SECTION III

SWATARA CREEK WATERSHED - PART I: RESULTS OF INVESTIGATIONS

GENERAL DESCRIPTION

The Swatara Creek watershed covers approximately 576 square miles in portions of Schuylkill, Lebanon, Dauphin, and Berks Counties. Swatara Creek rises in the southern Pocono Mountains a few miles northeast of Tremont Borough and flows southwestward through a gap in Second Mountain where it is joined by Upper Little Swatara Creek at Pine Grove Borough. It then continues southward through Swatara Gap in Blue Mountain and southwestward across the Lebanon Plateau to enter the Susquehanna River at Middletown. The general location of the watershed is shown on Plate I.

There are 20,510 acres of public lands in the watershed drainage area. These lands are comprised of 1,340 acres of State Forest Land and 19,170 acres of State Game Lands. The State Game Lands include Nos. 80, 145, 160, and 229 as well as portions of Nos, 110 and 211. All of these lands provide many hours of hunting for large and small game.

Major watershed industries, with the number of employees shown in parentheses, are fabricated metal products (5,700), food and kindred products (5,500), wearing apparel (3,300), textiles (1,850), printing (1,000), leather products (800), and plastics (375) as well as farming and farm products in its middle reaches. The principal farm products include hogs, chickens, eggs, tobacco, wheat, and barley.

The population of the watershed is currently estimated at 132,600. The largest population centers are the City of Lebanon, Lebanon County (28,600), and Derry Township, Dauphin County (16,050).

A 43-square mile area situated north of Second Mountain on the headwaters of Swatara Creek is underlaid by a portion of the southern anthracite field. Past deep and strip mining have caused widespread acid mine drainage pollution in this area. Gannett Fleming Corddry and Carpenter, Inc., has conducted investigations in the extreme headwaters of Swatara Creek, which rises approximately three miles northwest of Branch Dale Village. The area investigated, which is referred to as the project area, extended to and included Echo Valley Village as well as the drainage area of Blacks Creek and covered approximately 18.7 square miles. The remaining 24.3 square miles of Swatara Creek headwaters area were apportioned between the other two consulting engineering firms. The three project areas are shown on Plate II.

Anthracite coal mining, once the mainstay of the economy in the headwaters area, has significantly declined in recent years. Mining was started in the Swatara Creek watershed more than 130 years ago and reached its peak during World War I. In 1917 Pennsylvania's anthracite production exceeded 100,000,000 tons which were mined by approximately 156,000 men. By 1971 the production had dwindled to slightly more than 8,000,000 tons mined by about 5,100 men.

The decline in anthracite production is obvious when Schuylkill County's figures are examined. In 1924 slightly more than 19,000,000 tons were mined in Schuylkill County by about 38,000 men, but in 1970 only 4,000,000 tons were mined by 2,600 men. In the project area, ten deep mines and one strip mine operator produced about 126,000 tons of coal in 1970. However, by July 1972 eight of the deep mines had ceased operations. The two remaining deep mines and one remaining strip mine operator in the project area produced approximately 60,000 tons of coal during 1970.

Surface or strip mining became a significant contributor to anthracite tonnage in the watershed during the thirties. Early strip mining was mostly confined to surface reservation pillars, geologically complex areas, and marginal quality coal veins. As underground mining costs increased and competing fuels captured large market segments, strip mining expanded. During 1932, when the Department first kept records of strip mining tonnage, about 3.5 million tons, or approximately 7 percent of total anthracite production, were stripped. Strip mining increased in the anthracite field until 1948 when about 13.5 million tons, or approximately 23 percent of total anthracite production, were stripped. Since 1948, however, all anthracite production has declined. During 1970 approximately 4.6 million tons, or about 50 percent of total anthracite production, were strip mined.

More than 130 years of mining in the headwaters area of the Swatara Creek watershed has caused mine drainage pollution of streams draining that area. The streams so affected include Panther Creek, Coal Run, Middle Creek, Good Spring Creek, Lower Rausch Creek, and Lorberry Creek as well as the main stem of Swatara Creek. Acid mine drainage discharges enter these streams from mine drainage discharge points, some of which drain extensively mined areas. Extensive mining underneath portions of these streams has interrupted surface-water and groundwater flow to the extent that flows in some of these streams are diminished. In addition, Tremont Borough and Donaldson Village discharge untreated sanitary wastewaters into surface streams in the headwaters area. The streams draining this area are therefore polluted and are not suitable for public use. An exception is Black Creek, which is ordinarily clean and is used as a source of public water supply by Pine Grove Borough.

Although significant anthracite reserves remain in the Swatara Creek watershed, mining is not expected to increase substantially in the near future. Past deep mining has left substantial pools of water overlying remaining coal in now inactive major underground mines. Past strip mining has removed much of the most easily reached reserves of the best quality. Coal production in the watershed will probably continue at a low level unless new mining techniques are developed or the demand for the more easily accessible poor quality coal increases dramatically.

GEOLOGIC CONSIDERATIONS

Within the Swatara Creek headwaters area, acid mine drainage is caused by numerous man-made subsurface and surface conditions. These conditions and their interrelationship must be defined to determine the causes of acid mine drainage and to develop abatement plans. For these reasons geochemical considerations are discussed in this section.

The current water quality in the watershed is the result of the types of rocks laid down millions of years ago and the conditions then existing under which deposited vegetable matter decayed. Sediments were deposited in either an oxidizing or reducing environment. Vegetable matter accumulating on the land surface or in well-aerated water was oxidized. In this environment the organic matter was converted by aerobic bacteria to water and carbon dioxide, and iron present reached the ferric state. Conversely, vegetable matter deposited in stagnant water decayed, after quickly depleting available dissolved oxygen, by a slow process of destructive distillation. In this oxygen-poor reducing environment, facultative and anaerobic bacteria obtained oxygen from sulfates and other available ions, with hydrogen sulfide being produced. Hydrogen sulfide reacted with soluble compounds to form disulfide which precipitated as pyrite. The production of pyrite in sedimentary deposits was directly related to the presence of organic matter in a reducing environment. Where enough organic matter was deposited, coal was eventually formed with the pyrite. With subsequent mining of the coal, the pyrite was uncovered, broken, and much of its surfaces exposed. These exposed surfaces oxidized to form ferrous sulfate and sulfuric acid in the presence of water. Water flowing over these surfaces eventually conveyed these oxidation products as acid mine drainage discharges into the streams in the watershed.

