COWANSHANNOCK CREEK MINE DRAINAGE POLLUTION ABATEMENT PROJECT

OPERATION SCARLIFT

COMMONWEALTH OF PENNSYLVANIA
Milton J. Shapp, Governor
Department of Environmental Resources
Maurice K. Goddard, Secretary

SL-159

NOVEMBER
1972

CARSON ENGINEERS
Greensburg, Pennsylvania

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CONSULTING

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July, 1973

Honorable Maurice K. Goddard, Secretary
Commonwealth of Pennsylvania
Department of Environmental Resources
Harrisburg, Pennsylvania 17120

Dear Dr. Goddard:

We are pleased to submit the Watershed Study and Quick Start comprehensive reports for the Cowanshannock Creek Watershed and the Yatesboro and Margaret mine complexes located in Armstrong and Indiana Counties, Pennsylvania. We appreciate the opportunity to perform these services.

Respectfully submitted,

Ronald F. Carson, P.E.
President

RFC/jlh

Enclosure

COMMONWEALTH OF PENNSYLVANIA
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DEPARTMENT OF ENVIRONMENTAL RESOURCES

REVIEW NOTICE

This report, prepared by outside consultants, has been reviewed by the Department of Environmental Resources and approved for publication. The contents indicate the conditions that are existing as determined by the consultant, and the consultant's recommendations for correction of the problems. The foregoing does not signify that the contents necessarily reflect the policies, views, or approval of the Department.

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Introduction

Problem

In brief, the watershed study problem associated with the Cowanshannock Creek drainage area has been to determine sources of acid mine drainage and to make recommendations for the abatement of the pollutants in order of importance via an in-depth study of the critical sources.

The matter was complicated in that for each source of mine drainage pollution an evaluation of the type of connective measure necessary for the abatement of pollution was required. The evaluation in turn could lead to either a straight forward recommendation for required action, such as strip mine reclamation, or to a recommendation for an in-depth study of the more complex areas of pollution sources, such as some of the deep mine complexes.

Coexistent with abatement measures, is the problem of estimating costs for each abatement project and then determining via a cost-benefit analysis those projects that should be considered for further action.

Orientation

The State of Pennsylvania, responding to increasing demand for environmental renewal has undertaken a wide range of projects aimed at the control and prevention of pollution in all of its worst forms. Part of this effort has involved the Department of Environmental Resources in a concentrated drive to eradicate the blight of coal mine drainage pollution from the Pennsylvania scene.

As in many other regions, mine drainage pollution has for a considerable number of years worked its deleterious effects on the Cowanshannock Creek, a tributary to the Allegheny River. An extensive complex of abandoned and operating mines has persistently posed a serious pollution problem; and, in consequence, the Department of Environmental Resources has moved to give close attention to this region.

In July of 1970, the Department contracted with Carson Engineers to execute a total watershed study for Cowanshannock Creek, to be coupled with a "quick start" project aimed specifically at developing an abatement plan for the mine complex designated Yatesboro 4 and 5 predominately located north of Cowanshannock Creek.

An addendum to the original contract dated September, 1971, expanded the study to include a "quick start" project aimed specifically at developing an abatement plan for the mine complex designated as the Yatesboro 1, 2, 3, and Margaret 6 and 8 mine complex located to the south of the Cowanshannock.

Specifically, our contract objectives for the watershed study called for (1) Securing existing available information on the watershed; (2) Determining locations of mine openings, deep mines, strip mines, refuse areas, coal contours, and coal outcrops; (3) Selecting and establishing water sampling stations; (4) Evaluating types of corrective measures; (5) Evaluating and preparing cost estimates for abatement construction and listing alternative abatement plans; and, (6) Preparing recommendations for necessary abatement projects.

Following a general description of the subject watershed, a precise formulation of the project problem is given after which the solution, in the form of conclusions and recommendations, is presented. The latter are developed as the logical consequences of those facts and conditions which the pollution situation at Cowanshannock Creek exhibits, together with economic and other criteria having a bearing upon the work to be done and the ultimate benefits desired. Backup material, including field data and detailed location drawings, are presented second in a set of appendices filling out this volume of the comprehensive report.

Definition of Terms

Acidity	- The quantitative capacity of aqueous solution to react with hydroxyl ions. It is measured by titration with a standard solution of a base to a specified end point. Usually expressed as milligrams per liter of calcium carbonate.
Air Seals	- The function of the air seal is to exclude air from entering the mine but permitting normal flow of water at the discharge.
Air Shaft (AS)	- An opening into a mine by which air can be forced to circulate.
Alkalinity	- The capacity of water to neutralize acids, a property imparted by the water's content of carbonates, bicarbonates, hydroxides, and occasionally borates, silicates, and phosphates. It is expressed in milligrams per liter of equivalent calcium carbonate.
Anticline	- A high point of geologic contour.
Bore Hole (BH)	- Boring or drilling of a hole into a deep mine.
CaCo3	- See acidity or hardness.
Coal Contour	- A line of equal elevation above a specified datum, usually mean sea level.
Coal Pillars	- Natural coal columns used in deep mines for roof support.
Confluence	- The meeting or junction of two or more streams.
Core Drilling	See Test Hole.
CFS	- Cubic Feet Per Second.
Curtain Grouting	- See Grouting.
D.B.	- Deed Book.
Deep Mine	- An underground excavation of economic minerals.
D32	- D (Deep Mine) 32 (Station No.)
Demography	- The study of human vital statistics and population dynamics.
Down or Up Dip	- The angle at which a bed, stratum, or mineral vein is inclined from the horizontal.

Dry Seals	- The installation of dry seals consists of the closure of mine drifts, slopes, shafts, and subsidence areas where there will be very little or no hydrostatic pressure in the area.
Easement	- A right of one person to use the land of another for some special purpose.
Ecosystem	- Energy-driven complex of a community of organisms and its controlling environment.
Egress	- A place or means of exit; an outlet.
Flow Meter or Current Meter	- A device for determining the velocity of moving water.
GPM	- Gallon Per Minute.
Gob Piles	- That part of the mined material, either coal or other minerals that is not marketable and is therefore wasted.
G2	- G (Gob) 2 (Station No.)
Grouting	- To seal off or to fill in with concrete or other sealant.
Hardness (CaCo3)	- The peculiar quality exhibited by water containing certain dissolved salts.
Head	- Energy contained by fluid because of its pressure, velocity, and elevation, usually expressed in feet of fluid.
Head Water	- Source of a stream: water upstream.
Hydraulic Seals or Wet Seals	- Consists of the sealing of mine entries, drifts, slopes, shafts, and adjacent strata where there is hydrostatic pressure in the area of the seal.
Highwall	- The vertical working face of a strip or surface mine.
Hydrologic Cycle	- The circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages or processes such as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration. Also called water cycle.

Definition of Terms (Cont'd)

Hydrology	- The study of the characteristics and occurrence of water and of the hydrologic cycle.
Hydrostatic Pressure	- (1) The pressure, expressed as a total quantity of per unit of area, exerted by a body of water at rest. (2) In the case of groundwater, the pressure generally due to the weight of water at higher levels in the same saturation zone.
Influent	- Water, wastewater, or other liquid flowing into a reservoir, basin, or treatment plant, or any unit thereof.
Infra	- A prefix meaning below.
L.F.	- Lower Freeport Coal Seam. Referred to as "D" vein.
L.K.	- Lower Kittanning Coal Seam. Referred to as "B" vein.
Monitor	- The procedure or operation of scheduled observation.
M.K.	- Middle Kittanning Coal Seam. Referred to as "C" vein.
NT4	- NT (North Tributary) 4 (Station No.)
Outcrop	- That part of a stratum which appears at the surface of the ground.
Overburden	- Consolidated and unconsolidated material that overlies a coal bed or other mineral deposit, especially in surface mining operations.
p.	- Page.
Parameter	- A quantity to which the operator may assign arbitrary values, as distinguished from a variable, which can assume only those values that the form of the function makes possible.
Physiography	- A description of nature or natural phenomena in general.
Point of Discharge	- The single geographical location at which all drainage from a given area comes together as outflow.

Definition of Terms (Cont'd)

PIN	- Pollution Index Number.
Portal Shaft (PS)	- Opening into a mine.
ppd	- Pounds per day.
ppm	- Parts per million.
Precipitation	- Rain, snow, hail, dew, and frost.
Pyrite	- A common mineral of a pale brass-yellow color and metallic luster, chemically iron metallic-looking sulfides (FeS_2).
Rock Roll	- A large solid rock intrusion.
Seam	- Synonymous with bed, vein, etc.
Shaft	- A vertical or inclined excavation in a mine extending downward from the surface or from some interior point as a principal opening through which the mine is exploited.
ST4	- ST (South Tributary) 4 (Station No.)
Spoil	- That part of the coal deposit that is too low in grade to be of. economic value at the time.
Stratigraphic Columns	- Arrangement of strata as it is found in geologic investigations.
Strip Mines	- Removal of mineral or other resources from the earth by first removing overlying soil and rock materials.

S5	S,(Strip Mine) 5 (Strip mine designation Number).
Subsidence	- A downward movement of natural ground surface not induced by external loads.
Subsurface.	- Soil just below land surface.
Sulfates	- A salt or ester of sulfuric acid (S04).
Syncline	- A low point of geologic contour.
Test Hole or Core Drilling	- A well hole drilled for. experimental or exploratory purposes.
Test Station	- An established location where water samples are obtained.
Total Iron (ppm	- A total measure of both ferrous and ferric iron.
Tributary main channel.	- Branch of a stream that contributes flow to the primary or
Ultra	- A prefix meaning beyond.
Up Dip	- See Down Dip.
U.F.	- Upper Freeport Coal Seam. Referred to as "E" vein.
U.K.	- Upper Kittanning Coal Seam. Referred to as "C Prime" vein.
Water Sampling Stations	- A point at which water is collected for chemical analysis and where flow is measured.
Water Table	- The upper boundary of a free ground-water body, at atmospheric pressure.
Watershed	- All land drained by a stream or river, and its tributaries.
Wet Seals	- See Hydraulic Seals.

Mine Maps Available

Mine Name	Operated By	Seam	Maps* Available
Yatesboro 1 & 2	R & P Coal Co.	U.F.	1, 2, 5
Yatesboro 3	R & P Coal Co.	L.F.	1, 2, 5
Yatesboro 4 & 5	R & P Coal Co.	U.F.	1, 2, 5
Margaret 6, 7, & 8	R & P Coal Co.	U.F.	1, 2, 5
Decker #2	Powell Coal Co.	U.F.	1, 4, 5
Decker #3	Powell Coal Co.	U.F.	1, 4, 5
Decker #4	Powell Coal Co.	U.F.	1, 4, 5
Decker #5	Powell Coal Co.	U.F.	1, 4, 5
Sagamore Mine			1, 3
Melrose Mine	Universal Coal & Coke Co.	L.K.	1
Brilliant Mine	Allegheny Gravel & Sand Co.	L.K.	1
Rayburn No. 1 & No. 2	Kittanning Iron & Steel Mfg. Co.	U.F. & L.K.	1

*1 U.S. Bureau of Mines
Pittsburgh, Pa.

2 Rochester & Pittsburgh Coal Co.
Indiana, Pa.

3 Kovalchick Salvage Co.
Indiana, Pa.

4 Powell Coal Co.
Kittanning, Pa.

5 Carson Engineers

Acknowledgments

We of Carson Engineers are grateful to the representatives of the coal companies located within the watershed for their fine cooperation in furnishing much of the historical records, maps, and mine data on their respective mines where such information was available. We wish also to express our thanks to the many federal, state, and local water resource agencies for their cooperative response. Special acknowledgment is extended to the staff of the Pennsylvania Department of Environmental Resources for providing valuable information and suggestions pertinent to the conduct of this study.

Watershed Description

Physioqraphy

The Cowanshannock Creek watershed comprises 62.8 square miles of watershed area. It is a tributary to the Allegheny River with the confluence located directly north of Kittanning, Pennsylvania, near the town of Gosford. The watershed extends in an easterly direction from the Allegheny River and is located in both Armstrong and Indiana Counties.

The watershed is bounded in the north by the Hays Run, Pine Creek, and Glade Run watersheds; in the east by the Little Mahoning Creek watershed; and to the south by the Plum Creek, Cherry Run, and Garret Run watersheds.

The length of Cowanshannock Creek is 24 miles, and at its eastern extremity the creek bisects into a north and south branch. The creek channel is sinuous with a rate of fall averaging from 15.4 ft/mile to 50.8 ft/mile over its length.

A narrow flood plain exists in the western reaches of the creek and then widens to a low flat flood plain area over its central section and along the north branch in the eastern section of the stream. Flood plain areas are most pronounced in the Yatesboro NuMine area of the watershed. Outside the flood plain the topography is broken and hilly, flanked by steep inclines some 400 to 500 feet high.

Geologic Factors

In its geographic and geologic relationships the watershed forms a part of the Appalachian province, which extends from the Atlantic Coastal Plain on the east to the Mississippi lowlands on the west, and from Alabama to Canada. With respect to topography and geologic structure, the Appalachian province may be divided into two nearly equal parts by the Allegheny Front, a line following a general northeasterly direction through the Commonwealth and located approximately 75 miles east of the watershed. East of the front, rock formations are greatly characterized by faulting and folding; west of the line, rock formations lie nearly flat.

