Watershed, up until the start of this investigation, was obtained from the Pennsylvania Department of Health. They supplied most of the water quality data from 1958 to 1960, with some additional water quality data being obtained from the U. S. Army Corps of Engineers, Pittsburgh District, and from the Federal Water Quality Administration, Ohio River Basin, Wheeling Field Station.

The aerial photographs used in this investigation were made by Michael Baker, Jr. , Inc. in 1968-69. These aerial photographs were compared with photo coverage also made by Michael Baker, Jr., Inc. in 1959 for the U. S. Department of Agriculture.

Recommendations on soil treatment and information on the planting of trees, grass and legumes was obtained from Pennsylvania State University, Department of Agriculture. Information was also supplied by the U. S. Department of Agriculture, Soil Conservation Service, Elk County, and the Elk County Agent of the Pennsylvania Department of Agriculture.

The Northeastern Forest Experiment Station at Berea, Kentucky and Kingston, Pennsylvania, made available information on their experiments with the use of Weeping lovegrass for strip-mine reclamation.

Bituminous Coal Research, Inc. allowed for use of their extensive library on acid mine drainage research and loaned pertinent publications.

The Federal Water Quality Administration, Ohio River Basin, Wheeling Field Station, supplied information on their water quality testing methods and made helpful suggestions.