In the project area, significant amounts of coal are found in 14 persistent and I1 non-persistent beds. The actual extent of these, beds has not been proved, although they are known to persist to a depth of at least 6,000 feet beneath the ground surface. The project area coal is of generally poorer quality than the same beds in other portions of the anthracite field. Most of the project area coal beds are friable and have considerably higher ash content as well as lower fusion temperatures than most other Pennsylvania anthracite coals. It is probably for this reason that these coal beds have not been completely defined.

Conglomerates, sandstones, and shales comprise the major rock types in the watershed headwaters area. The streams in the headwaters area usually have (1) a very low solids content, (2) a pH less than 7.0, and (3) trace amounts of various metals including iron. These streams have a low buffering capacity and their pH values are depressed by atmospheric carbon dioxide and organic acids from decaying vegetable matter. The small iron concentrations in these streams are derived from the rocks from which they originate.

MAJOR SUBSURFACE CONDITIONS BEARING UPON THE FORMATION OF ACID MINE DRAINAGE

The major project area subsurface conditions causing acid mine drainage are set forth in this section. The information used to define these conditions was obtained from geologic maps, aerial photographs, available mine maps, individuals knowledgeable about the watershed, and field investigations. Geologic maps were obtained from the United States Geological Survey. Aerial photographs and mine maps were made 'available by. the Department of Environmental Resources. Department personnel, coal operators, and other knowledgeable individuals provided information. Field investigations were made by Gannett Fleming Corddry and Carpenter personnel to verify the information and data obtained from other sources as well as to secure supplementary information and data.

The project area of approximately 18.7 square miles situated north of the crest of Second Mountain is underlaid with coal comprising a portion of the southern anthracite field. Fourteen persistent and 11 non-persistent veins of coal have been found in this area. Virtually all of these 25 project area coal veins have been deep or strip mined to some extent. These veins are identified in Exhibit A by name and by the geologic formation in which they are found.

The coal measures in the project area were originally deposited over a much larger surface area than they now underlie. Subsequent severe folding of the earth's crust displaced these measures so that the coal veins pitch as steeply as 6,000 feet beneath the ground surface from their outcrops along the ridges. Alternate ridges, or anticlines, and depressions, or synclines, generally trending northeast to southwest were formed in the project area by the displacement and faults were created as the coal-bearing rocks broke and adjacent broken surfaces were forced past each other. As a result, the coal-bearing strata in the project area contain a series of ridges and valleys interspersed with faults occurring at odd angles.

The natural inclination of the coal veins dictated the manner in which deep mining was undertaken. Slope entries were driven down the steeply pitching veins for a few hundred feet where tunnels were driven through intervening rock to intercept other coal veins. Several veins were mined from that level to the ground surface through those tunnels and slopes. Where mining was extended too close to the ground surface, subsidence of the ground surface into the underlying voids occurred. When the mineable coal had been removed from that area, the slopes were extended to deeper levels where the same procedures were repeated. In some instances, shafts were constructed at strategic places throughout the coal-bearing strata. In one property, a water-level tunnel was driven in the rock entirely through a ridge to enable access to the coal and to provide water for coal-processing operations. In other instances, drift entries were driven into the coal measures where limited mining was planned and accomplished. As deep mining progressed in the project area, an intricate system of interconnected drifts, slopes, shafts, and rock tunnels was formed. Barriers of unmined coal were left between mines being developed by different owners. Under this original development, then, each mine had its own system of drifts, slopes, shafts, or rock tunnels connecting the veins being mined.

As deep mining developed and continued in the various mines, surface water and ground water were encountered. This water flowed down the mined veins to the levels being worked. From these levels, it was necessary to pump the water to the surface for discharge to the nearest watercourse. Where drifts and water-level tunnels were driven, water entering deep mined areas above their levels was passed by gravity through these entries to adjacent streams. As mining progressed to even deeper levels, more water was intercepted. Eventually, the mine operators established pump relay stations to remove water in stages from the deepest levels. Naturally, the costs of mining and mine dewatering increased as mining progressed to yet deeper levels. Eventually, some mine operators decided to discontinue mining because of increased costs, the depressed market for coal, and other reasons. These discontinued mines then began to fill with water, forming underground pools where mining had progressed beneath the levels of relief to surface streams. Limited current mining operations continue to extract coal above established pool levels.

Deep mining in the project area has occurred in three basic categories: major and independent mining companies opened and developed large mining operations; independent mining companies opened small operations, with major mining companies eventually developing these into large operations; and independent mining companies opened small operations within the large mines, after the major mining companies discontinued operations, to recover the remaining available coal.

Acid-producing materials are associated to varying degrees with all of the mined veins in the project area. As surface and ground water encounter these materials in the presence of air, ferrous sulfate and sulfuric acid are formed. Ferrous sulfate is very soluble in water. Acid mine drainage has been formed through this interaction between the acid-producing materials, air, and water since mining began and will continue to be created as long as these substances remain in contact with each other. Hence additional acid mine drainage probably will be formed in the mined project area for many years to come. The extent of deep mining in the project area and other related features are shown on Plate II.

EXTENT OF SURFACE AND SUBSURFACE AREAS DRAINING INTO OR OUT OF THE PROJECT AREA

In certain areas along the perimeter of the project area, ground water is conveyed both into and out of the project area. This condition results from deep mine workings extending under the` project area limits.

Extensive independent deep mining occurred in the Buck Mountain vein, which underlies the northernmost tip of the project area. These workings extend from the west under the Hans Yost Creek watershed through the project area eastward under the Crystal Run watershed. Approximately 85 acres of the project area contribute surface and ground waters to these underlying workings, which are drained by the Newmeister drift mine. This drainage subsequently reenters underlying deep mine workings, which are drained by the Pine Knot-Oakhill Drainage Tunnel discharge located on the West Branch of the Schuylkill River north of Minersville Borough.