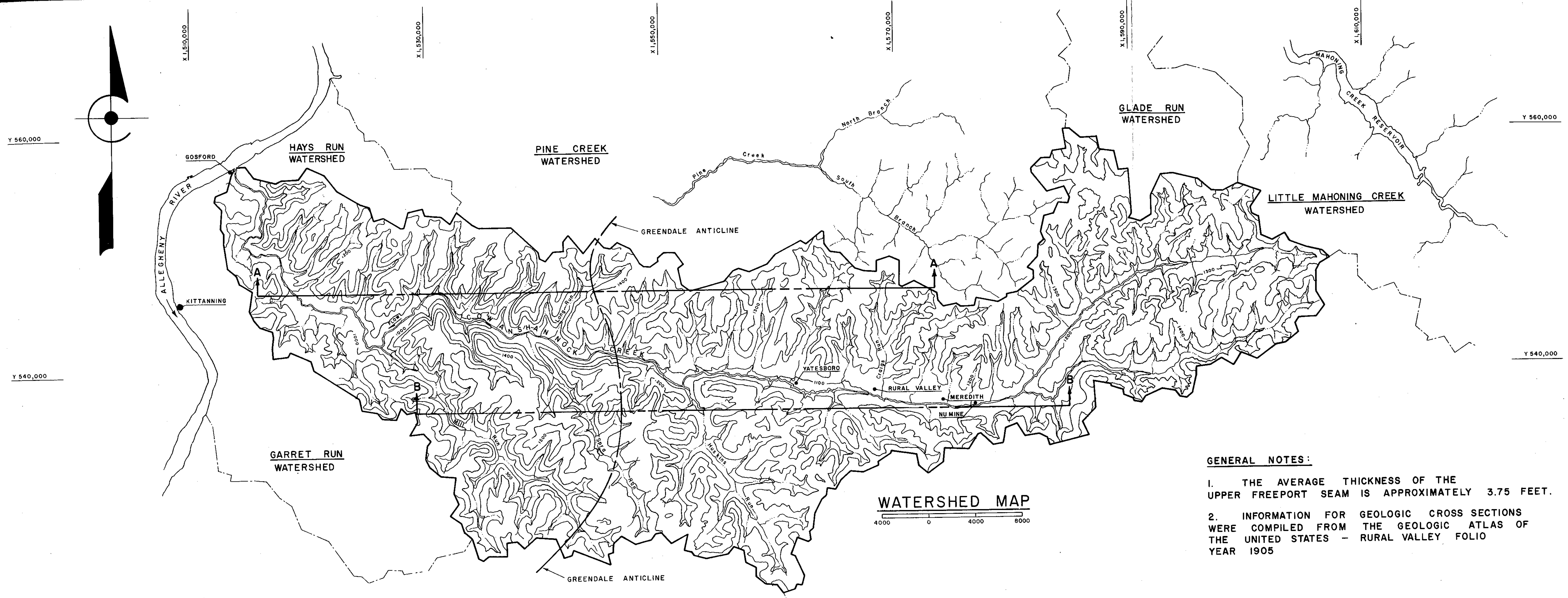
The few folds that break the regularity of the structure are so broad that they are scarcely noticeable. This area, west of the Allegheny Front, is generally referred to as the Allegheny Plateaus of which the watershed is a part.

The rocks within this area are of the Carboniferous Age. These rocks are divided into two series, the Mississippian series, the lower of the two series, and the Pennsylvanian series of which we are primarily concerned. Formations of the Pennsylvanian series are co-extensive with the Appalachian coal field and consists essentially of sandstones and shales but contains extensive beds of limestone and fire clay. The Pennsylvanian series is especially distinguished, however, by its coal seams. Three formations within the Pennsylvanian series are of concern to this study. They are the Conemaugh formation, the top formation; the Allegheny formation; and the Pottsville formation, the lowest of the three. Of the three formations, the Allegheny is the most critical to the study of coal formations. This formation succeeds the Pottsville conformity and extends upward to the top of the Upper Freeport coal. It is composed of sandstones, limestones, shales, clays, and coals, aggregating about 350 feet in thickness. The coal seams, though varying from a few inches to 5 feet in thickness, are the most persistent members of the formation and occur in it from top to bottom at intervals averaging about 40 feet. The intervening strata are generally shale, which is prevailingly gray and sandy though both dark- and light-colored clay shale occurs. Within the shale comparatively thin layers of sandstone are common and atcertain horizons lenses of sandstone varying much in texture and bedding frequently replace the shale and are classed as members of the formation. Limestones within the formation rarely exceed 10 feet in thickness with the exception of Vanport limestone, they occur as lenses at definite horizons. Fire clay occurs as the underclay of the coal seams. These underclays are co-extensive with the coal seams, and the thickness of any particular bed varies greatly.

Three coal seams appear to be most dominate within the watershed; Upper Kittanning, Lower Freeport, and Upper Freeport. Upper Kittanning coal occurs 40 to 50 feet below the Lower Freeport vein and is recoverable in thickness up to 18 inches over some portions of the watershed. Lower Freeport coal reaches a thickness of 4 feet in places and is persistent over a considerable area. Upper Freeport Coal (Plate 1) comprising the top of the Allegheny Formation occurs from 20 to 60 feet above the Lower Freeport coal. This vein is generally 3 to 5 feet thick throughout the watershed. All three veins outcrop along the central and eastern portions of the watershed on both sides of the Cowanshannock. Southeast of the Greendale anticline the coal soon dips beneath the surface just west of Yatesboro. Most deep mine activity has been concentrated in the area east and south of Yatesboro where the Yatesboro, Margaret, and Sagamore mine complexes are located, and where mining activity has principally concentrated in the Upper Freeport vein. Other coals within the watershed are Middle Kittanning, Lower Kittanning, Clarion, Craigsville, Brookville, and Brush Creek; however, these coals are generally not considered economically recoverable.

Vanport limestone, known throughout western Pennsylvania as the Ferriferous limestone, runs uniformly about 8 feet in thickness wherever it has been observed. Its horizon is above water on the Cowanshannock starting about 2 miles west of Yatesboro and extending for approximately 4 miles to the west. This limestone has been mined for commercial use within the watershed. It is the most important limestone in the region and can be used as a source for flux stone for the iron and steel industry, and also for cement, agricultural limestone, aggregate, and roadstone. The Vanport consists in general of dense, gray fossils: ferrous limestones are generally massive although thin beds are common in some places. Chemically it cannot be ranked as an exceptionally high grade stone, but its composition is quite uniform and it characteristically has a low magnesium-carbonate content. Chemical analysis of the local source shows the following composition: CaC03, 93.2%; MgC03, 1.7%; S102, 3.4%; R203, 1.7%; and P, 0.032%.

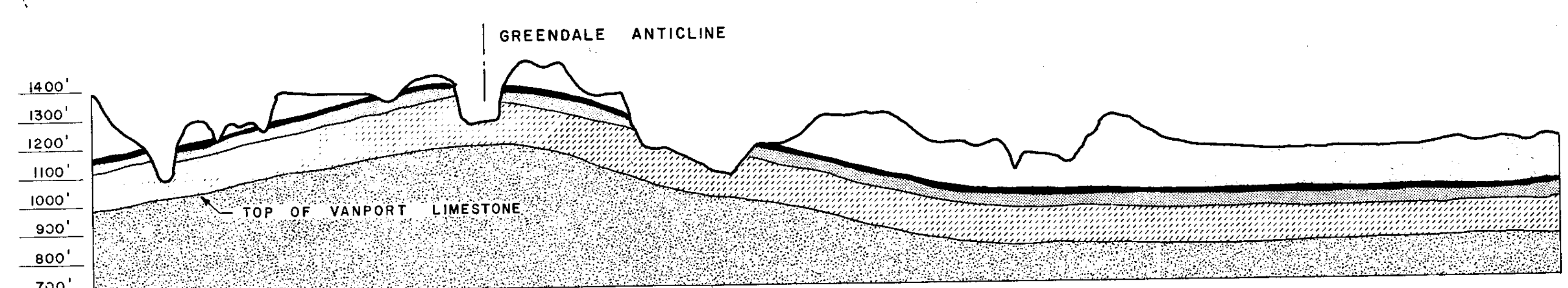
The Conemaugh Formation begins directly above the Upper Freeport coal vein. Mahoning sandstone is normally found near the base



WATERSHED MAP

GENERAL NOTES:

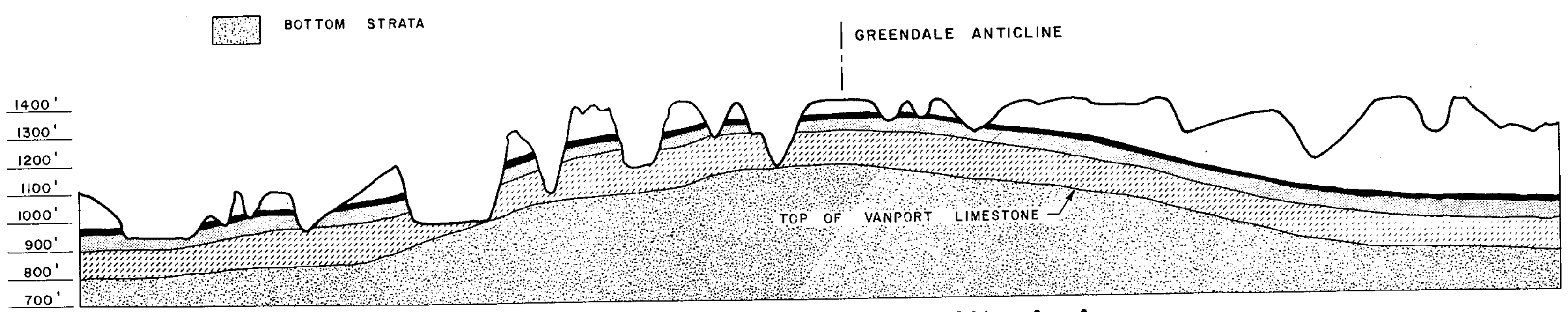
1. THE AVERAGE THICKNESS OF THE UPPER FREEPORT SEAM IS APPROXIMATELY 3.75 FEET.
2. INFORMATION FOR GEOLOGIC CROSS SECTIONS WERE COMPILED FROM THE GEOLOGIC ATLAS OF THE UNITED STATES – RURAL VALLEY FOLIO YEAR 1905



GEOLOGIC CROSS SECTION B - B

LEGEND FOR CROSS SECTIONS

- UPPER FREEPORT COAL
- FREEPORT LIMESTONE & BUTLER SANDSTONE
  LOWER FREEPORT COAL (INTERMITTENT)
- FREEPORT SANDSTONE
  UPPER KITTANNING COAL (GENERALLY THIN)
  FREEPORT SANDSTONE
  MIDDLE KITTANNING COAL (GENERALLY THIN)
  FREEPORT SANDSTONE
  LOWER KITTANNING COAL
- BOTTOM STRATA



GEOLOGIC CROSS SECTION A - A

SCALE OF CROSS SECTIONS

HORIZONTAL – 0 1 MI. 2 MI.

VERTICAL – AS SHOWN

COWANSHANNOCK CREEK WATERSHED		
SCALE: AS SHOWN	PREPARED FOR: PROJECT SL-159 COMMONWEALTH OF PENNSYLVANIA	PREPARED BY: R.F.C.
DATE: 4-20-72	DEPT. OF ENVIRONMENTAL RESOURCES	DRAWN BY: S.V.S.
WATERSHED GEOLOGIC CROSS SECTIONS		
SUBMITTED BY: CARSON ENGINEERS		DRAWING NO. PLATE 1

of the Conemaugh between the Upper Freeport and Brush Creek coal vein which lies about 100 feet above Upper Freeport coal. The Mahoning sandstone in this watershed is a variable stratum; over most of the area there is nothing to indicate its presence, probably because it is entirely wanting or very thin, but locally it is thick and heavy. However, in this area the Conemaugh Formation is mostly sandshale with thin sandstone layers.

Mining History

Early mining activity within the area dates back to the late 1800's, however, it wasn't until the early 1900's that mining was undertaken with serious endeavor within the watershed when the Rochester and Pittsburgh Coal Company consolidated a number of small operations and then operated the Yatesboro mines. An extension of the original Yatesboro mine complex, the Margaret No. 7 mine, is still in operation. One other major coal producing deep mine is still active; the Brinker No. 5 owned by the Powell Coal Company in the western portion of the watershed near the city of Kittanning. Major mining activity has been within the Upper Freeport "E" vein; however, there has been some deep mine activity in the Lower Freeport "D" vein of the now abandoned Yatesboro No. 9 and 3 mines as well as some activity in the Upper Kittanning coal in the western section of the watershed.

The watershed comprises some 12,400 acres of undermined area with principal deep mine workings located in the central to eastern portions of the watershed and within the west section closer to Kittanning.

Serious surface mine activity began between 1940 and 1950 and is yet continuing on some portions of the watershed. This type of mining activity concerns itself with the Upper Freeport, Lower Freeport, and Upper Kittanning coal veins and contributes to some 2500 acres of the total watershed. Most of the stripped areas have been at least partially reclaimed.

The majority of the mining on the Cowanshannock Creek was undertaken prior to passage of effective pollution control legislation.

The Commonwealth's first Clean Streams Law, passed in 1937, specifically exempted control of mining operations. In 1945, the law was amended to disallow pollution from active mines located on clean streams. Lack of proper funding delayed effective implementation of this amendment for several years. By that time the Cowanshannock was already considered a polluted stream.

It was not until 1963 that the control of active surface mines was effectively strengthened and not until 1965 that active deep mines were required to control pollution regardless of the quality of the receiving streams. None of the present legislation can require a coal company to undertake any reclamation work or pollution control on mines, both surface and deep, that had been abandoned prior to the enactment of regulatory legislation.

Hydrologic Factors

No part of the watershed was covered by glaciers during the ice invasion from the north. The Allegheny Valley, however, carried waters which had resulted from melting of the glaciers, and these waters deposited glacial outwash in the Allegheny River Valley at the mouth of the Cowanshannock. The remnants of outwash material are found in two layers, one at about 200 to 300 feet above the present river, and the lower deposit about 60 feet above the river. These gravels are water bearing, and the city of Kittanning, located directly south of the watershed on a gravel flat, derives water from the underlying gravel.

The watershed is fairly well supplied with ground water. Small springs are found on the steep slopes and are utilized in some instances for domestic supply. However, they fluctuate considerably with the season and are therefore not very trustworthy sources of supply. Most sources of domestic water is via drilled wells. Sandstones in the area can usually be relied upon to yield moderate quantities of water, though in some places, especially in areas where they are thin-bedded or shaley, they yield little or no water. A member of any formation may have different waterbearing properties in different locations because the beds may change from sandstone to shale in short distances.

Water from sandstone is in general high in iron, in some beds so high that unless the water is treated for partial removal of the iron it will not be satisfactory. Deep well drilling in the area is not advisable because of the likelihood of encountering salt water.

The domestic water supplies of both villages of Yatesboro and NuMine are obtained from treated well water. Interviews with some local inhabitants indicate that the water supply is generally undesirable probably because of the iron content. On the other hand, some individual wells supplying local inhabitants indicate the water to be satisfactory. Water depths observed from old well records indicated water depths from 20 to 110 feet below surface. Cowanshannock Creek is located in an area where average annual rainfall is approximately 40 inches per year. Records from the U.S. Weather Bureau show an average rainfall of 36.87 inches for the weather station located at Kittanning, just south of the watershed. Low rainfall can be expected during the month of February with an average of 1.89 inches, and highest rainfall can be expected during the month of August when the average is 4.24 inches. Average runoff for the area is estimated at 20 in/yr.

The Cowanshannock is in a low flow area of approximately 0.0 to 0.1 c.f.s. per square mile. This is a measure of minimum flow during dry months of the year and is characteristic of most of western Pennsylvania. The study area is in a moderate flood zone area with peak flows for a 50 year storm estimated at 11 to 12 thousand c.f.s. per 100 square miles of drainage area (about 6,900 to 7,600 c.f.s. for the watershed). The study area is considered, generally, to have a moderate to low silt flow in the stream (not withstanding strip mine silt). Average annual sediment yield is 20 to 250 tons per square mile.