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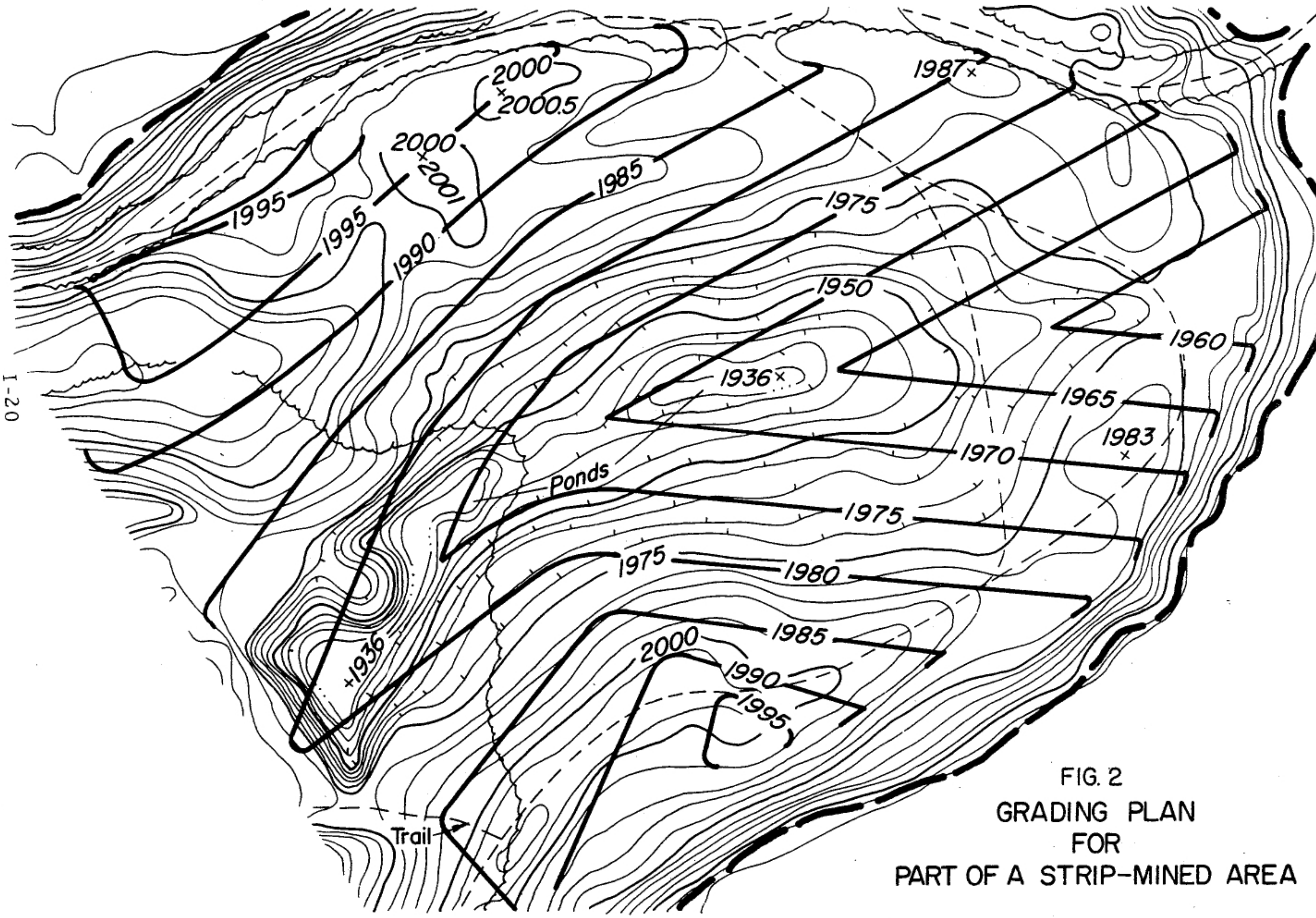