Independent deep mine workings were developed in the Buck Mountain Underlap vein, located on the northwestern edge of the project area. These workings extend westward under the Middle Creek watershed. Approximately 22 acres of the project area contribute ground water and some surface water to underlying workings. An additional 43 acres of ground surface within the project area contribute surface water to these underground workings. These waters discharge to Middle Creek via an overflow from a strip mine impoundment which forms a part of the underground mine water pool.

Extensive deep mine workings have been developed and interconnected by independent miners in the Buck Mountain and Seven Foot veins in a geologic formation known locally as the Buck Mountain Basin. The basin is located along the northwestern edge of the project area immediately south of the Buck Mountain Underlap workings. Approximately 94 acres of ground surface in the project area along with an estimated 35 acres in the Middle Creek watershed overlie the basin and contribute ground water and some surface water to the workings. In addition, an estimated 93 acres of ground surface contribute surface-water runoff to the mine water pool. This pool surfaces in a strip mine near the southeast edge of the basin and discharges to Swatara Creek via Discharge Point 4.

As a result of folding and upthrusts, the measures containing the splits of the Mammoth vein have formed a small basin known locally as the Fisher Basin. This basin is located approximately 5,000 feet south of the Buck Mountain Basin and underlies approximately 27 acres of the project area and 105 acres of the Gebhard Run watershed. The splits of the Mammoth vein were initially developed by independent miners but were more extensively developed by the Middle Creek Colliery. Although the underlying Seven Foot and Buck Mountain veins were also mined by Middle Creek Colliery and independent miners, there is no record of the Mammoth veins being interconnected with the underlying workings, which lie approximately 250 feet under the Bottom Split Mammoth vein in this area.

As a result of past strip mining practices, Gebhard Run and surface-water runoff from approximately 276 acres was directed into the underlying workings in the Mammoth veins. As a result of recommendations by Gannett Fleming Corddry and Carpenter, Inc., in a 1968 report to the Federal Water Pollution Control Administration entitled, "Acid Mine Drainage Abatement Measures for Selected Areas within the Susquehanna River Basin," the Department constructed a lined channel across the basin to convey the flow of Gebhard Run. Today only 47 acres of ground surface remain that contribute to the underground mine water pool that has formed in the old workings. This pool finds relief as Discharge Point 11 via an old drift mine entry in the project area.

The underground workings of two major collieries Otto and Middle Creek -extend across the central section of the project area. The workings of these collieries are separated by the Swatara Fault and a barrier pillar that is considered effective.

The Otto Colliery workings extend eastward from the barrier pillar and fault and also encroach beneath the south-central fringes of the project area. The total project area underlaid by these workings is approximately 421 acres. Approximately 1,348 acres of ground surface in the project area also contribute surface water runoff to the mine water pool in the Otto Colliery workings. The pool finds relief at an elevation of 830 feet via an overflow point located approximately 2,000 feet east of the project area in the vicinity of the village of Branchdale on the Muddy Branch of the West Branch of the Schuylkill River watershed.

The Middle Creek Colliery workings extend westwardly from the barrier pillar and fault, and underlie approximately 169 acres of ground surface in the project area which contribute both ground and surface waters to the mine water pool in the underground workings. In addition, an estimated 212 acres of ground surface contribute surface-water runoff to the Middle Creek Pool. The pool finds relief at an elevation of 880 feet approximately 7,500 feet west of the project area on the Coal Run watershed.

The Blackwood Colliery workings extend along the northern slopes of Sharp Mountain south of Swatara and Panther Creeks in the project area and also extend northeastward beneath the Schaefer Creek watershed.

The deep mine workings underlie approximately 417 acres of ground surface, of which 398 acres are in the project area and the remaining 19 acres in the Schaefer Creek watershed. The ground surface contributing surface-water runoff to these workings totals 270 acres. The eastern limit of the Blackwood Colliery is defined by a barrier pillar separating the mine workings of the Blackwood Colliery from the Branch Coal Company. It is believed, based on available information, that this barrier pillar has been breached in the Holmes, Primrose, Tracy, and Diamond veins by the subsequent mining in the Bosack Tunnel Mine, which reopened the Branch Coal Company workings. Through subsequent interconnections, it is estimated that an additional 400 acres of ground surface underlaid by deep mine workings outside the project area contribute some ground and surface water to the Blackwood Colliery workings. Also, it is estimated that an additional 370 acres of ground surface east of the project area contribute some surface-water runoff. Flows from the Blackwood Colliery and adjacent deep mine workings to the east are discharged from the north end of the Blackwood Tunnel via Discharge Point 24 into Panther Creek.

The extent of the surface and subsurface areas contributing to mine drainage discharges within and outside of the project area is shown on Plate III.

MAJOR SURFACE CONDITIONS BEARING UPON THE FORMATION OF ACID MINE DRAINAGE

The major surface conditions causing acid mine drainage are discussed in this section. The sources of information used to define subsurface conditions causing acid mine drainage are utilized in this section.

Approximately 10.2 percent, or 1.91 square miles, of the project area has been affected by active and inactive strip mines. Most of the strip mining has been or is being conducted in certain of the Post-Pottsville coal veins, specifically the Buck Mountain, Seven Foot, Skidmore, the three major splits of the Mammoth, Holmes, Primrose, Orchard, Diamond, Peach Mountain, and Tunnel. The other veins occurring in the project area have been stripped to a lesser extent. At the end of 1971, two active strip mines were noted in the project area, both within the confines of areas previously stripped.

Because of past inadequate restoration, many inactive strip mines in the project area serve as catch basins that collect direct precipitation, surface runoff, and ground water. Considerable volumes of water so collected find their way into underlying deep mine workings which have been cut by the strip mines, or through fissures in the intervening rock. Partial restoration and sedimentation within portions of certain strip mines allow some water to collect in the pits from which overflows to adjacent surface streams occur.