Average Monthly Precipitation
Kittanning, Pa. (Lock #7)

	J	F	M	A	M	J	J	A	S	O	N	D
1966	3.70	3.14	2.53	3.35	4.36	1.59	1.93	4.66	3.17	2.27	4.22	2.83
1967	0.79	2.63	5.03	3.31	3.94	0.46	3.49	4.32	2.36	3.10	2.33	2.92
1968	2.53	0.82	3.12	2.52	6.94	0.87	3.27	3.87	3.52	2.45	3.35	3.79
1969	2.86	0.44	0.96	4.31	3.33	3.24	3.15	2.17	1.22	2.71	3.26	4.13
1970	1.67	1.89	2.84	4.78	2.90	3.34	2.62	6.88	4.30	4.41	3.83	3.36
1971	2.11	3.69	2.00	0.93	3.86	1.63	3.22	4.00	5.14			

Demography

Demography of the area and historic trends that go hand in hand with our surface relations presentation in the quick start section of the report is introduced here in order to give a brief picture of general "people" trends within and surrounding the watershed.

Armstrong County is rural in development. The county had enjoyed a steady growth in manufacturing employment that reached a peak in the early 1950's and has since been on the down run. Employment in mines and quarries has decreased steadily since around 1920. This decrease most likely occurred because economically workable coal seams were steadily worked out and because of the advent of technologically improved facilities for mining that required less manpower for operation.

The county is following the trend of the general southwestern Pennsylvania region in that it is losing population, having reached a peak in 1950.

The watershed is located entirely within a rural area. Rural Valley, the largest borough within the watershed, showed an increase in population, counter to general trends, of 11.7% between 1960 and 1970. Population density of the watershed is estimated to be 111 persons per square mile.

Per capita personal income for the county was $2070 in 1963. This was approximately 16% less than the average per capita personal income for Pennsylvania. Interestingly enough mining accounted for a high 5.1 percent of total wages and salaries within the county.

TABLE 1

Population 1960-1970

Area	1970	1960	% Change
Cowanshannock Twp.	2977	3471	-14.2
Valley Twp.	562	502	+12.0
Rayburn Twp.	1962	2179	-10.0
Rural Valley Borough	961	860	+11.7
	6462	7012	- 7.8
Armstrong County	74403	79524	- 6.4

TABLE 2

Employees in Industry
Armstrong County

Year	Manufacturing	Mines & Quarries
1919	4788	5926
1930	4261	4872
1940	5394	4528
1951	7850	2916
1966	6322	1235
1968	6379	1363

TABLE 3

Population Trend 1910-1970

Armstrong County

1910	67880	1950	80842
1920	75568	1960	79524
1930	79298	1970	74403
1940	81087		

Watershed Study

General Discussion

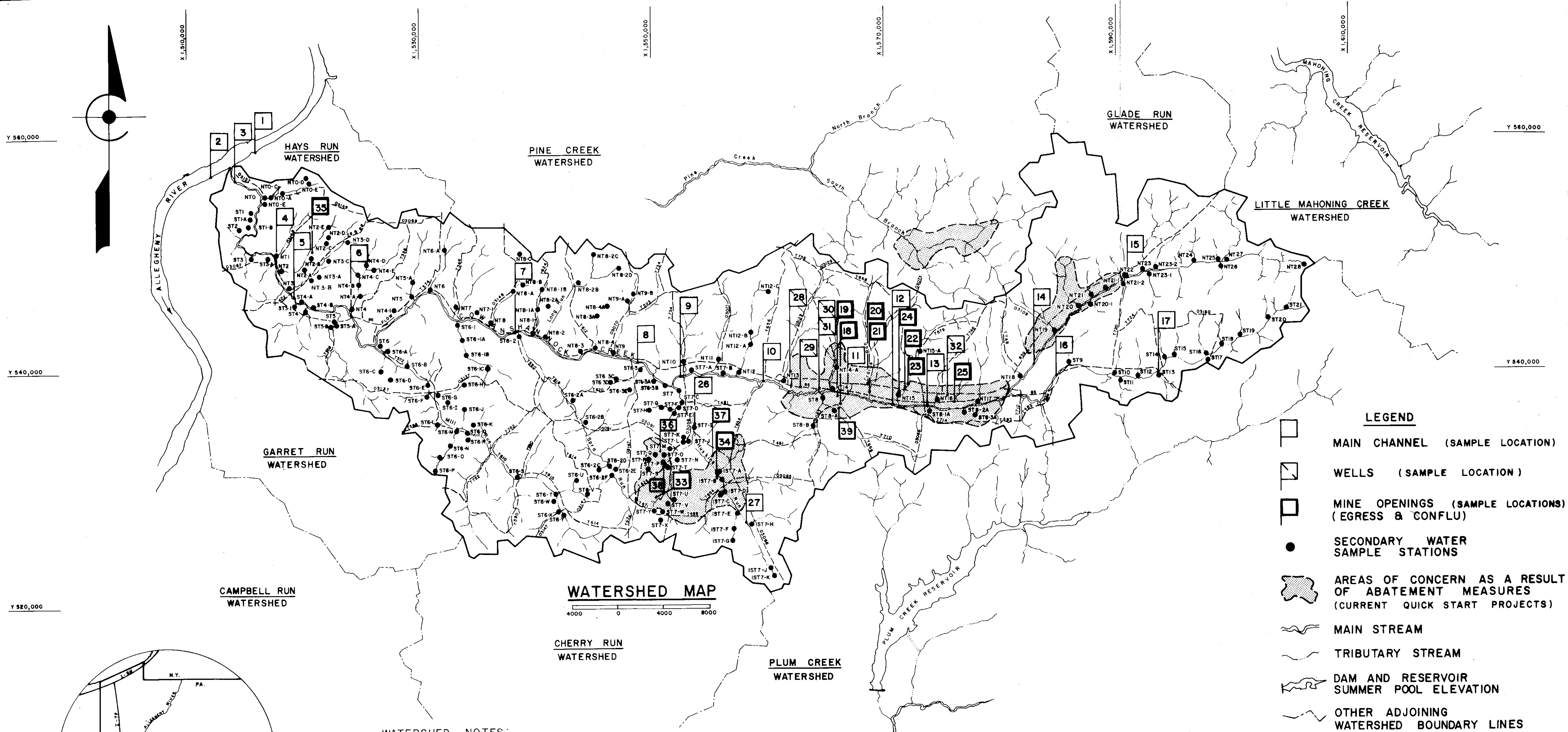
A determination of pollution source locations had to be undertaken prior to the analysis. This determination was then followed by a study of each source in order to ascertain its effect upon the watershed.

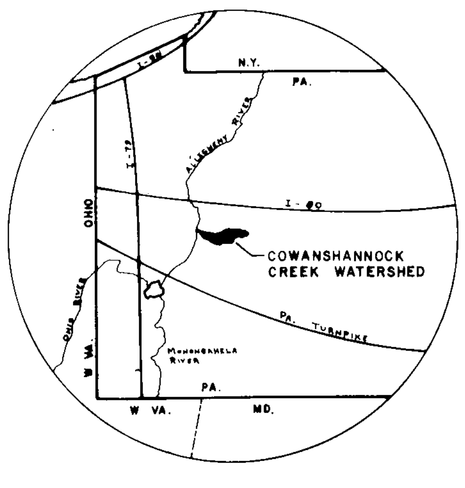
The determination of the location of pollution sources within the watershed consisted of three operations.

1. The establishment of permanent monitoring stations along the main stream of the Cowanshannock, major tributaries and suspected areas of major pollution.
2. The investigation of all abandoned deep mines for sources of polluted flow via field location and water sampling.
3. The investigation of all abandoned surface mining activity and deep mine refuse areas via field location and water sampling.

The establishment of permanent monitoring stations was begun early in the study and continued on a monthly basis for a minimum of twelve months. This monitoring program gave a continual picture of pollution activity along the entire length of the stream and helped to determine those areas in the watershed that are most affected by pollution and thus served as a guide for determining areas that were most critical to the investigation. During the sampling period, water was tested for field pH and temperature, laboratory pH, acidity, alkalinity, total iron, sulfates, and hardness. Plate No. 2 shows the locations of water sampling stations within the watershed.

Permanent sampling stations were established above and below the confluence of the main tributaries to the Cowanshannock and spaced along the stream to obtain a representative cross-section of the areas along the stream most affected by pollution. In addition, permanent sampling stations were established at deep mine openings where flows were known to exist in the area of the Yatesboro 1, 4, and 5 mines and at selected water wells for the villages of Yatesboro and NuMine.





LOCATION MAP

NO SCALE

WATERSHED NOTES:

1. COWANSHANNOCK CREEK LENGTH - 24 MILES
2. DRAINAGE AREA 62.8 SQ. MI.
3. TOPOGRAPHY - BROKEN, HILLY, FLANKED BY STEEP HILLS - 400 TO 500 FT. HIGH
4. CHANNEL SINUOUS, SANDSTONE & LIMESTONE FORMATIONS
5. SUBSURFACE - BITUMINOUS COAL & GAS
6. PROFILE - RATE OF FALL AVERAGES 15.4 FT./MI. TO 50.8 FT./MI. OVER ITS LENGTH
7. PRECIPITATION - MEAN ANNUAL 30 TO 45 INCHES

COWANSHANNOCK CREEK WATERSHED

SCALE: AS SHOWN	PREPARED FOR: PROJECT SL-159 COMMONWEALTH OF PENNSYLVANIA DEPT. OF ENVIRONMENTAL RESOURCES	PREPARED BY: R.F.C.
DATE: 4-20-72		DRAWN BY: J.M.H.

MONITORING PROGRAM
WATER SAMPLING STATIONS

SUBMITTED BY: CARSON ENGINEERS	DRAWING NO. PLATE 2

The location and investigation of deep mines was made simultaneously with the water sampling analysis at permanent sampling stations, and additional stations were established at severe pollution sources as they were found.

Before a field investigation and location of the deep mines was made, all available information on mine locations and history was obtained from various federal, state, and local sources including the Department of Environmental Resources, the U.S. Bureau of Mines located in Pittsburgh, the Environmental Protection Agency, and mine operators. Information on the location or extent of some of the mine workings could not be obtained.

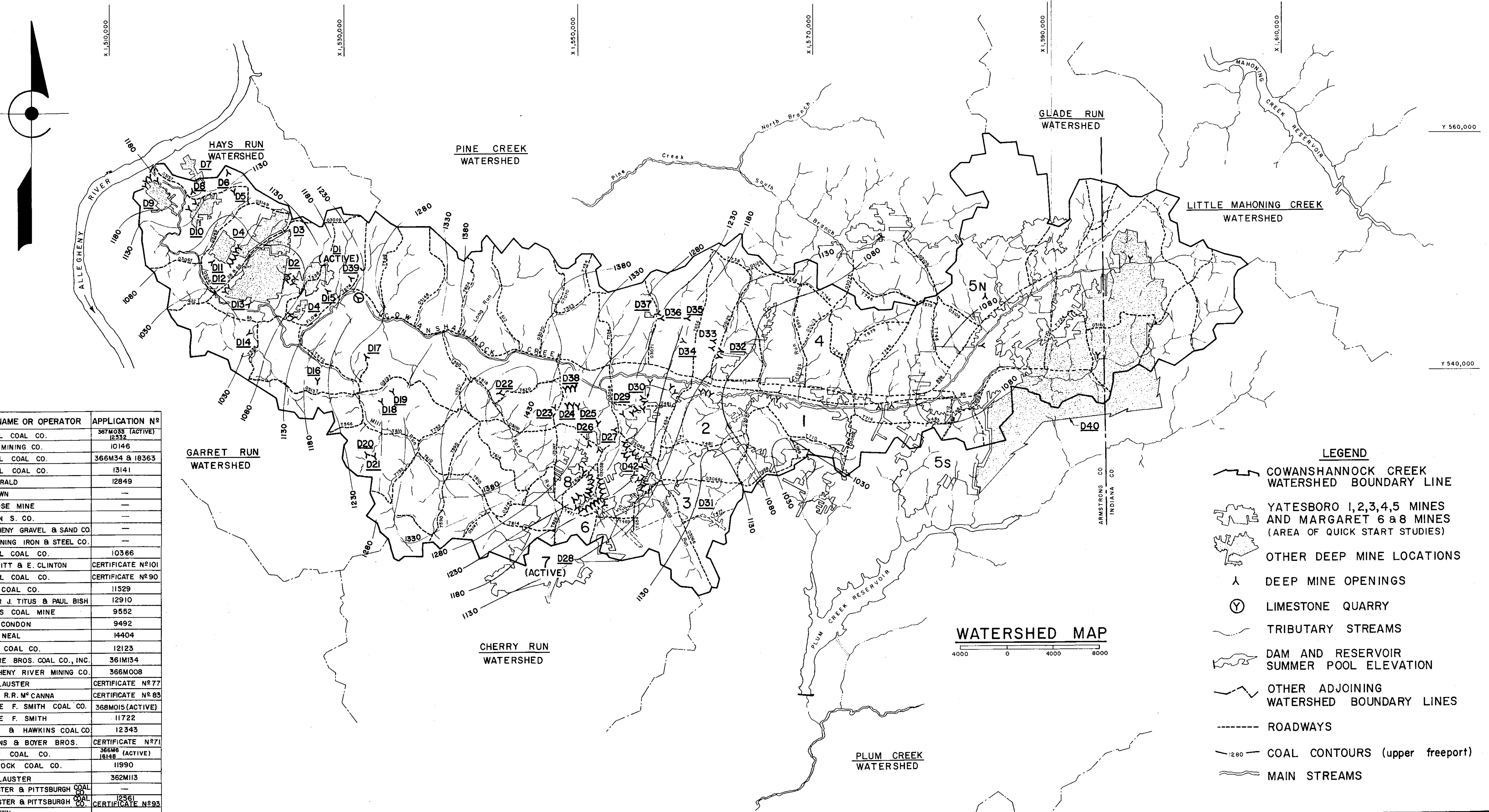
Most of the deep mines found did not show evidence of flowing, or the flow was so small that a water sample could not be taken or the flow measured.

There are 42 deep mines identified on the watershed (Plate 3). Of these, 12 mines show some evidence of flowing; and of the flowing abandoned mines, 5 should be considered for abatement programs.

The location and investigation of surface mine activity and deep mine refuse areas followed the investigation of deep mines. Surface mines and gob piles were located with the help of the local Department of Agriculture field office, review of aerial photographs and field investigation including air observation. Each strip mine was thoroughly walked at least twice; once during the dry season at which time water samples were taken, and once during the wet season when water samples were taken at all measurable points of flow.