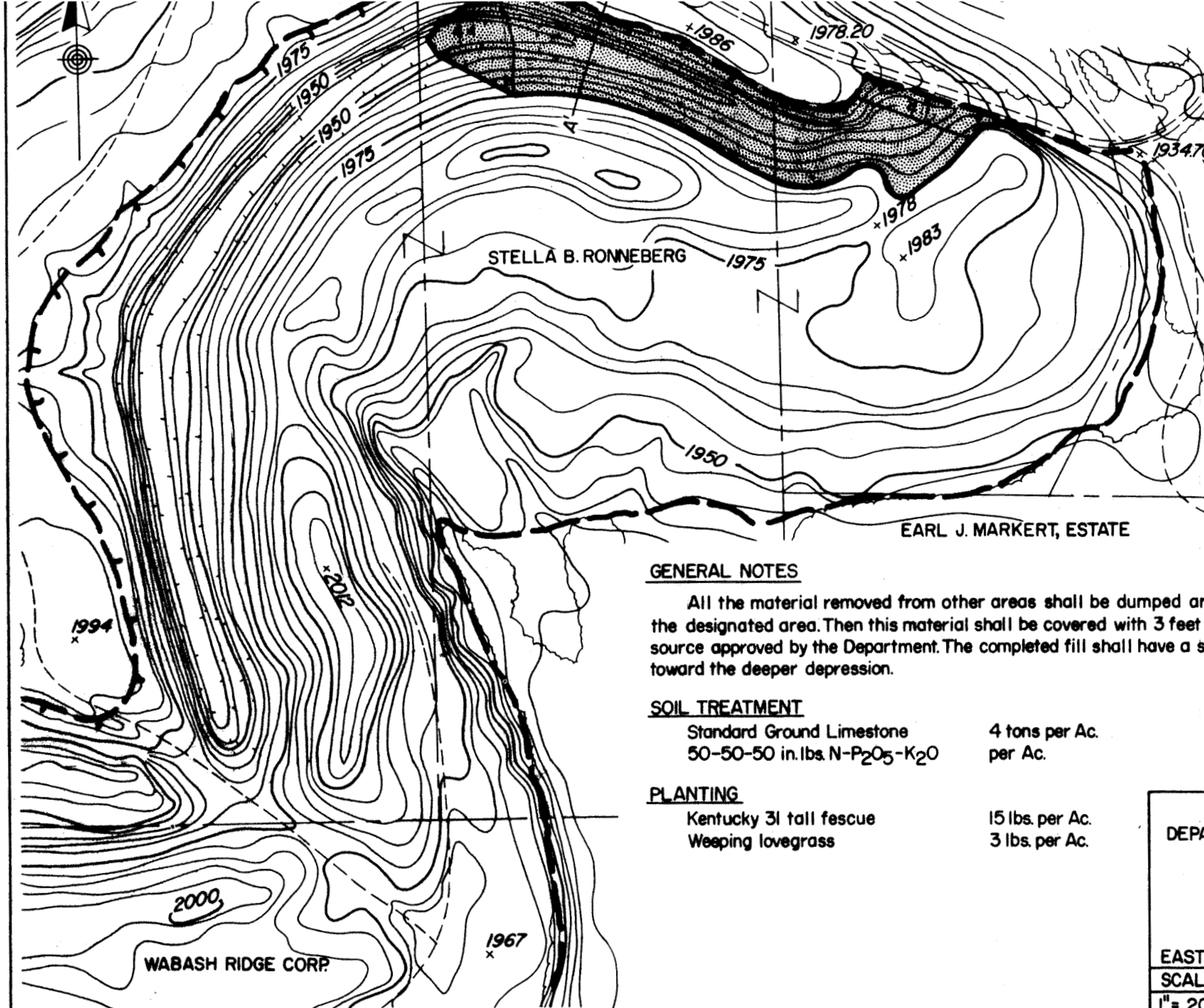
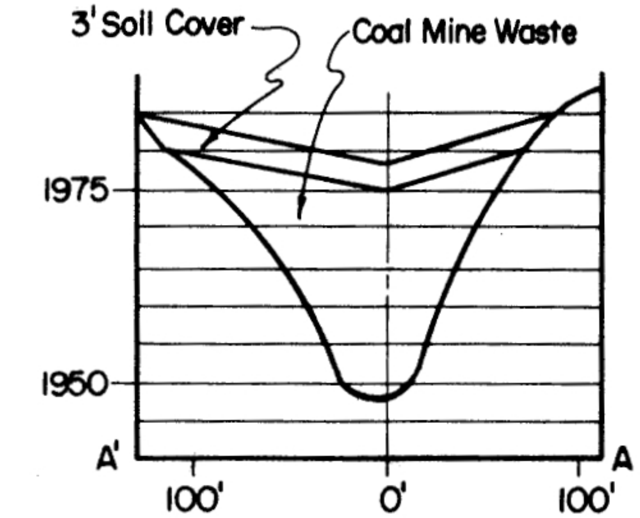