On five unnamed project area streams- two tributaries to Panther Creek and three to Swatara Creek- as well as on two stretches of Swatara Creek, past strip mining has interfered with stream flow. On all five of the unnamed project area streams, strip mining cut across the stream beds and intercepted stream flow. One Swatara Creek tributary stream bed was subsequently reconstructed, but some stream water continues to go into the strip mine where it contributes to acid mine drainage discharges from that strip pit. In three of the other four tributaries, stream flow contributes to pools impounded in those strip mines and to overflows, which all have characteristics typical of project area ground water. In the remaining tributary, stream flow continues to be intercepted, enters underlying deep mine workings, and then contributes to the Otto Colliery overflow.

On both stretches of Swatara Creek, its stream bed was relocated. Through the upstream stretch, the relocation allowed strip mining under the stream bed. Through the downstream stretch, the relocation prevented direct stream flow into a break in the stream bed into underlying deep mine workings. Swatara Creek flow is diminished through both relocated stream beds by loss of water into underlying deep mine workings.

Acid mine drainage discharges, mostly during wet weather, have been caused by discarding of acid-producing material on the project area ground surface. Large piles of this refuse material have accumulated at past major underground mining operations and at coal-processing operations throughout the project area. At these project area coal-breaking operations, process water is obtained from adjacent surface streams, impoundments in a strip mine, and reportedly from underlying deep mine workings. The water is retained in sedimentation basins within closed systems from which there are periodic discharges.

The extent of active and inactive strip mining in the Swatara Creek watershed, as well as the locations of large refuse areas and other geographic features are shown on Plate II.

WATER FLOW ROUTES INTO AND THROUGH DEEP MINE WORKINGS

After the major subsurface and surface conditions causing acid mine drainage within the project area were established, water flow routes into and through deep mine workings were determined. The specific points at which surface and ground water enter deep mine workings had to be located before effective acid mine drainage abatement measures could be developed. Water flow routes also had to be traced through underground workings before mine drainage design volumes and quality could be established, and before estimates could be made of acid mine drainage reductions attributable to the construction of preventive measures. The major points of interconnection between the ground surface and deep mine workings, and water flow routes through the deep mine workings are summarized below.

1. Deep Mine Entries

   Numerous deep mine entries are located within the project area, including drifts, slopes, shafts, and rock tunnels. More than half of such entries were subsequently obliterated by strip mining along outcrops of the coal veins. Currently existing deep mine entries are not significant points of entry for surface and ground water into deep mine workings. The existing deep mine entries in the project area are shown on Plate II.

2. Subsidence Areas

   Many areas exist in the project area where the ground surface has subsided into underlying deep mine workings. Most of these areas are associated with the Buck Mountain, Seven Foot, and Skidmore veins, as well as the three major splits of the Mammoth, Holmes, and Primrose veins. Minor amounts of subsidence areas are associated with the other mined veins. Many such areas were subsequently strip mined. Consequently, the subsidence areas shown on Plate II include only those areas not subsequently obliterated by strip mining.

3. Stream Infiltration Areas

   Past major deep mining has extended under two separate stretches of Swatara Creek and one of its unnamed tributaries within the project area. These three areas have been discussed in the chapter entitled "Major Surface Conditions Bearing upon the Formation of Acid Mine Drainage," because strip mining was also accomplished over these areas. As a result of the past mining under stream beds, infiltration areas have been created. During other than heavy rainfall and runoff conditions, Swatara Creek stream flow diminishes in its two undermined stretches. The entire flow of the unnamed tributary is intercepted by the underlying deep mine workings into which an overlying strip mine had cut and is conveyed underground to the Otto overflow outside the project area. The extent of deep mining underneath project area streams is shown on Plate II.

4. Strip Mines

About 10.2 percent of the project area has been strip mined. Most of the strip mining was performed in the Buck Mountain, Seven Foot, and Skidmore veins, as well as the three major splits of the Mammoth, Holmes, Primrose, Orchard, Diamond, Peach Mountain, and Tunnel veins. Many strip mined areas encompass several veins. Some of the strip mines have cut into the underlying deep mines. Surface waters are intercepted by the strip mines through which large volumes of such waters flow to underlying deep mines. The locations of all of the strip mines in the project area are noted on Plate II.

5. Interconnected Deep Mines, Pools, and Pool Overflows

Five interconnected deep mine complexes exist in the project area. Three of these complexes - the Blackwood Tunnel and the Buck Mountain and Fisher Basins - contribute to pools from which overflows occur. The fourth complex is that drained by the Middle Creek pool overflow in another of the project areas. The fifth comprises the Otto pool overflow, which discharges to the east to the Schuylkill River watershed. Through past deep mining by major operators and independent miners, barrier pillars have been breached. Surface and ground waters have filled these collieries to levels at which they find relief to surface streams via overflows. The subsurface areas draining through the various current pool overflows are color coded on Plate III.

The information and data shown in this section relative to water flow routes through deep mine workings are based on the investigations described in this report. However, in reviewing this information and these data, it should be borne in mind that gobbing practices, the pulling of pillars, interconnecting strip mines, and roof falls since major deep mining ceased may have blocked, restricted, or altered the water flow routes through deep mine workings. The extent to which this may have occurred is difficult to determine, but apparently the major underground flow routes are carrying considerable volumes of water as many as 55 years after major deep mining operations were discontinued.

A small portion of the project area ground surface underlaid by deep mines has experienced some fissuring. Surface and ground waters, therefore, have access to deep mine workings through these fissured areas in addition to the specific interconnections located during the investigations.

MINE DRAINAGE DISCHARGE POINTS

Locating mine drainage discharge points was also essential in defining the current extent of mine drainage pollution as well as the kind and extent of applicable abatement measures for the project area. In addition to the investigations described in this report, mine drainage discharge flow and quality data in the watershed were obtained from the files of the United States Environmental Protection Agency and the Department.

The quality data had limited utility because of their age and change of status, in some instances from active pump discharges to pool overflows. The small amount of the quality data considered usable tended to corroborate the results of the gauging, sampling, and analytical program.