Fifty-five (B`) strip mines and twelve (12) major gob piles were identified on the watershed. All of the strip mines evidence various stages of reclamation, but only two of the fifty-five can be considered fully reclaimed. All of the strip mines have been planted, usually with conifers. Fifty-three strip mines have been graded on a swallow-tail type cross-section, and each of these strip mines show various stages of erosion and landscape blight.

Strip mine and gob pile locations are shown on Plate 4. Of the fifty-five strip mines located only one is considered a major polluter and should be considered for immediate abatement action. Two of the gob piles found associated with abandoned deep mine activity. should be considered for immediate attention.



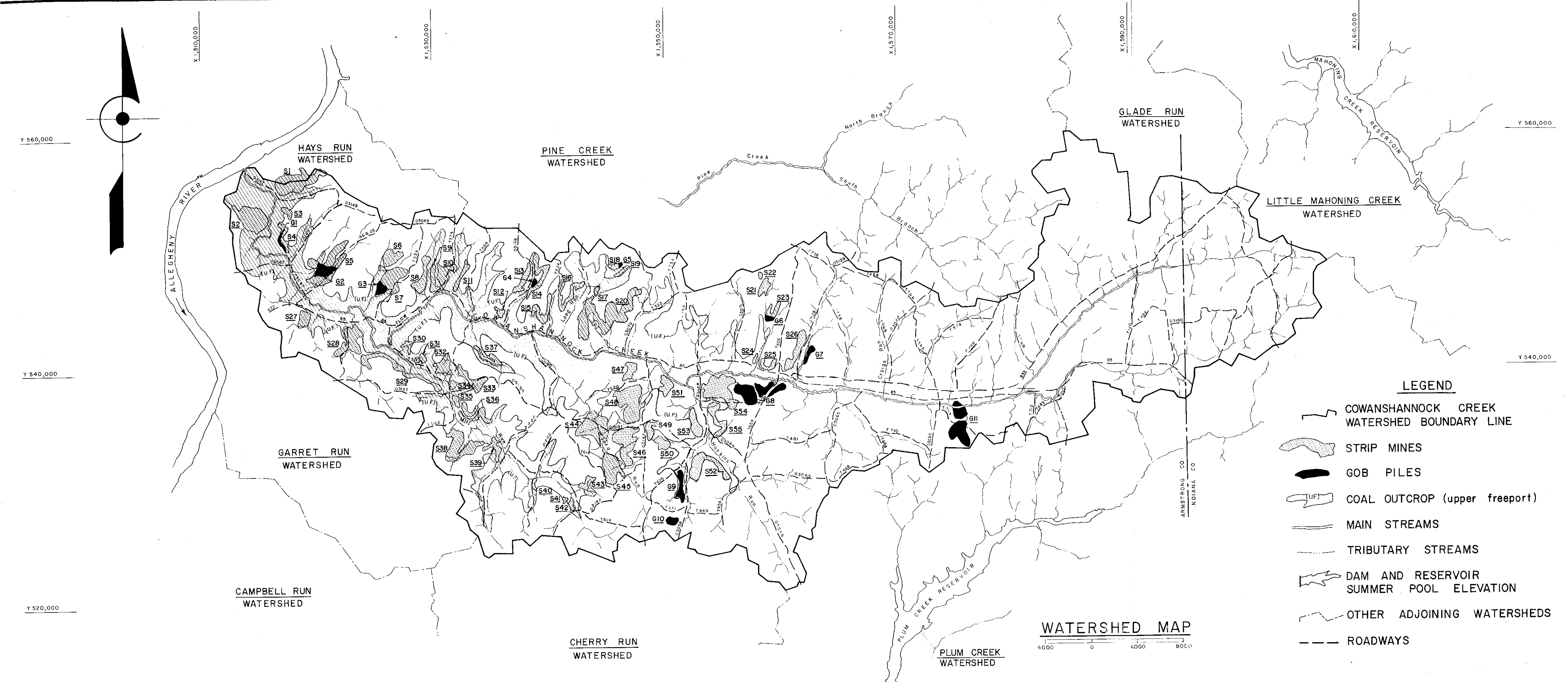
DEEP MINE Nº	MINE NAME OR OPERATOR	APPLICATION Nº
D1	POWELL COAL CO.	367M033 (ACTIVE) 12532
D2	MECH MINING CO.	10146
D3	POWELL COAL CO.	366M34 & 18363
D4	POWELL COAL CO.	13141
D5	FITZGERALD	12849
D6	UNKNOWN	—
D7	MELROSE MINE	—
D8	CARBON S. CO.	—
D9	ALLEGHENY GRAVEL & SAND CO.	—
D10	KITTANNING IRON & STEEL CO.	—
D11	POWELL COAL CO.	10366
D12	L.D. STITT & E. CLINTON	CERTIFICATE Nº101
D13	POWELL COAL CO.	CERTIFICATE Nº90
D14	HOOD COAL CO.	11529
D15	ARTHUR J. TITUS & PAUL BISH	12910
D16	THOMAS COAL MINE	9552
D17	EARL CONDON	9492
D18	CHAS. NEAL	14404
D19	BRINK COAL CO.	12123
D20	ALTMIRE BROS. COAL CO., INC.	361M134
D21	ALLEGHENY RIVER MINING CO.	366M008
D22	ROY LAUSTER	CERTIFICATE Nº77
D23	C.D. & R.R. McCANNA	CERTIFICATE Nº83
D24	GEORGE F. SMITH COAL CO.	368M015 (ACTIVE)
D25	GEORGE F. SMITH	11722
D26	SMITH & HAWKINS COAL CO.	12343
D27	HAWKINS & BOYER BROS.	CERTIFICATE Nº71
D28	R & P COAL CO.	366M6 16148 (ACTIVE)
D29	SHANNOCK COAL CO.	11990
D30	ROY LAUSTER	362M113
D31	ROCHESTER & PITTSBURGH COAL CO.	—
D32	ROCHESTER & PITTSBURGH COAL CO.	12561 CERTIFICATE Nº93
D33	UNKNOWN	—
D34	PGH. & BUFFALO	—
D35	SHANNOCK COAL CO.	—
D36	GOLDSTROHM & HAWKINS COAL CO.	363M251
D37	GOLDSTROHM COAL CO.	367M017
D38	ROY LAUSTER	—
D39	UNKNOWN	—
D40	SAGAMORE MINE	—
D41	DAVID WHITE	—
D42	ELMER BRINK	14581

COWANSHANNOCK CREEK WATERSHED

SCALE: AS SHOWN	PREPARED FOR: PROJECT SL-159 COMMONWEALTH OF PENNSYLVANIA DEPT. OF ENVIRONMENTAL RESOURCES	PREPARED BY: R.F.C.
DATE: 4-20-72		DRAWN BY: J.M.H.

WATERSHED & DEEP MINE LOCATION MAP

SUBMITTED BY: CARSON ENGINEERS	DRAWING NO. PLATE 3



GOB PILE Nº	ASSOCIATED MINE		COAL SEAM
G1	D10	KITTANNING IRON & STEEL	U.F.
G2	D4	POWELL COAL CO.	U.F.
G3	D1	POWELL COAL CO.	U.F.
G4	S14	M & E COAL CO.	U.F.
G5	S18	M & E COAL CO.	U.F.
G6	D36	GOLDSTROHM HAWKINS	U.F.
G7	D32	R & P COAL CO.	U.F.
G8	D31	R & P COAL CO.	U.F. & L.F.
G9	D31	R & P COAL CO.	U.F.
G10	D31	R & P COAL CO.	U.F.
G11	D32	R & P COAL CO.	U.F.

STRIP MINE Nº	OPERATORS NAME	APPLICATION Nº	STRIP MINE Nº	OPERATORS NAME	APPLICATION Nº	STRIP MINE Nº	OPERATORS NAME	APPLICATION Nº	STRIP MINE Nº	OPERATORS NAME	APPLICATION Nº
S1	DANTELLA BROS.	14084	S18	M & E COAL CO.	14897	S33	LOVES COAL CO.	14089	S43	FENNELL BEATTIE COAL CO.	9504
S2	ROBIN COAL CO., INC.	3570BSM3	S19	M & E COAL CO.	14897	S34	P & L COAL CO. PEARY FARESTER	18961	S44	LUMSTEAD COAL CO.	14403
S3	MARAL CO.	13594	S20	M & E COAL CO. LLOYD G. DUNCAN	13734 & 14897 2866BSM4	S35	MARAL CO.	14332	S45	J. R. CRAVENER	13685
S3	DANTELLA BROS.	362M58	S21	J. RUSSELL CRAVENER	12477	S35	P & L COAL CO. PEARY FARESTER	18961	S45	LUMSTEAD COAL CO.	18862
S4	MARAL CO.	13594	S22	J. RUSSELL CRAVENER	12477	S35	ERNEST D. SMITH	362M165	S46	LUMSTEAD COAL CO.	14403 & 363M39
S4	DANTELLA BROS.	362M58	S23	J. RUSSELL CRAVENER	12476	S36	P & L COAL CO. PEARY FARESTER	18961	S46	LLOYD G. DUNCAN	2648SM10
S5	DANTELLA BROS.	13122 & 13417	S24	LUMSTEAD COAL CO.	14800	S36	P & N COAL CO.	19526	S47	MARTIN BROS.	13377
S5	J. R. CRAVENER	8540	S25	LUMSTEAD COAL CO.	14800	S36	CONBRO COAL CO.	—	S48	LUMSTEAD COAL CO.	17012 & 18862 15506
S6	MARAL CO.	14334	S26	LUMSTEAD COAL CO.	17011	S36	PEARY FARESTER	14705	S48	M & E COAL CO., INC.	13447
S7	DANTELLA BROS.	12114	S27	FREEBROOK CORP.	9486	S37	JOHN ALEX	14257	S48	HARL E. BOWSER	14535
S8	KITTANNING CONST. CO.	11617	S27	MARAL CO.	14172	S37	P & L COAL CO.	19080	S49	HARL E. BOWSER	14534
S9	ISEMAN BROS.	9848	S28	KITTANNING CONST. CO.	12861	S38	SHALL BROS.	10123	S50	HARL E. BOWSER	14534
S10	KITTANNING CONST. CO.	12420	S28	DANTELLA BROS., INC.	18868 & 14053	S38	M & E COAL CO.	15080	S51	LUMSTEAD COAL CO.	19610
S11	KITTANNING CONST. CO.	12420	S29	GARRETT RUN COAL CO.	9423	S38	ALTMIRE BROS. COAL CO.	19355	S51	HARL E. BOWSER	15260
S12	M & E COAL CO., INC.	16223	S29	RED MILL C.M. CORP.	15036	S39	ALTMIRE BROS. COAL CO.	19355	S52	R & P COAL CO.	2868BSM19
S13	M & E COAL CO., INC.	16223	S30	COMSTOCK FUEL CO.	13836	S39	GARRETT RUN COAL CO.	9583	S53	LUMSTEAD COAL CO.	19637
S14	M & E COAL CO., INC.	16223	S31	PEARY FARESTER	14226	S40	J. R. CRAVENER	13686	S53	R & P COAL CO.	9219
S15	P & L COAL CO.	19821	S32	PEARY · FARESTER	14227	S41	J. R. CRAVENER	13686	S54	HARL E. BOWSER	16714
S16	M & E COAL CO.	14897	S32	P & L COAL CO. PEARY FARESTER	18961	S42	J. R. CRAVENER	13688 & 9923	S54	LUMSTEAD COAL CO.	16765 & 16801
S17	M & E COAL CO.	14897	S33	PEARY FARESTER	13945 & 14705	S43	J. R. CRAVENER	13688 & 13687	S55	R & P COAL CO.	9219

COWANSHANNOCK CREEK WATERSHED

SCALE: AS SHOWN	PREPARED FOR: PROJECT SL-159 COMMONWEALTH OF PENNSYLVANIA DEPT. OF ENVIRONMENTAL RESOURCES	PREPARED BY: R.F.C.
DATE: 4-20-72		DRAWN BY: J.M.H.

STRIP MINE & COAL REFUSE LOCATIONS

SUBMITTED BY:	CARSON ENGINEERS	DRAWING NO. PLATE 4

On August 20,1970, the first water sampling test was conducted by a three man crew on the Cowanshannock Creek Watershed. Once the permanent testing stations were established, a two man crew could complete the sample run in ten hours. On the initial run a total of twenty-five samples were taken, then on a later date additional stations were added on Huskins Run and in the area of the Powell Coal Company's Decker No. 3 mine.

Once the samples were collected, they were shipped to the Seewald Laboratories in Williamsport, Pennsylvania,or during the latter part of the study, to Microbac Laboratories Inc. in Pittsburgh, Pennsylvania. A listing of the laboratory testing methods and discussion are shown herein. After the results were received they were recorded in graphic and tabular form. The graphic presentations compare the results to the tolerance level of that particular parameter for a cold water fishery. This enables a visual analysis of the existing waters and what their affect would be on a fish population in this class. It also narrows the field of concern.

After the testing sites were established they were staked and flagged for future identification. Detailed sketches are enclosed in the appendix of each sample location that are used on water sample runs.

The accuracy of our initial run was impaired by a weekends delay between sample gathering and lab testing; therefore, it is considered unreliable. Our second run included testing for a number of other parameters relevant to determination of class of mine drainage and its total environmental and ecological impact on the fish and wildlife communities.

A biological report is enclosed which has furnished us with a valuable tool, when interpreted, for evaluating the degree of mine drainage pollution.

A method for analyzing the results of the water sampling program was necessary in order to determine a priority or severity rating for each pollution area. A discussion of the analysis method is enclosed.

Water Quality Criteria

Population growth combined with increased per capita use of water, expanding industrial requirements, and the mounting emphasis placed on recreational use of surface water all contribute to the importance of maximum protection and utilization of water resources. Certain constituents may affect a given water use at one concentration and affect another water use at a different concentration. Also, certain characteristics or compounds may be synergistic with each other. For instance, the toxicity to fish of various elements or compounds varies substantially with pH.

Other constituents found in mine drainage are produced by secondary reactions of sulfuric acid with minerals and organic compounds in the mine and along the stream valleys. Such secondary reactions produce concentrations of aluminum, manganese, calcium, sodium, and other constituents in the drainage water. These mine drainage constituents, along with iron and sulfate, are indicators of mine drainage pollution that may persist long after the acid in the drainage has been neutralized.

The criteria in Table 4 have been used to define the concentrations or ranges of values at which concern over water quality is indicated. The parameters listed are common to mine drainage waters.

During the later stages of this report the Department of Environmental Resources determined that the water quality criteria to be used for the identification of AMD is: a pH of less than 6.0, any quantity of net acidity and an iron content greater than 7.0 ppm. These parameters were incorporated in this report and a comparison of parameters is made in the analysis.