FIG. 2
GRADING PLAN
FOR
PART OF A STRIP-MINED AREA

FOR COAL MINE WASTE





Area Designated For Disposal of Coal Mine Waste and Trash
3.7 Acres

GENERAL NOTES

All the material removed from other areas shall be dumped and spread within the designated area. Then this material shall be covered with 3 feet of soil from a source approved by the Department. The completed fill shall have a slope of 1' in 100' toward the deeper depression.

SOIL TREATMENT

Standard Ground Limestone	4 tons per Ac.
50-50-50 in. lbs. $N-P_2O_5-K_2O$	per Ac.

PLANTING

Kentucky 31 tall fescue	15 lbs. per Ac.
Weeping lovegrass	3 lbs. per Ac.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF MINES & MINERAL INDUSTRIES

AREA NO. 11 STRIP MINE
DISPOSAL OF COAL MINE WASTE

EAST BRANCH CLARION RIVER ELK COUNTY, PA.

SCALE	MICHAEL BAKER, JR., INC.	DWG. NO.
1" = 200'	ROCHESTER, PENNSYLVANIA	SC-12

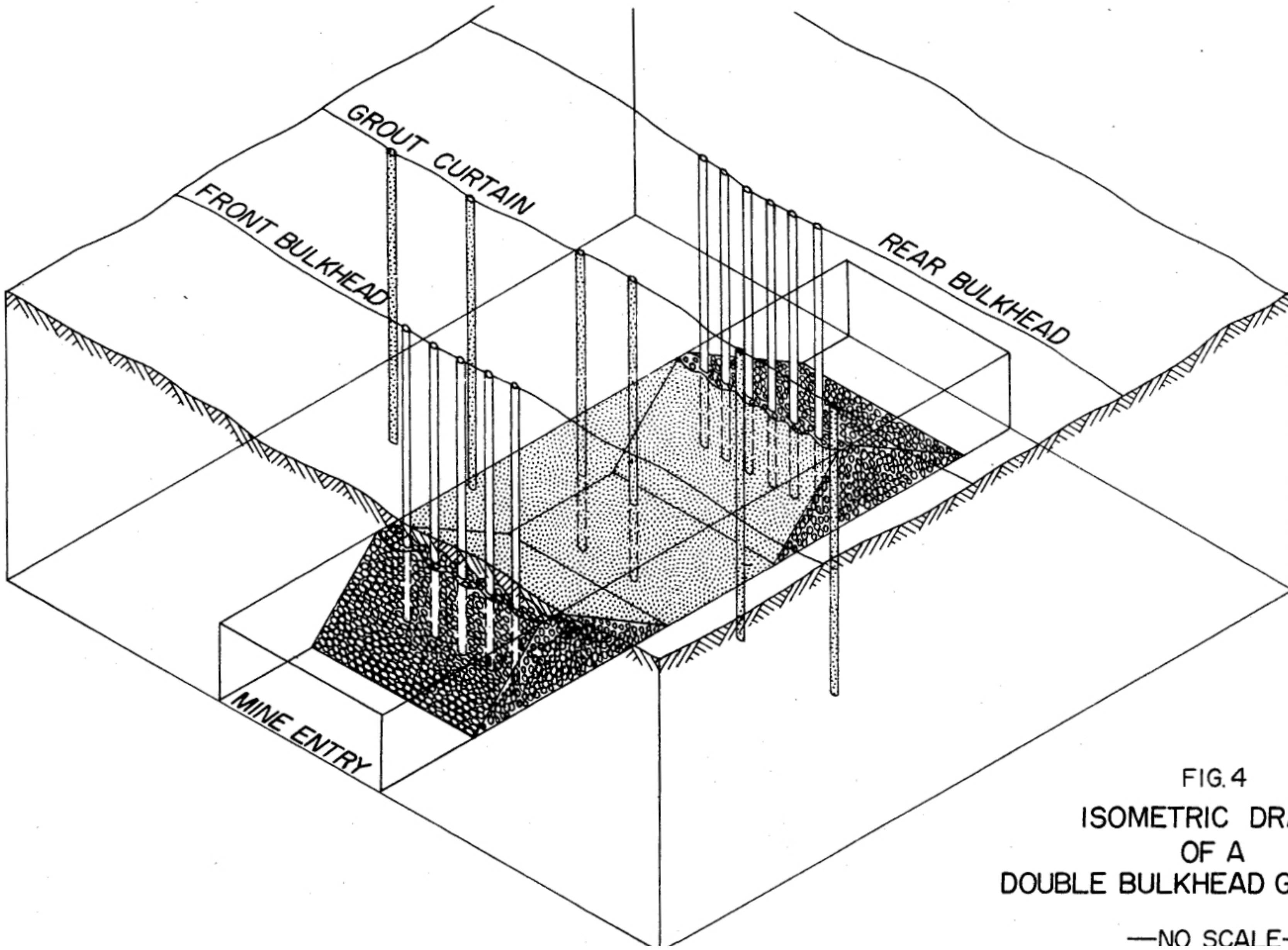


FIG. 4
ISOMETRIC DRAWING
OF A
DOUBLE BULKHEAD GROUT SEAL

—NO SCALE—

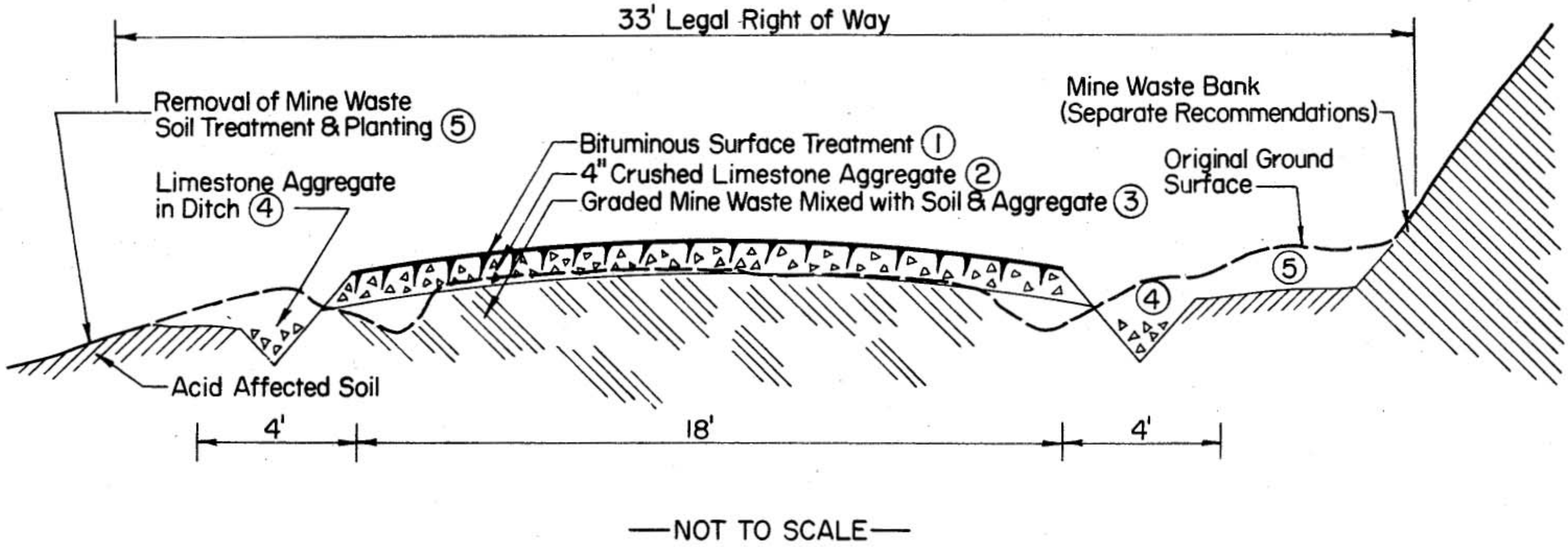


FIG. 5

RECONSTRUCTION AND SOIL TREATMENT OF A
SECTION OF PUMPKIN HILL ROAD (TOWNSHIP ROAD 363)