As part of the field investigations, 51 mine drainage discharge points were located, identified, and marked. These discharges were monitored during field investigations conducted from December 1970 through September 1971. The mine drainage discharges are scattered throughout the project area. Additional discharges probably exist in the project area under certain weather conditions not encountered during the field investigations. The findings, conclusions, and recommendations contained in this report are based solely upon the discharge points observed from December 1970 through September 1971.

The mine drainage discharge points located during the field investigations are summarized as follows:

1 . Underground Mine Water Pool Discharges

Three mine drainage discharge points relieve underground mine water pools existing within the project area. One discharges through a backfilled strip mine, another through a drift entry, and the third via a rock tunnel driven into the coal measures.

2. Strip Mines

Twenty-three mine drainage discharge points were associated with 23 strip mines. All of these discharge points pass mine drainage resulting from direct precipitation as well as surface runoff and ground water intercepted by the strip mines.

Twenty-one of the strip mines are not associated with deep mine workings. The remaining two strip mines have cut into underlying deep mine workings but still have three mine drainage discharge points.

3. Refuse Areas

Ten major refuse areas are located in the project area. Apparently, all of these refuse areas discharge mine drainage to some extent during and immediately following wet weather. However, continuous discharges. were noted from five refuse areas, and an intermittent discharge was noted from another. These discharges have their origins in precipitation being trapped in, and bleeding from, these refuse areas as well as from spring water originating beneath or running through them. Two of the discharges originate from an extensive rock dump.

4. Deep Mine Entries

Deep mine entries provide gravity drainage for 12 mine drainage discharges. Eleven of these discharges apparently originate in limited deep mine workings opened behind these entries, while one discharge drains more extensive workings.

5. Coal Preparation Areas (Sedimentation Basins)

Four mine drainage discharges exist as a result of sedimentation basin overflows from coal preparation areas. The rate of discharge from these basins ordinarily is a function of the rate of water usage in the breakers.

6. Miscellaneous Mine Drainage Discharge Points

Three mine drainage discharge points not covered previously are comprised of ground and surface water flows through three proving or test pits.

Exhibit B describes the nature and condition of these 51 project area discharge points. The locations of all mine drainage discharge points are shown on Plate 11.

MINE DRAINAGE GAUGING, SAMPLING, AND ANALYTICAL PROGRAM

To define the current extent of project area mine drainage pollution, the current volume and quality of mine drainage discharges had to be established. Therefore, the discharges from all of the known discharge points were gauged, sampled, and analyzed from December 1970 through September 1971. As part of the field investigations, nine instantaneous flow measurements and grab samples were obtained at most of these discharge points during dry, normal, and wet weather. All samples collected were analyzed for pH, iron, and acidity. In addition, some samples were analyzed for sulfate, aluminum, manganese, dissolved solids, dissolved oxygen, and phosphate concentrations. The sporadic nature of mine drainage discharges from refuse areas did not permit them to be gauged and sampled to the same extent as the other discharges.

Thirty-two of the 51 discharge points located during the field investigations appear to discharge mine drainage continuously. Although the discharges from the remaining 19 points appear to be intermittent, they were observed at some time during the field investigations. Based on discharge conditions encountered during low, average, and high ground-water levels, the combined mine drainage volumes in the watershed and their major constituents and characteristics approximated the following:

	Ground-Water Levels		
	Low	**Normal**	**High**
Volume - mgd	2.95	4.95	6.88
pH	2.6 - 6.8	2.6 - 6.9	2.7 - 6.9
Total Iron			
mg/1	7.7	5.5	5.9
tons per day	0.09	0.11	0.17
Acid (as $CaCO_3$)			
mg/1	138.0	91.0	76.0
tons per day	1.70	1.88	2.17

Exhibit C presents mine drainage volumes, constituents, and characteristics measured at each discharge point during the gauging, sampling, and analytical program.

During the period covered by this program, the yearly precipitation in the watershed was approximately 1.5 percent less than the average yearly precipitation over the period of record. Also, the total precipitation during the period affecting spring high flows (December 1970 through April 1971) was approximately 16.7 percent less than the December through April average over the period of record. The total watershed precipitation during dry weather (August through September 1971) was approximately 36.5 percent more than average precipitation during these months over the period of record.

MINE DRAINAGE DESIGN VOLUMES AND QUALITY

In addition to the establishing of water flow routes into, through, and out of deep mine workings, the design conditions at each discharge point had to be established before abatement measures could be planned and their effectiveness estimated. In this section of the report the mine drainage design volumes, constituents, and characteristics used in planning and evaluating the effectiveness of abatement measures are described.

Three conditions of discharge were established at each discharge point to determine the necessity for abatement measures, to design abatement measures, and to estimate their effectiveness. The three conditions may be described as follows:

Design Average
: Average daily mine drainage volumes, constituents, and characteristics during a year of normal precipitation.

Design Wet Weather
: Average daily mine drainage volumes, constituents, and characteristics during spring high ground-water level periods caused by normal precipitation from December through April.

Design Maximum
: Maximum daily mine drainage volumes, constituents, and characteristics resulting from the maximum 24-hour accumulation of rainfall occurring, on the average, no more often than once every 10 years.

The design maximum conditions could have been selected from a wide range of precipitation conditions. Maximum mine drainage discharges resulting from as little as the 72-hour accumulation of rainfall occurring no more often than once a year to as much as the 30-minute accumulation of rainfall occurring no more often than once every 1,000 years could have been adopted. After discussions with personnel from the Department of Environmental Resources, the recommended design maximum conditions were selected to provide reasonable protection to receiving streams. Excess mine drainage over design maximum loads can be absorbed by receiving streams whose flows have been significantly increased by excess precipitation.

Design average, wet-weather, and maximum mine drainage volumes were calculated using precipitation records, assumed surface-water runoff coefficients and evaporation-transpiration losses, as well as other information developed during the investigations. The mine drainage constituents and characteristics for design average and wet-weather conditions were based upon the previously discussed sampling and analytical program results obtained during normal and high groundwater level periods, respectively. The design maximum constituents and characteristics were estimated from sampling and analytical results as well as previous experience.