TABLE 4

Criteria Significant in Evaluating
AMD Pollution in Appalachia*

Parameter	Range of Values of Concern	Major Water Use(s) Protected	Usual Values in Unpolluted Waters in Appalachia
pH	less than 6.0	uses involving aquatic life	6.0 - 9.0
Acidity	sufficient to lower alkalinity below 20 mg/l	uses involving aquatic life	less than alkalinity
Alkalinity	<20 mg/l	uses involving aquatic life	>20 mg/l
Sulfates	>250 mg/l	domestic and industrial water supply	<20 mg/l
Hardness	>250 mg/l	domestic and industrial water supply	<150 mg/l
Total Iron	>1.0 mg/l	uses involving aquatic life, domestic and industrial water supply	<0.3 mg/l
Manganese	>1.0 mg/l	uses involving aquatic life, domestic and industrial water supply	<0.05 mg/l
Aluminum	>0.5 mg/l	uses involving aquatic life	absent

*Mine Drainage Abstracts 67-182. <u>Stream Pollution By Coal Mine Drainage In Appalachia</u>. U.S. Dept. of Interior, 1967.

Testing Methods and Discussion

l. pH

Method - Glass electrode pH meter
Reference - Standard Methods for the Examination of Water and Waste Water. American Public Health Association, et. al. Twelfth Ed., 1965, p. 226.
Discussion - pH is the reciprocal of the logarithm of the hydrogen ion concentration and is, therefore, based on a logarithmic scale rather than an arithmetic one.

Natural waters in Appalachia usually exhibit a pH in the range of 6 to 9. The pH of mine drainage may occasionally be lower than 2.5. (See the listed reference for additional discussion).

2. Hot Acidity

Method - Potentiometric titration to pH 8.3
Reference - Standard Methods for the Examination of Water and Waste Water. American Public Health Association, et. al. Twelfth Ed., 1965, p. 438 (modified).
Discussion - The hot acidity test as modified consists of preliminary oxidation with 2 ml of 30% hydrogen peroxide solution followed by boiling for not less than two minutes and titration while at 90°C or higher to pH 8.3, using a thermally compensated pH meter or an uncompensated meter standardized with an appropriate buffer at 90°C to 95°C. Pre-oxidation and boiling are used to insure complete hydrolysis of the acid producing salts. However, boiling also drives off carbon dioxide. The method, therefore, determines the acidity due to free mineral acids and acid salts, but does not measure the contribution to acidity of carbon dioxide. Acidity is reported as milligrams per liter of calcium carbonate ($CaCO_3$). The molecular weight ratio $CaCO_3/H_2SO_4$ is 1.02.

Reported as Net acidity
Discussion - Net acidity is the acidity that is present in excess of alkalinity.

3. Net Alkalinity

Method - Potentiometric titration to pH 4.5
Reference - Standard Methods for the Examination of Water and Waste Water. American Public Health Association, et. al. Twelfth Ed., 1965, p. 370.
Discussion - The alkalinity of a water is the capacity of that water to neutralize a standard acid. When alkalinity is present in excess of acidity, there is a net alkalinity in most waters of Appalachia alkalinity is essentially bicarbonate and/or carbonate in origin.

4. Iron (total)

Method - Phenanthroline method
Reference - Standard Methods for the Examination of Water and Waste Water. American Public Health Association, et. al. Twelfth Ed., 1965, p. 156.
Discussion - Mine drainage generally contains iron in the ferrous and ferric states. At pH values less than 3, ferric and ferrous iron are both in solution and the hydrolyzable acid salts of both forms can contribute to acidity. At pH values above 3, ferric iron is found in solution only as part of complexes formed with organic chelates, phosphates, and other anions, and acid salts of ferrous iron provide the contribution to acidity. Unpolluted streams in Appalachia have iron concentrations of less than 0.3 mg/l. Mine drainage influence may raise iron concentrations to in excess of 100 mg/l.

5. Sulfate

Method - Turbidimetric method. The photometer used is a Coleman Junior.
Reference - Standard Methods for the Examination of Water and Waste Water. American Public Health Association, et. al. Twelfth Ed., 1965, p. 291.
Discussion - A mole of sulfate accompanies each mole of sulfuric acid and sulfate is, therefore, an excellent indicator of the amount of mine drainage acidity formed. This is particularly true because calcium sulfate, the most common sulfate salt, is relatively soluble. Unpolluted waters in Appalachia have been observed to have concentrations of generally less than 20 mg/l; polluted waters frequently have concentrations of several hundred milligrams per liter.

6. Ferrous Iron

Method - Same as 4 except deletion of 1 ml of sodium sulfite solution.
Reference - Standard Methods for the Examination of Water and Waste Water. American Public Health Association, et. al. Twelfth Ed., 1965, p. 158.
Discussion - Ferrous iron is rapidly oxidized to ferric iron after mine drainage enters an aerated stream and high concentrations of ferrous iron are not generally found very far downstream from the last mine drainage source.

7. Manganese

Method - Persulfate oxidation
Reference - Standard Methods for the Examination of Water and Waste Water. American Public Health Association, et. al. Twelfth Ed., 1965, p. 173.

Manqanese (cont'd)

Discussion - Concentrations of manganese in unpolluted streams do not usually exceed 0.05 mg/l. This indicator is usually associated with mine drainage pollution. Concentrations in the order of 5 mg/l to 20 mg/l are not uncommon in mine drainage.

8. Aluminum

Method - Aluminum reagent
Reference - Standard Methods for the Examination of Water and Waste Water. American Public Health Association, et. al. Twelfth Ed., 1965, p. 54.
Discussion - High concentrations of aluminum are usually found as a result of the leaching of deposits of clays or clayey soils by acid mine waters.

9. Calcium

Method - EDTA titration to hydroxynapthol blue endpoint
Reference - Standard Methods for the Examination of Water and Waste Water. American Public Health Association, et. al. Twelfth Ed., 1965, p. 151.
Discussion - Concentrations of calcium in unpolluted surface waters in Appalachia are generally less than 50 mg/l. Very high concentrations of calcium may result when mine drainage acidity is neutralized by reaction with limestone or dolomite.

10. Maqnesium

Method - Methods and references are the same as for Calcium, p. 151.
Dicsussion - High concentrations of magnesium may result from the reaction of mine drainage acidity with limestone or dolomite.

11. Hardness

Method - EDTA titration
Reference - Standard Methods for the Examination of Water and Waste Water. American Public Health Association, et. al. Twelfth Ed., 1965, p. 147.
Discussion - Hardness is defined as a characteristic of water which represents the total concentration of the calcium and magnesium ions expresses as calcium carbonate. Other hardness producing ions commonly present in significant amounts in mine drainage are iron, manganese, and aluminum.

12. Conductivity

Method - Conductivity method

Conductivity (cont'd)

Reference - See manuals of instrument manufacturers.
Discussion - Conductivity is measured in mhos (reciprocal ohms). Uncontaminated surface waters in Appalachia generally have a dissolved solids content of less than 250 mg/l and a conductivity of less than about 400 micromhos.

13. Bioloqical

Types - Strep-Feculis and E. Coliform
Method - High dilution bacteriological
Reference - Standard Methods for the Examination of Water and Waste Water. American Public Health Association, et. al. Twelfth Ed., 1965, p. 599.
Discussion - Used to indicate the degree of fecal contamination. While E. Coliform are not in themselves pathogenic, their presence indicate possible other pathogenic organisms.

14. Acidity

Method - Phenolphthalein titration
Reference - Standard Methods for the Examination of Water and Waste Water. American Public Health Association, et. al. Twelfth Ed., 1965, p. 46.
Discussion - The carbonate and bicarbonate can be estimated by titrating the alkalinity with standard acid to the bicarbonate equivalence point of pH 8.3 and then to the carbonic acid equivalence point in the pH range of 4 to 5.

A fading and impermanent endpoint characterizes the phenolphthalein acidity titration performed at room temperature on a sample containing iron and aluminum sulfate.

Effects of Parameters on Aquatic Biota

Temperature affects the metabolic levels of fish. When excessively high, the respiration rate increases to the point that all available energy is used for respiration instead of being distributed among several processes such as food intake and behavior patterns, etc. Fish become increasingly sluggish, lose equilibrium, followed by death.

Excessive amounts of acids or alkalies causes a great increase in mucous layer covering the skin. This adversely affects movements, metabolic levels, respiration rate, and food gathering ability.

Acids and the heavy metals also coagulate mucous within the gill structure. This cuts off the fish's oxygen supply.

Dissolved oxygen is essential for respiration and one of the most critical parameters.

Chemical parameters generally affect fish on the organ level (gills, liver, intestines, etc.). Effects may be on only one organ but usually multiple. Additionally, toxic levels and target organs may vary from species-to-species. Interspecies variation and a multitude of primary and secondary effects preclude discussion of each parameter.

The effects of the parameters on the aquatic ecosystem (life support system) is equally as important as the effects on fish themselves. When considering the whole environment, the parameters become critical at every level of organization. While the organ level is generally the most important in fish, the target organization level varies down to the sub-cellular in the primary producers.

While most of these effects are not documented, and enumerating those that are known would be a great task, the following guideline it helpful in obtaining a desirable ecosystem. A less extreme environment has a greater diversity of species; and the greater species diversity, the greater the stability. Therefore, the less extreme the parameters, the more stable the ecosystem.

Classes of Water Quality---Discussion

(1) DOMESTIC. Criteria for this class are officially established by the U.S. Public Health Service. Parameter values in the table are maximum permitted for this class, except dissolved oxygen. 2 mg./l. D.O. selected as minimum concentration to prevent nuisance. It is assumed that parameters not established by USPHS are not critical or are correctable by ordinary water treatment.

(2) INDUSTRIAL. Parameter values for this class not established. The important parameters and values will vary greatly with different industries. Parameter values must be established for specific industries, rather than a general class.

(3) FISH. Parameter limits have not all been determined for all game and pan fish. This is due primarily to the following reasons: 1) Amount of time needed to investigate a parameter, eliminating all other variables. 2) Great number of important commercial game, and pan fish. 3) Many game and pan fish do not lend themselves to laboratory investigations.

Information is scattered through the literature and often concerns non-harvestable fish which are more easily studied in the laboratory. Much research has been done in ;Europe on species not native to North America.

Parameter values in the table represent general maximum limits which appear to be safe for a number of fish species and food organisms. Many fish species exhibit a very high tolerance to one or a few parameters; however, these exceptions are not included in the class values in the table.

The three fish classes considered in the table are significantly separated by only two parameters, temperature and dissolved oxygen. While there is sometimes great interspecies variation within and between classes, it appears that the same general chemical parameter values apply to all three classes.
Pumpkinseeds (*Lepomis gibbosus*) and bullheads (*Ictalorus spp.*) are the most tolerant to mine water pollution. pH4 and an acidity of about 100 mg./l. $CaCO_3$ will probably support populations of these fish.

It is recommended that bioassays be performed on all species considered for stocking with pilot plant treated water. This is necessary for the following reasons: 1) Determine that individual species are tolerant to class parameter values; 2) May include parametersnot considered in table;3) Possible synergistic effect of several parameters.

4) WILDLIFE. This is matter of taste, comfort, and toxicity. The broad range of animals for consideration and research limitations preclude definite criteria. Parameter values for this class are those which are most critical and taken from domestic or fish classes.

5) NON-HARVESTABLE BIOTA. A biota of sorts will develop under most conditions except when parameter values are so extreme they prevent vital cellular life processes.

NOTE: Low concentrations of heavy metals are very important (such as mercury and lead). These are very toxic and often become highly concentrated in some areas of the food chain. When this happens, predator species (such as man, etc.) are subject to lethal doses.

CLASS / PARAMETER	DOMESTIC	INDUSTRIAL	COLD WATER SPORT FISH	WARM WATER SPORT FISH	COARSE FISH	WILDLIFE	NON-HARVESTABLE BIOTA
TEMPERATURE °F			70	85	87	87	90
COLIFORM MPN (#/100 ml)			70	70	70	70	
CONDUCTIVITY mho X 10^{-6}			400	400	400	400	
SUSPENDED SOLIDS mg/l			20,000	20,000	20,000		
DISSOLVED SOLIDS mg/l	2000						
DISSOLVED OXYGEN mg/l	2	2	6	5	3	2	2
pH	6.5		6.0	6.0	6.0	6.0	
ACIDITY mg/l $CaCO_3$	20		50	50	50	50	
ALKALINITY M.O. mg/l			180	180	180	180	
HARDNESS mg/l			50	50	50	50	
CARBON DIOXIDE mg/l			20	20	20		
TOXIC & DELETERIOUS SUBSTANCES							
ALUMINUM mg/l			5	5	5	0.07	
BARIUM mg/l	1.0		5	5	5		

CLASS / PARAMETER	DOMESTIC	INDUSTRIAL	COLD WATER SPORT FISH	WARM WATER SPORT FISH	COARSE FISH	WILDLIFE	NON-HARVESTABLE BIOTA
NITROGEN mg/l			1.3	1.3	1.3		
PHOSPHORUS mg/l			0.04	0.04	0.04		
POTASSIUM mg/l			50	50	50		
SILICON mg/l			8.0	8.0	8.0		
SILVER mg/l	0.05		0.004	0.004	0.004	0.05	
SODIUM mg/l			500	500	500		
STRONTIUM mg/l			1,000	1,000	1,000		
TIN mg/l			1	1	1		
ZINC mg/l	5		.15	.15	.15		
AMMONIA mg/l			1.0	1.0	1.0		
PHOSPHATE mg/l			.5	.5	.5		
SULFATE mg/l	250		400	400	400		
ARSENIC mg/l	0.05		1	1	1	0.05	
CYANIDE mg/l	0.01					0.01	

CLASS / PARAMETER	DOMESTIC	INDUSTRIAL	COLD WATER SPORT FISH	WARM WATER SPORT FISH	COARSE FISH	WILDLIFE	NON-HARVESTABLE BIOTA
CADMIUM mg/l	0.01		0.3	0.3	0.3	0.3	
CALCIUM mg/l			300	300	300		
CHLORIDE mg/l	250		1500	1500	1500		
CHROMIUM mg/l	0.05		.05	.05	.05	1.3	
COBALT mg/l			10	10	10		
COPPER mg/l	1.0		.02	.02	.02	1.0	
GOLD mg/l			0.4	0.4	0.4		
IRON mg/l	0.3		.2	.2	.2	0.3	
LEAD mg/l	0.05		0.1	0.1	0.1	0.1	
LITHIUM mg/l			100	100	100		
MAGNESIUM mg/l							
MANGANESE mg/l	0.05		1.0	1.0	1.0		
MERCURY mg/l	?		0.008	0.008	0.008	0.008	
NICKEL mg/l			0.8	0.8	0.8	0.8	

PARAMETER \ CLASS	DOMESTIC	INDUSTRIAL	COLD WATER SPORT FISH	WARM WATER SPORT FISH	COARSE FISH	WILDLIFE	NON-HARVESTABLE BIOTA
NITRATE mg/l	45		.1	.1	.1		
SELENIUM mg/l	0.01						
FLUORIDE mg/l	1.2		1.5	1.5	1.5		
PHENOL mg/l	.001		.2	.2	.2		
COD mg/l			100	100	100		

Analysis

The benefits of designating any particular area as a source of pollution may involve considerable judgment of various parameters, e.g., flow, pH, acidity, etc. especially if the sources of major pollution are to be determined and catalogued in sequence of severity. In order to make this determination, a system was established whereby a judgment could be made on any one or all of the parameters involved. This was accomplished by assigning each parameter a number designation in a range from 1 to 10; the assigned number being dependent upon the severity of the particular parameter (see Table 5). The volume of flow was also assigned a number ranging from 0.1 to 10; the assigned number

TABLE 5

Pollution Rating

	1	2	3	4	5
pH	5-6	4-4.9	3.5-3.9	3-3.4	2.5-2.9
Acidity		0-9	10-29	30-99	100-199
Alka	1-20				
Fe	1.0-1.4	1.5-2.9	3-4.9	5-8.9	9-14.9
SO_4	50-149	150-349	350-599	600-999	1000-1399
Hdn	50-149	150-349	350-599	600-999	1000-1399

	6	7	8	9	10
pH	2-2.4	1.5-1.9	<1.4		
Acidity	200-499	500-999	1000-1999	2000-3999	>4000
Alka					
Fe	15-24.9	25-49.9	50-99.9	100-199.9	>200
SO_4	1400-1899	1900-2499	2500-3499	3500-4499	>4500
Hdn	1400-1899	1900-2499	2500-3499	3500-4499	>4500

being proportional to the volume of flow (See Table 6). Flow rates were considered to have a multiplier effect upon the summation of assigned parameter values for the pollution source.