For design average conditions, mine drainage volumes at discharge points range from 0.003 to 2.837 mgd, iron concentrations from 0.1 to 71.0 mg/l, and acid concentrations from 10 to 4,420 mg/l. The combined mine drainage volumes as well as major constituents and characteristics used for design purposes are summarized as follows:

	Design Average	Design Wet Weather	Design Maximum
Volume - mgd	5.01	8.03	177.0
pH Range	2.6 - 7.1	2.6 - 6.9	2.6 - 6.9
Total Iron			
mg/l	5.5	5.9	5.7
tons per day	0.12	0.20	4.20
Acid (as $CaCO_3$)			
mg/l	92.0	75.1	58.0
tons per day	1.92	2.51	42.7

Exhibit D presents the assumptions and calculations used to establish combined design volumes. Exhibit E shows the design volumes, major constituents, and characteristics of discharges .for each of the 51 discharge points.

EVAPORATION-TRANSPIRATION
LOSSES AND RUNOFF COEFFICIENTS

In this study precipitation data collected at the United States Weather Bureau's permanent Zerbe Airport precipitation station for the period of October 1970 through September 1971 were used. During this period, the precipitation at the recording station was equivalent to 46.31 inches of rain. Since the Zerbe Airport station is relatively new, average annual precipitation figures have not been published. Based on information reported by the U.S. Geological Survey in Water Supply Paper 1829, however, the average annual precipitation for the project area is 47.00 inches. The design average mine drainage flows were obtained by adjusting gauging results obtained during the same period to compensate for the 1.5 percent deficiency in precipitation.

The design wet-weather mine drainage flows were determined by adjusting the gauging results obtained during 1971 high ground-water flows to compensate for a deficiency in precipitation of 16.7 percent, which occurred in Pennsylvania's East Central Mountain District during the period of December 1970 through April 1971.

The design maximum mine drainage flows were estimated using assumed values for evaporation-transpiration losses and runoff coefficients that were based on past experience. Flows for the three Design Conditions are shown in Exhibit D.

PRESENT MINE DRAINAGE
DISCHARGE LIMITATIONS OF
THE DEPARTMENT OF ENVIRONMENTAL RESOURCES

One set of conditions used in the development of abatement plans for the project area was that of bringing various mine drainage discharges under design average, wet-weather, and maximum conditions into compliance with present Department of Environmental Resources limitations. These discharge limitations are as follows:

pH not less than six or greater than nine

Iron concentration not in excess of seven mg/l

No acid

No additional mine drainage discharge limitations have at present been established for the project area.

MINE DRAINAGE DISCHARGES IN COMPLIANCE WITH PRESENT DISCHARGE LIMITATIONS OF THE DEPARTMENT OF ENVIRONMENTAL RESOURCES

None of the existing project area mine drainage discharges meet all current Department of Environmental Resources limitations for the design average, design wet-weather, and design maximum conditions. Forty-seven of the 51 discharges consistently meet Department iron limitations, and three of these 47 also consistently meet Department pH limitations. However, not one discharge in the project area meets Department acid limitations.

Many of the project area mine drainage discharges are of marginal quality and have chemical characteristics of project area ground water. A comparison of this similarity is made in a later section..

EXTENT AND EFFECTIVENESS OF PAST MINE DRAINAGE PREVENTIVE MEASURES

One preventive measure was implemented by a deep mine operator several years ago in the project area. Support beneath the bed of Swatara Creek north of its crossing by U.S. Route 209 had been weakened by deep mining, causing a break in the stream bed which allowed the stream flow to enter the underlying mine workings. To correct this situation, the operator relocated approximately 800 feet of the stream bed and repaired the break. However, a reduction in stream flow still appears to occur during normal and low ground-water conditions within this affected portion of Swatara Creek.

Within the Swatara Creek headwaters area, but west of the project area considered in this study, the Department of Environmental Resources constructed a flume to convey Gebhard Run flow across the Fisher Basin. This work was the result of one of the recommendations in the 1968 report to the Federal Water Pollution Control Administration entitled "Acid Mine Drainage Abatement Measures for Selected Areas within the Susquehanna River Basin," which was prepared by Gannett Fleming Corddry and Carpenter, Inc. The flume has prevented Gebhard Run flow from becoming a part of the flow from Discharge Point 11 within the project area, and is still effective.

PROJECT AREA DESIGN POLLUTION LOAD

From December 1970 through September 1971, 17 ground-water sources in addition to the mine drainage discharge points were monitored. Flows were measured and samples obtained for analysis on a regular monthly basis at 16 of these sources, whereas only one flow measurement was made and one sample obtained for analysis at the other source.

Under normal ground-water conditions, flows from these sources ranged from 0.002 to 0.274 mgd, their pH from 3.9 to 6.4, their iron concentrations from 0.1 to 1.1 mg/l, and their acidities from 12 to 27 mg/l. These sources had average concentrations of 0.5 and 20 mg/l for iron and acid, respectively.

In comparing these analytical results with those from the mine drainage discharge points, 28 of the mine drainage discharge points had comparable pH as well as iron and acid concentrations. These discharges then have the same characteristics as does the ground water in the project area. It was concluded that implementation of preventive measures at the sources of these 28 mine drainage discharges would not change their characteristics. On this basis, these discharges have been eliminated from consideration in the development of abatement plans for the project area. In addition, four of the remaining 23 mine drainage discharge points are from sedimentation basins at coal-processing plants or breakers. They are Discharge Points 13, 16, 18, and 36. Since the effluent quality at these breakers is dependent upon water source quality and since these facilities are subject to regulation by the Department of Environmental Resources, no evaluation of their pollution potential was attempted.

The remaining 19 discharge points, for design average conditions, have flows ranging from 0.039 to 2.84 mgd, iron concentrations from 0.1 to 71.0 mg/l, and acid concentrations from 25 to 4,420 mg/l. Their combined mine drainage volumes as well as major constituents and characteristics used for design purposes are summarized as follows:

Exhibit F shows flow and quality information for the 17 ground-water sources described above. Design flow and quality data for the 19 discharges considered to comprise the project area design mine drainage pollution load are shown in Exhibit G.