TABLE 6

Flow Rate Multiplier

Flow gpm	Multiplier	Flow gpm	Multiplier
0-.9	0.1	15-19	1.0
1.0-1.9	0.2	20-49	2.0
2.0-2.9	0.3	50-99	3.0
3.0-3.9	0.4	100-199	4.0
4.0-4.9	0.5	200-399	5.0
5.0-6.9	0.6	400-699	6.0
7.0-8.9	0.7	700-1099	7.0
9.0-10.9	0.8	1100-1599	8.0
11.0-14.9	0.9	1600-2499	9.0
		>2500	10

Resulting summations of the parameters and multiplier resulting from water volumes allowed us to determine what we call a "pollution index number". The establishment of this pollution index number well satisfies the requirements of this report for identifying the severity of pollution sources within the watershed.

Example 1:

Gob Pile Designation G7; Sample Station NT13

NT13

Parameter	(Avg) ppm	Assigned No.
pH	6.7	0
Acidity	0	0
Alkalinity	30	0
Iron	0.5	0
Sulfates	38	0
Hardness	95	1
		$\Sigma=1$
Flow	227	5 = Multiplier

Pollution Index Number = 5

Example 2:

Deep Mine Designation D32; Sample Stations 20, 22, 23, 25

Sta 20

Parameter	(Avg) ppm	Assigned No.
pH	6.2	0
Acidity	0	0
Alkalinity	210	0
Iron	19.92	6
Sulfates	527	3
Hardness	207	2
		$\Sigma=11$
Flow	275 gpm	5 = Multiplier ∴ PIN = 55

Sta 22

Parameter (Avg) ppm		Assigned No.
pH	6.5	0
Acidity	0	0
Alkalinity	192	0
Iron	11.3	5
Sulfates	342	2
Hardness	220	2
		=9
Flow	165 gpm	4 = Multiplier PIN = 36

Sta 23

Parameter (Avg) ppm		Assigned No.
pH	6.4	0
Acidity	1.	2
Alkalinity	186	0
Iron	10.4	5
Sulfates	350	3
Hardness	177	2
		=12
Flow	913 gpm	7 = Multiplier PIN = 84

Sta 25

Parameter (Avg) ppm		Assigned No.
pH	6.5	0
Acidity	0	0
Alkalinity	115	0
Iron	22.1	6
Sulfates	336	2
Hardness	174	2
		=10
Flow	139	4 = Multiplier PIN = 40

Pollution Index Number = 55+36+84+40 = 215

Many other parameters could be introduced into the system such as the closeness of the pollution source to human habitation or closeness to recreation areas etc. However, the addition or deletion of parameters must be a matter of judgment for each individual case.

The rank according to degree of pollution is found in Table 7.

TABLE 7

Mining Areas of Concern
By Rank
Using Six Parameters
pH, Acidity, Total Iron, Sulfates, Hardness,
and Flow

	Rank	Source	Sampling Station	Pollution Index No.
Areas of Primary Concern	1	D32	20, 22, 23, 25	215
	2	D31	39, 18, 34, 37, 38, 36	209
	3	D1*	NT4	114
	4	G2	NT2A, NT2B, NT2C	84
	5	S5	NT2B, NT2C, NT2D	81
	6	D13	NT3A	68
	7	D3	NT3A	68
	8	S20	NT8-3A, NT8-4A, NT9A	67
	9	S2	ST1, ST1A, ST1B, ST2	64
	10	G10	ST7Y, ST7X	60
	11	D24*	ST7C, ST7G, ST7H	42
	12	D4	35	34
Areas of Secondary Concern	13	S29	ST6C, ST6D	32
	14	G11	ST8-1A, ST8-2A, ST8-3A	32
	15	D2	NT4C	28
	16	S14	NT8A, NT8B	28
	17	G9*	ST7P, ST7T	21
	18	S16	NT8-2A	20
	19	S15	NT8-1A, NT8-1B	17
	20	S6	NT4D, NT4E	16
	21	S28	ST5	16
	22	D35	NT12B	14
	23	D41	NT4B	13
	24	S7	NT4E	12
	25	S27	ST4	12
	26	D6	NT0D	10
	27	G8	10, ST7B	10
	28	G1	NT0E	6
	29	D10	NT0E	6
	30	G7	NT13	4

*Active Mine

TABLE 7A

Mining Areas of Concern
By Rank
Using Four Parameters
pH (<6.0), Net Acidity, Total Iron (>7.0)
and Flow

Rank	Source	Pollution Index No.	Rank Using Six Parameters
1	D32	109	1
2	D31	89	2
3	S5	65	5
4	G2	54	4
5	D1	48	3
6	D13	44	6
7	D3	44	7
8	G10	37	10
9	S2	35	9
10	D24	28	11
11	D4	22	12
12	S14	20	16
13	G11	20	14
14	D2	20	15
15	S29	16	13
16	S20	16	8
17	S16	14	18
18	G9	13	17
19	D41	6	23
20	D6	6	26
21	S15	2	19
22	S7	0	24

Table 7A is included in order to compare the results of using parameters now considered by the Commonwealth (pH, net acidity and total iron) versus parameters considered in this report. It is observed that the severity of pollution for each source tends to remain in the same severity group using both systems. The greatest exception to this tendency being strip mine S20 which fell from 8th place in Table 7 to 16th place in Table 7A.

Conclusions

The primary concentration of acid mine drainage pollution is found in the eastern section of the watershed where the Yatesboro and Margaret deep mine complexes are located (see Plate 3). Other primary deep mine sources of concern are located in the western portion of the watershed in the area of the Powell Coal Company mines. These areas of concern have workings almost exclusively within the Upper Freeport ('E' vein). An exception is a portion of the Rochester and Pittsburgh Coal Company's Yatesboro complex, Yatesboro No. 3 mine, located in Lower Freeport coal ('D' vein).

Other deep mines scattered throughout the watershed used the Upper Freeport vein as the prime source of economically recoverable coal; however, the Allegheny Gravel and Sand Company mine and other smaller complexes mined Upper Kittanning coal in the extreme western section of the watershed.

All of the major deep mines produce some degree of pollution. The small mines, normally used to produce house coal, and referred to locally as "country banks" or "dog holes", indicated a very small potential for pollution. Most of these small deep mines are located along coal outcrops, and in some cases these mines were utilized when overburden removal for strip mine operations became uneconomical.

Strip mines are scattered throughout the watershed west of the community of Yatesboro. Most of these surface mines can be seen as blighted scars to natural beauty of the watershed. These mines have all been reclaimed to some extent by partial grading and the planting of conifers. Some of the older abandoned strip mines are overgrown with natural vegetation; however, a number of these mines are sources of acid mine drainage pollution (See Plate 4).

Gob piles, normally associated with deep mine activity, are a prime source of acid mine drainage. The gob piles in the watershed have been identified and the major pollutions are located near the Yatesboro, Margaret, and Powell mines.

Deep mine, strip mine, and gob pile pollution sources are listed in order of concern for this watershed in Table 7.

TABLE 8

Pollution Loads For Various Areas
Within The Cowanshannock Creek Watershed

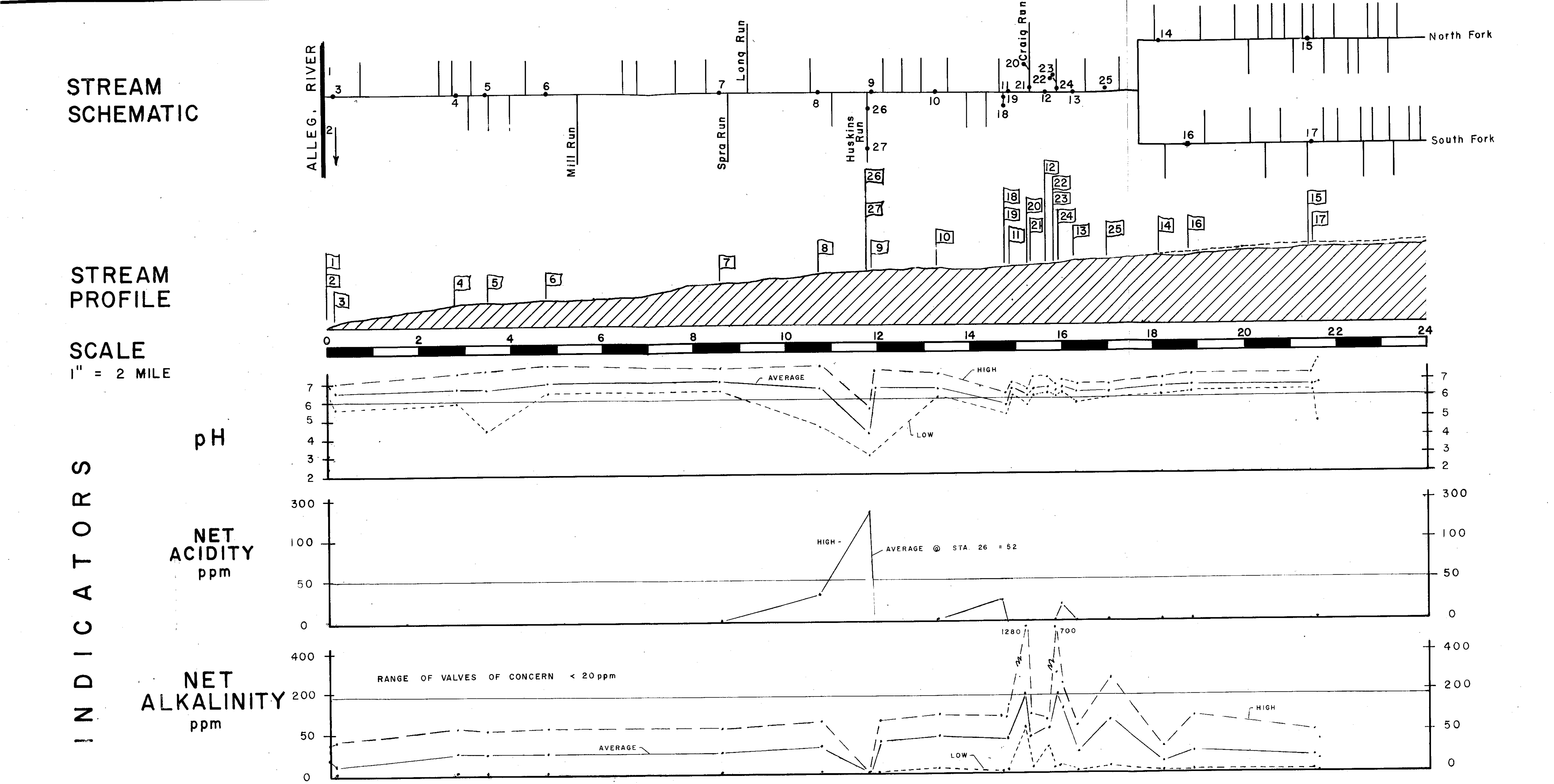
Area	Acidity		Fe (Total)		SO4		Hardness	
	Ton/yr.	% of Tot.	Ton/yr.	% of Tot.	Ton/yr.	% of Tot.	Ton/yr.	% of Tot.
D32	2.6	0.16	44	17.46	1198	13.76	589	7.60
D31	70	4.34	16	6.35	2249	25.84	1154	14.88
D-4, G-2 S5	1088	67.41	45	17.86	2086	23.96	324	4.18
D-3, D13	5.5	0.34	5.1	2.02	280	3.22	85	1.10
S20			5.5	2.18	304	3.49	414	5.34
S2	7.1	0.44	1.9	0.75	57	0.65	48	0.62
*D1, G3	85	5.27	3.2	1.27	529	6.08	693	8.94
*G10	94	5.82	8.8	3.49	222	2.55	22	0.28
*D24	8.3	0.51	0.3	0.12	33	0.38	32	0.41
G11	31	1.92			51	0.59	54	0.70
	1391.5	86.21	129.8	51.50	7009	80.52	3415	44.05

TABLE 9

Estimated Total AMD Pollution Load
Contributed By The Cowanshannock Creek Watershed

Acidity	1614 tons/yr
Iron	252 tons/yr
Sulfates	8705 tons/yr
Hardness	7752 tons/yr

*Active Mine Area



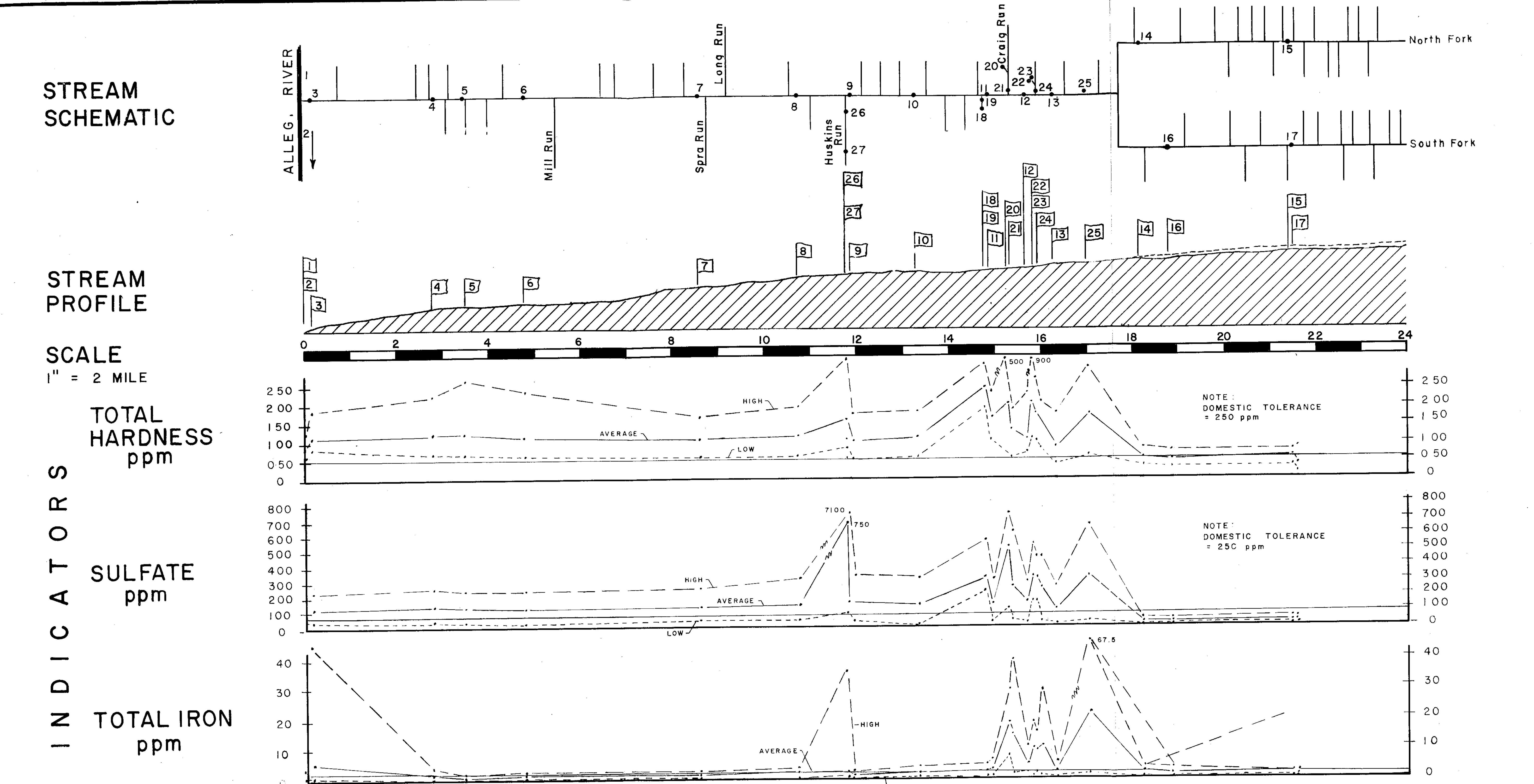
EXPLANATORY NOTES:

TESTING STATION

• TESTING STATION

—— ESTABLISHED LEVEL OF TOLERANCE FOR COLD WATER FISHERY

COWANSHANNOCK CREEK WATERSHED		
P.No. SL 159	ANALYST SEEWALD LAB. 1403 W. 4th St. WILLIAMSPORT, PENNA.	PREPARED BY: R.F.C
DATE: 5-2-72		DRAWN BY: S.Y
WATER SAMPLING TEST RESULTS	pH NET ACIDITY NET ALKALINITY	
SUBMITTED BY:	CARSON ENGINEERS	DRAWING NO. PLATE 5



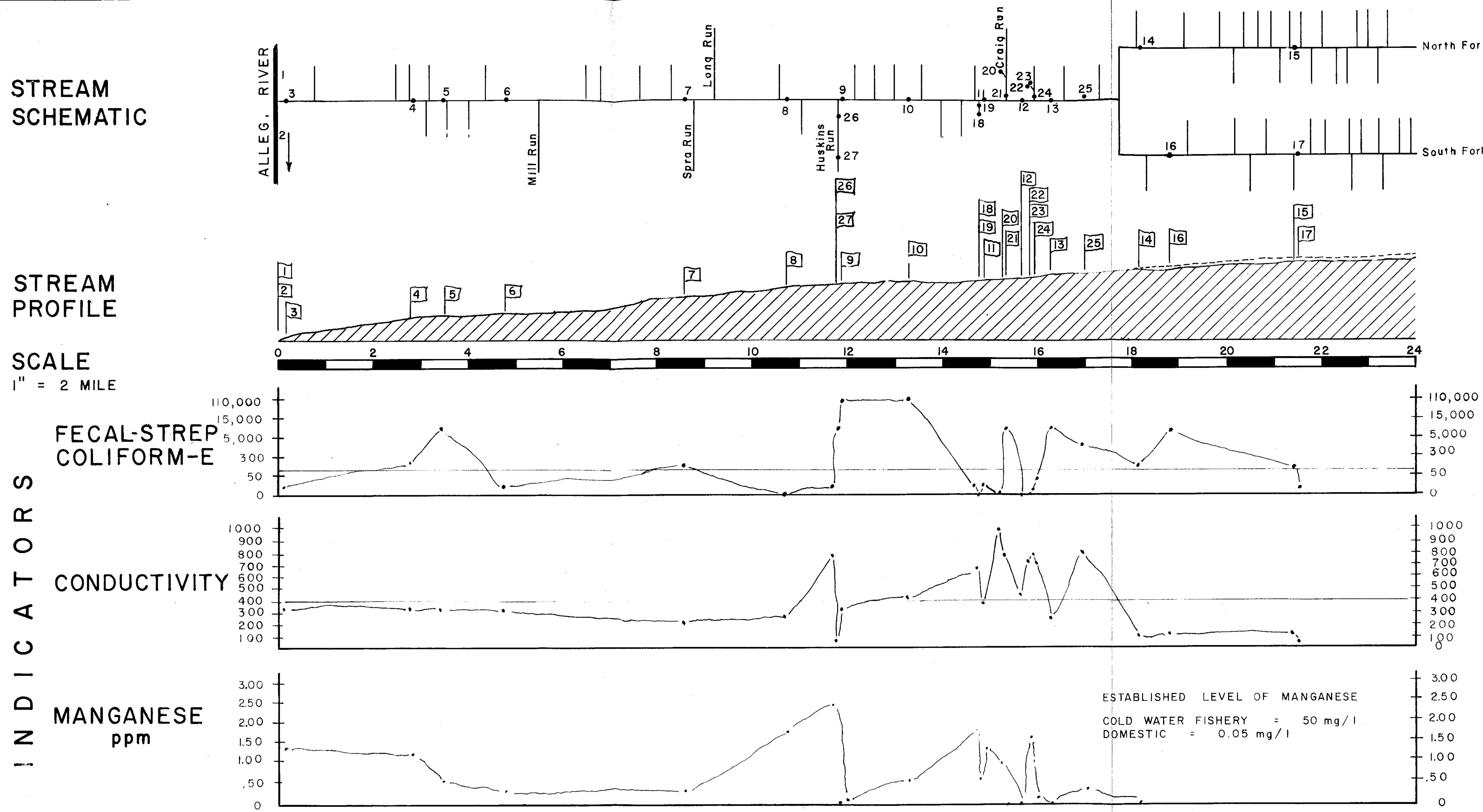
EXPLANATORY NOTES:

TESTING STATION

• TESTING STATION

— ESTABLISHED LEVEL OF TOLERANCE FOR COLD WATER FISHERY

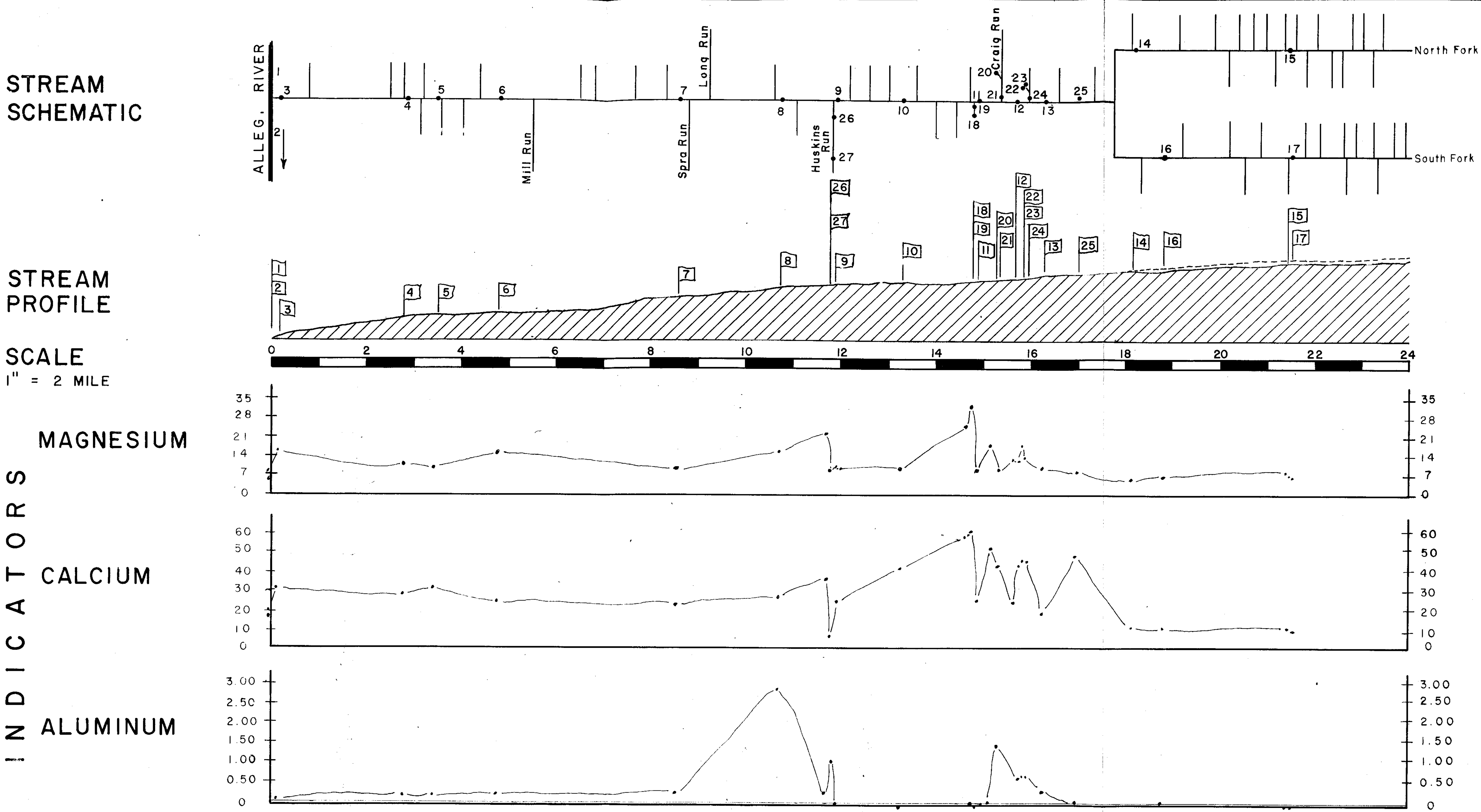
COWANSHANNOCK CREEK WATERSHED		
P.No. SL 159	ANALYST SEEWALD LAB. 1403 W. 4th St. WILLIAMSPORT, PENNA.	PREPARED BY: R.F.C
DATE: 5-2-72		DRAWN BY: S.Y
WATER SAMPLING TEST RESULTS	TOTAL HARDNESS SULFATE TOTAL IRON	
SUBMITTED BY:	CARSON ENGINEERS	DRAWING NO. PLATE 6



EXPLANATORY NOTES:

- TESTING STATION
- LINE OF LABORATORY RESULTS FOR STREP-FECALIS ALL RESULTS WERE NEGATIVE EXCEPT STATIONS 13 & 14 WHICH REGISTERED POSITIVE
- • TESTING LOCATION
- —— ESTABLISHED LEVEL OF TOLERANCE FOR COLD WATER FISHERY
- —·— E COLIFORM MPN - 100 ML

COWANSHANNOCK CREEK WATERSHED		
P.No. SL 159	ANALYST SEEWALD LAB. 1403 W. 4th St.	PREPARED BY: R.F.C
DATE: 5-2-72	WILLIAMSPORT, PENNA.	DRAWN BY: S.Y
WATER SAMPLING TEST RESULTS	FECAL-STREP COLIFORM CONDUCTIVITY MANGANESE	
SUBMITTED BY:	CARSON ENGINEERS	DRAWING NO. PLATE 7



EXPLANATORY NOTES:

TESTING STATION

· TESTING LOCATION

—.— LINE OF LABORATORY RESULTS

—— ESTABLISHED LEVEL OF TOLERANCE FOR COLD WATER FISHERY

EST. LEVEL FOR CALCIUM = 300 MG/L

EST. LEVEL FOR MAGNESIUM = 100 MG/L

COWANSHANNOCK CREEK WATERSHED		
F.No. SL 159	ANALYST SEEWALD LAB. 1403 W. 4th St. WILLIAMSPORT, PENNA.	PREPARED BY: R.F.C
DATE: 5-2-72		DRAWN BY: S.Y.
WATER SAMPLING TEST RESULTS		MAGNESIUM CALCIUM ALUMINUM
SUBMITTED BY:	CARSON ENGINEERS	DRAWING NO PLATE 8

Plates 5 thru 8 show the results of water sampling at permanent stations along the Cowanshannock and its tributaries. The major pollution source in the watershed is identified in the area of Huskins and Craigs Run, in the vicinity of the Yatesboro and Margaret deep mine complexes. Water sampling here shows high concentrations of iron and sulfates from the Yatesboro 4 and 5 complex. High concentrations of iron, sulfuric acid, and sulfates are in evidence along Huskins Run in the area of the Yatesboro 1, 2, 3, and Margaret 6, 7, and 8 mines.

The Cowanshannock has evidenced the capacity to recover from the adverse effects of these two major deep mine complexes. After passing Huskins Run, and as it flows towards the Allegheny River, the creek shows a good history of recovery as e result of dilution with alkaline tributaries until it reaches an area west of Mill Run. Here the Powell Mine complex is located, and there is a tendency from time to time for a "slugging" effect to take place as a result of the mine discharge. This slugging is evidenced by a low pH reading, low alkalinity readings, end a substantial increase in iron content as the Cowanshannock passes these mines and approaches its confluence with the Allegheny River.

The amount of pollution contributed by areas of prime concern was calculated and presented in Table 8. An estimate of the total pollution load for the watershed is shown in Table 9. This allows a presentation of pollution loadings as an estimated percentage of the total loadings for each area of concern.