	Design Average	Design Wet Weather	Design Maximum
Volume - mgd	4.25	6.49	148.0
pH Range	2.6 - 6.1	2.6 - 6.1	2.6 - 6.1
Total Iron			
mg/l	6.4	7.1	6.7
tons per day	0.11	0.19	4.14
Acid (as $CaCO_3$)			
mg/l	105.0	88.0	65.0
tons per day	1.86	2.39	40.3

MAJOR MINE DRAINAGE VOLUME, IRON, AND ACID POLLUTION LOAD CONTRIBUTORS

During the investigations, considerable variation was observed in' the volume as well as in the tons of iron and acid contributed by mine drainage discharge points comprising the project area pollution load. The major contributors to the mine drainage volumes are the three underground mine water pool overflows whose combined flows comprise 84 percent of total volumes. Two of these overflows, specifically the Buck Mountain Basin and the Blackwood, contribute 79 percent of total project area iron load. The third largest contributor of iron is the discharge from a major refuse area, which when combined with the two largest contributors accounts for 93 percent of the total project area iron load. Also, the two pool overflows together with the discharge from the major refuse area contribute 82 percent of the total project area acid load.

The major mine drainage volume, iron, and acid contributors in the project area, therefore, are the three underground mine water pool overflows together with the discharge from one major refuse area. These four sources on the average contribute 86, 94, and 93 percent, respectively, of the total project area volume, iron, and acid loads.

The number of discharge points contributing various percentages of total project area design average mine drainage volume, iron, and acid pollution loads are summarized below:

	Approximate Percentage of Total Project Area Mine Drainage Volume, Iron, and Acid Pollution Loads			
	50	**85**	**95**	**100**
Volume				
mgd	2.84	3.58	4.04	4.25
number of discharges	1	3	7	19
Total Iron				
tons per day	0.054	0.089	0.107	0.11
number of discharges	1	2	4	19
Acid				
tons per day	1.00	1.52	1.77	1.86
number of discharges	1	3	5	19

Exhibits H, I, and J present tabulations in descending order of magnitude of all discharge points and percentages of total project area volume, iron, and acid pollution loads represented by each under design average conditions.

STREAM QUALITY CRITERIA

In addition to the mine drainage discharge limitations previously presented, the Department of Environmental Resources has adopted general and specific stream quality criteria for the Susquehanna River Basin, of which Swatara Creek is a part. The stream quality criteria are based on the anticipated use of Susquehanna River Basin surface streams for (1) the maintenance and propagation' of cold- and warm-water fish; (2) water supply for domestic, industrial, livestock, wildlife, and irrigation purposes; (3) boating, fishing, and water contact sports; (4) power; and (5) treated waste assimilation.

The Department's general stream quality criteria apply to all streams in the project area and are as follows:

> The water shall not contain substances attributable to municipal, industrial, or other waste discharges in concentration or amount sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant, or aquatic life. Specific substances to be controlled include, but are not limited to, floating debris, oil, scum, and other floating materials; toxic substances; substances that produce color, tastes, odors or settle to form sludge deposits.

The specific stream quality criteria adopted by the Department are as follows:

pH	Not less than 6.0 or greater than 8.5.
Dissolved Oxygen	Minimum daily average 5.0 mg/l; no value less than 4.0 mg/l.
Total Iron	Not to exceed 1.5 mg/l.
Total Manganese	Not to exceed 1.0 mg/l.
Temperature	Not to exceed 50F. rise above ambient temperature or a maximum of 870F., whichever is less; not to be changed by more than 20F. during any one hour period.
Dissolved Solids	Not to exceed 500 mg/l as a monthly average value; not to exceed 750 mg/l at any time.
Bacteria	For the period 5/15 to 9/15 of any year - not (coliforms/100 ml) to exceed 1,000/100 ml as an arithmetic average value; not to exceed 1,000/100 ml in more than two consecutive samples; not to exceed 2,400/100 ml in more than one sample. For the period 9/16 to 5/14 of any

year - not to exceed 5,000/100 ml as a monthly average value, or to exceed this number in more than twenty percent of the samples collected during any month; not to exceed 20,000/100 ml in more than five percent of the samples.

The specific stream quality limitations represent maximum or minimum values that can be reached in the receiving stream only during critical stream flow conditions. The critical flow is considered as the average minimum stream flow that occurs during seven consecutive days of any one year and has a recurrence interval of 10 years, whether the flow is regulated or not. For stream flows lower than critical flow, the general stream quality criteria would apply.

The Department realized that mine drainage pollution from abandoned mines must be abated throughout the watershed headwaters area to effect an improvement in stream quality. Based on discussions with Department personnel, the treatment of all discharges from abandoned workings would not be required to the extent necessary to meet Department limitations. The basic intent of the Department appears to be that of initially protecting the major streams in the watershed. To achieve this end, the Department would apparently require the elimination, reduction, or treatment of mine drainage discharges to the extent necessary to remove the pollutants primarily responsible for degradation of major streams. If the removal of additional pollutants appeared warranted, the Department would so indicate.

STREAM SAMPLING AND ANALYTICAL PROGRAM

An important aspect of the investigations was that of determining the existing quality of project area streams. Knowledge of current stream quality was considered essential for evaluating abatement plans.

Available stream quality data were extracted from files of the United States Environmental Protection Agency and the Department of Environmental Resources. These data, although limited, tended to corroborate those collected during the stream sampling and analytical program. Project area stream flow and quality have probably changed very little within the past 40 years. Limited deep mining below the now established overflow was being conducted in the Buck Mountain Basin as recently as 1961. In the last 11 years these lower-level mine workings have flooded and an overflow was created. This limited area and relatively small volume overflow would not have caused any substantial change in stream flow and quality.

Before authorizing these, investigations, the Department installed weirs at a number of locations on project area streams. Some of the weirs were washed out or rendered ineffective by high stream flows both prior to, and during, this stream sampling and analytical program.