This analysis tends to lead to the conclusion that there are seven major areas of abandoned mine activity within the watershed that contribute significantly to the mine drainage pollution of Cowanshannock Creek. The abatement of mine drainage pollution at these known sources would do much to improve the quality of water in the Cowanshannock. However, before selecting any area for additional work, a cost/benefits analysis is used to reinforce the ultimate selection of areas for further action.

Cost Analysis

The following estimate of costs is intended as an approximation only and are to be used as a guide as an estimate of cost for abating mine water pollution on the watershed. Refined cost estimates of investigations (core drilling, etc.) would be a part of the quick start studies. Detailed cost estimates can be made only after detailed plans and specifications are completed.

Cost/Benefit shown in the summary of costs is equivalent to the cost of each project in thousands of dollars divided by the estimated percent of combined iron-acid load contributed to the watershed by the project area.

A cost/benefit analysis of areas of primary concern (shown in Table 7) was made by considering only the total amount of iron and acidity from flows at seven project areas. This was done in order to be consistent with the Commonwealth's current practice of pollution definition. The analysis is found in Table 10. Table 11 presents an additional cost/benefits analysis of areas of secondary concern (Table 7) again using only total amounts of iron and acidity as parameters. Table 12 combines and integrates these two analyses in rank by cost/benefit. Generally the ranking here agrees well with the analysis used in Table 7 and Table 7A, however, there is some change in ranking because of cost considerations.

TABLE 10
Cost/Benefit Analysis
of Areas of Primary Concern
(Shown In Table 7)

Program	Project Area	Description of Abatement Measures	Cost	Acid ppd	Fe ppd	PPD % of Watershed	Cost/Benefit
Project Area 1	Quick Start I Yatesboro 4 & 5 Mine Complex	Mine Opening and Bore Hole Sealing	$292,000	14	241	2.4%	122
Project Area 2	Quick Start II Yatesboro 1, 2, & 3 Margaret 6 & 8 Mine Complex	Mine Opening and Bore Hole Sealing	$680,000	384	88	4.6%	148
Project Area 3	Decker #3 Deep Mine Decker #3 & #4 Gob Pile Dantella Strip Mine	Mine Opening Sealing Burial of Gob Regrading & Planting	$473,000	5962	246	60.7%	7.8
Project Area 4	Decker #2 Deep Mine Decker #4 Deep Mine	Mine Opening and Bore Hole Sealing	$222,000	30	28	0.6%	370
Project Area 5	Robin Coal Co. Strip Mine	Regrading & Planting	$261,000	39	10	0.5%	522
Project Area 6	M & E Coal Co. Strip Mine	Regrading & Planting	$244,000	-	30	0.3%	813
Project Area 7	Margaret 6, 7, & 8 Gob Pile	Burial Regrading & Planting	$201,000	515	48	5.5%	36.5

TABLE 11

Cost/Benefits Analysis
of Areas of Secondary Concern
(Shown in Table 7)

Area	Acid ppd	Fe ppd	PPD % of Watershed	Description	Reclamation Cost	Cost/ Benefit
D2	14.5	7.6	0.22	Deep Mine Seal 2 Openings	$ 50,000	227
S14	26.9	4.8	0.31	Strip Mine 48 Acres Grade Terrace & Plant	96,000	310
S16	7.2	0.8	0.08	Strip Mine 24 Acres Grade Terrace & Plant	48,000	600
G9	14.6	5.6	0.20	Gob Pile 20 Acres -- Bury Gob When Margaret 7 is Abandoned, Grade & Plant Deep Mine Seal 5 Openings	125,000	625
S27	0	5.4	0.05	Strip Mine 16 Acres Grade Terrace & Plant	32,000	640
D41	6.8	0.2	0.07	Deep Mine Seal 2 Openings	50,000	714
G11	84	0.1	0.82	Gob Pile 180 Acres -- Bury Gob, Grade, & Plant	630,000	768
D35	0	5.9	0.06	Deep Mine Seal 2 Openings	50,000	833

TABLE 11 (Cont'd)

Area	Acid ppd	Fe ppd	PPD % of Watershed	Description	Reclamation Cost	Cost/ Benefits
D6	0	6.1	0.06	Deep Mine Seal 2 Openings	$ 50,000	833
S15	0	4.7	0.04	Strip Mine 20 Acres Grade Terrace & Plant	40,000	1000
S29	0	3.6	0.04	Strip Mine 35 Acres Grade Terrace & Plant	70,000	1750
G7	0	1.6	0.02	Gob Pile 10 Acres -- Bury Gob, Grade & Plant	35,000	1750
S6	0	2.2	0.02	Strip Mine 22 Acres Grade Terrace & Plant	44,000	2200
D10	3.4	1.6	0.04	Deep Mine Seal 4 Openings	100,000	2500
G1	0.7	0.3	0.01	Gob Pile 10 Acres -- Bury Gob, Grade & Plant	35,000	3500
S7	0.0	0.2	0.0	Strip Mine 45 Acres Grade Terrace & Plant	90,000	-
G8	Unknown (Not Measurable)	Unknown (Not Measurable)	0.0	Gob Pile 100 Acres -- Bury Gob, Grade & Plant	-	-

Project Area 3 and 7, ranked 1 and 2 in Table 12, contribute 66.2% of acid mine drainage pollution in the form of iron and acid to the watershe d. Quick Start I and Quick Start II, ranked 3 and 4, contribute only 7.0% of the iron and acid pollution to the watershed. An accumulated percentage of the top four indicates a 73.2% contribution. Project Areas 4, 5, and 6 combined, contribute a minor 1.4% of the total pollution.

TABLE 12

Areas Ranked By Cost/Benefit

Rank	Area	Percent Pollution	Accumulated Percent Pollution	Cost/Benefit
1	Project Area 3	60.7	60.70	7.8
2	Project Area 7	5.5	66.20	36.5
3	Quick Start I	2.4	68.60	122
4	Quick Start II	4.6	73.20	148
5	D2	0.22	73.42	227
6	S14	0.31	73.73	310
7	Project Area 4	0.6	74.33	370
8	Project Area 5	0.5	74.83	522
9	S16	0.08	74.91	600
10	G9	0.20	75.11	625
11	S27	0.05	75.16	640
12	D41	0.07	75.23	714
13	G11	0.82	76.05	768
14	Project Area 6	0.3	76.35	813
15	D35	0.06	76.41	833
16	D6	0.06	76.47	833
17	S15	0.04	76.51	1000
18	S29	0.04	76.55	1750
19	G7	0.02	76.57	1750
20	S6	0.02	76.59	2200
21	D10	0.04	76.63	2500
22	G1	0.01	76.64	3500
23	G8	Not Determined	-	-

It appears most practical to consider only those areas with a cost benefit ratio of 150 or less because of the low percentage contributed by areas with cost benefit ratios beyond this; however, some special considerations must be taken into account before determining which project areas should be considered for further action.

First, although Project Area 3 contributes the bulk of the pollution load to the Cowanshannock, the effect on the main stream is minimized because of the tendency for dilution as indicated by Plates 5 thru 8.

Second, although Quick Start I and II contributes only 7.0% of the iron and acid pollution load to the watershed, these two areas are located where dilution effects are minimal. The results of pollution from these two areas had a major bearing on the Fish Commission's decision not to stock the Cowanshannock because of a high pollution load.

Third, the pollution load from Project Area 3 (Table 10) and Project Area 4 should be further investigated because it is suspected that some of the pollution load from Project Area 4 was monitored at Project Area 3 station NT2A. This was possibly the result of seepage from a covered opening in the Decker No. 2 Mine within Project Area 4.

A pollution load from gob pile G8 was not determined because flows were not measurable. This gob pile borders the Cowanshannock and it is expected that some leeching occurs into the stream.

Recommendations

Program

Results of our research lead us to submit the following program for the abatement of mine drainage on Cowanshannock Creek.

We recommend:

1. (Upon approval of this report)
Pursue the recommendations given in the Quick Start studies for Quick Start Project I, the Yatesboro 4 and 5 mine complex, and Quick Start Project II, the Yatesboro 1, 2, 3, and Margaret 6 and 8 mine complex. Both projects being part of this report.
Recommendations for Quick Start I and II consisting primarily of:
(a) Investigate selected bore holes and mine openings via core drilling, cleaning and calipering.

(b) Seal selected bore holes and mine openings.
(c) Provide for water to egress at its highest elevation.

(d) Monitor water flows and selected points on Cowanshannock Creek for a minimum of one year and evaluate the effectiveness of the abatement program.

2. Initiate abatement projects in the following areas as soon as possible:

	Possible Action	Alternate Action
(a) Project Area 3		
D-4 Decker #3 deep mine	water seals	treatment & ponding
G-2 Decker #3 & #4 gob pile	burial	treatment & ponding
S5 Dantella Brothers Strip Mine	regrading	treatment & ponding
(b) Project Area 4		
D-3 Decker #4 deep mine	water seal	treatment & ponding
D-13 Decker #2 deep mine	water seal	treatment & ponding

(c) Project Area 7

	Possible Action	Alternate Action
G10 Margaret 6, 7, and 8 gob pile	burial & grading in strip mine	burial in Margaret 7 upon abandon ment

Procedure

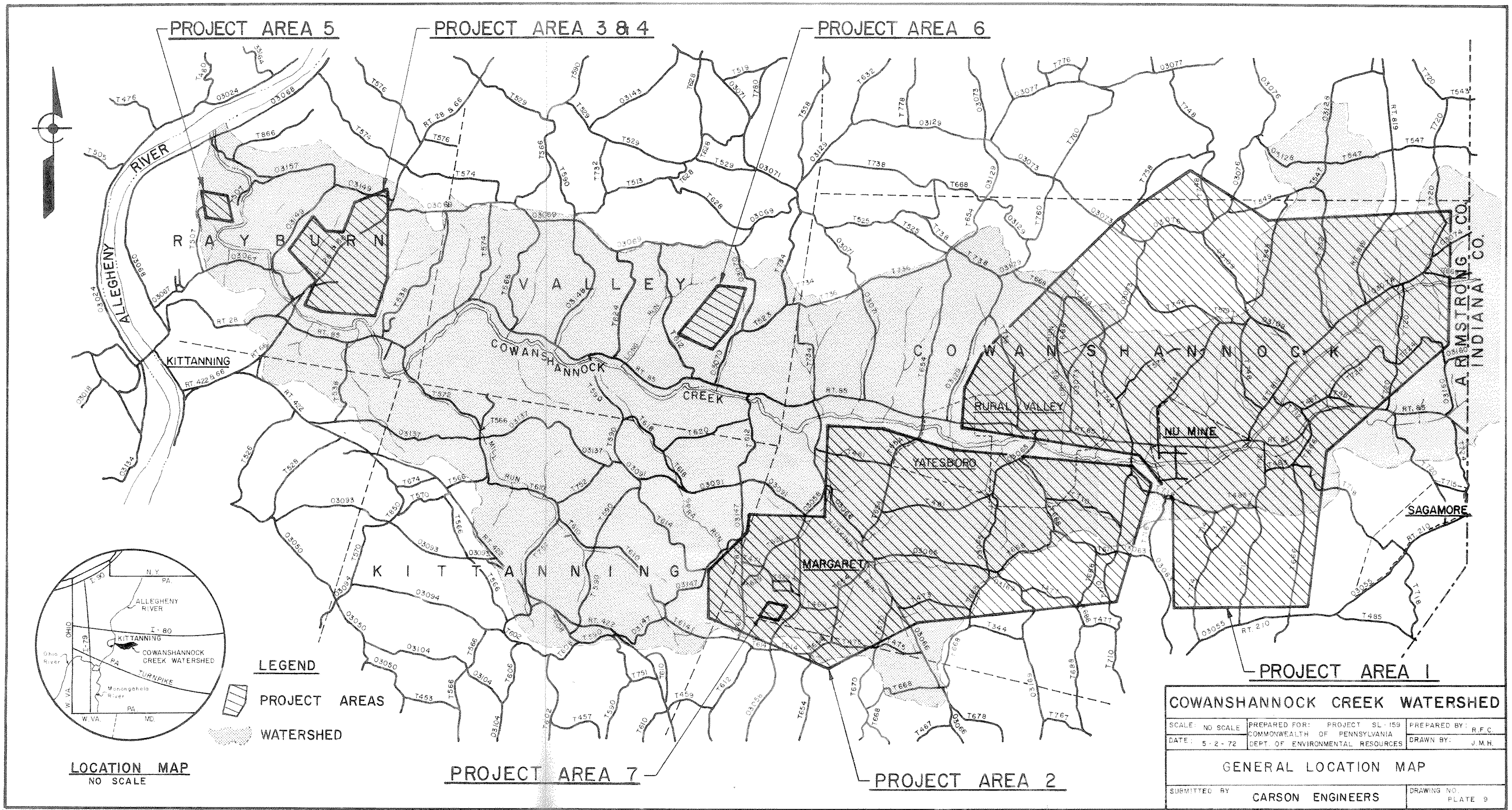
1. Complete the program as outlined in Quick Start Projects 1 and 2. This will include:

(a) Contracting for investigating services (Core drilling, calipering, cleaning bore holes, and pressure testing).

(b) Contracting for final construction and sealing in cluding engineering design of seals, valves, and channels.

2. Initiate a program of abatement studies for Project Areas 3, 4, and 7.

(a) Detailed studies and surveys of deep mines, strip mines, and gob piles to lead to recommendations for sealing or treating polluted sources including recommendations for detailed investigations such as core drilling, calipering, exploratory investigations and pressure testing.


PROJECT AREA 5
PROJECT AREA 3 & 4
PROJECT AREA 6
PROJECT AREA 7
PROJECT AREA 2
PROJECT AREA 1
ALLEGHENY RIVER
RAYBURN
VALLEY
COWANSHANNOCK
KITTANNING
COWANSHANNOCK CREEK
RURAL VALLEY
NU MINE
YATESBORO
MARGARET
SAGAMORE
ARMSTRONG CO.
INDIANA CO.
LEGEND
PROJECT AREAS
WATERSHED
LOCATION MAP
NO SCALE
N.Y.
PA.
OHIO
W. VA.
MD.
ALLEGHENY RIVER
I-80
I-79
I-90
KITTANNING
COWANSHANNOCK CREEK WATERSHED
Ohio River
Monongahela River
PA. TURNPIKE
COWANSHANNOCK CREEK WATERSHED
SCALE: NO SCALE
DATE: 5-2-72
PREPARED FOR: PROJECT SL-159 COMMONWEALTH OF PENNSYLVANIA DEPT. OF ENVIRONMENTAL RESOURCES
PREPARED BY: R.F.C.
DRAWN BY: J.M.H.
GENERAL LOCATION MAP
SUBMITTED BY CARSON ENGINEERS
DRAWING NO. PLATE 9