As part of the field investigations conducted by Gannett Fleming Corddry and Carpenter, Inc., three additional stream sampling stations were established. These included one station on Swatara Creek immediately south of U.S. Route 209 and stations on two unnamed tributaries on its upper reaches. In all, nine stream quality sampling stations were established throughout the project area, with stream flow measurements also being taken at six of these stations. Four of these stations were located along Swatara Creek, while the remaining five were on its tributaries. Samples were collected for analysis at eight of these stations from January 1971 until September 1971, with nine grab samples being obtained under dry, average, and wet-weather runoff conditions. On Panther Creek two samples were obtained for analysis during this period. The locations of all stream sampling stations are shown on Plate II.

Specific stream quality criteria such as pH, total iron, total manganese, and dissolved solids are applicable to project area streams when considering mine drainage discharges. All stream samples collected were analyzed for pH, total iron, acidity, and sulfate whereas some were also analyzed for aluminum, manganese, phosphate, dissolved solids, dissolved oxygen, and temperature. No effort was made during the investigations to determine the coliform bacteria content of streams. Any coliform bacterial population in project area streams would not be attributable to mine drainage.

For the purposes of this report, only pH and iron and acid concentrations have been used in evaluating stream quality and for determining the effectiveness of abatement plans.

CURRENT QUALITY OF PROJECT AREA STREAMS

The average quality of waters observed at Swatara Creek tributary stream sampling stations within and entering the project area from December 1970 through September 1971 is summarized below:

	Swatara Creek Tributaries Affecting the Project Area
pH	4.1 to 5.9
Total Iron-mg/l	0.3 to 2.0
Acid (as $CaCO_3$)-mg/l	10 to 59

The above ranges represent average quality of Black Creek, Good Spring Creek, Panther Creek, and two unnamed tributaries of Swatara Creek. A minor amount of mine drainage entered Black Creek during a portion of the sampling program but Black Creek normally contains no mine drainage discharges. Good Spring Creek contains significant volumes of mine drainage and enters the project area although it is not considered to be a part of the project area. The average quality of these tributaries is shown below:

	Black Creek	Good Spring Creek	Other Swatara Creek Project Area Tributaries
pH	5.4	4.1	4.6-5.9
Total Iron-mg/l	0.3	1.7	0.4-2.0
Acid (as $CaCO_3$)-mg/l	21	59	10-52

Based on analytical data, none of these tributaries on the average meet the Department's pH criterion, and they are all acidic. Black Creek, Panther Creek, and one unnamed tributary meet the Department's iron criterion, whereas Good Spring Creek and the other unnamed tributary do not.

The average quality of waters observed at Swatara Creek stream sampling stations from December 1970 through September 1971 is summarized below:

	Swatara Creek within Project Area
pH	3.6-4.0
Total Iron-mg/l	1.7-5.9
Acid (as $CaCO_3$)-mg/l	59-78

Swatara Creek within the project area on the average does not meet the Department's pH and iron criteria, and its waters are acidic.

A brief discussion of information and data on the quality of project area streams follows. All tributary sampling stations discussed were established near or at their mouths.

1. Good Spring Creek-Tributary of Swatara Creek entering but not considered a part of the project area.

   Good Spring Creek contains a significant volume of mine drainage. Its average pH was 4.l, with values ranging from 3.8 to 4.6. Iron concentration averaged 1.7 mg/l, with a range from 7.0 to 0.2 mg/l. Acidity varied from 88 to 40 mg/l, with an average concentration of 59 mg/l. Good Spring Creek contains raw sewage originating upstream from the Borough of Tremont. Based on available information and additional limited analytical data, manganese concentrations could be of sanitary significance.

2. Black Creek-Tributary of Swatara Creek within the project area having no mine drainage discharges.

   Although there are no mine drainage discharges, Black Creek had a suppressed pH ranging from 4.0 to 6.0, with an average of 5.4. Its iron concentrations varied from 0.8 to 0.1 mg/l. Its average iron concentration was 0.3 mg/l, which barely meets the limits of U.S.P.H.S. drinking water standards. Its acidity averaged 21 mg/l, with a maximum of 32 mg/l. Based on available information and limited analytical data, other constituents and characteristics do not appear at present to be of major sanitary significance from a mine drainage aspect.

3. Project area tributaries of Swatara Creek having mine drainage discharges, specifically Panther Creek and two unnamed tributaries.

   Although Panther Creek receives significant volumes of mine drainage, its quality is comparable to or better than Black Creek. Its pH ranges from 5.7 to 6.1, with an average of 5.9. Iron concentrations range from 0.5 to 0.2 mg/l, with an average concentration of 0.4 mg/l. Acidity averages 10 mg/l, with a maximum of 12 mg/l recorded. Other constituents and characteristics were not determined at this sampling station.

   The remaining project area tributaries have been affected by mine drainage to a degree. Average pH recorded ranged from 4.6 to 5.6, with a low of 3.2 having been recorded. Their average iron concentration ranged from 0.2 to 0.4 mg/l, with a high of 3.4 mg/l being recorded. Acidity, on the average, ranged from 18 to 52 mg/l, with a high of 96 mg/l being recorded. Based on available information and limited analytical data, manganese and dissolved solids concentrations are of sufficient magnitude to be of sanitary significance.

4. Swatara Creek within the project area.

Swatara Creek throughout its length within the project area is generally of poor quality. On the average, its pH ranged from 3.6 to 4.0, with a low of 3.4 being recorded. Iron concentration ranged, on the average, from l.7 to 5.9 mg/l, with a high of 42.9 mg/l being recorded. Its average acid concentration ranged from 59 to 78 mg/l, with a high of 150 mg/l being recorded. Based on available information and additional limited analytical data, manganese and dissolved solids are of sufficient magnitude to be of sanitary significance.

Exhibit K lists the constituents and characteristics measured at each sampling station during the sampling and analytical program. The locations of all sampling points and streams are noted on Plate II..

ACID MINE DRAINAGE ABATEMENT PLANS STUDIED IN DETAIL

Various abatement measures, separately or in combination, have the potential for eliminating mine drainage pollution in the project area. All abatement measures considered applicable to problems and conditions of the project area were reviewed separately and in combination to develop alternative abatement plans. The plans developed by this procedure and considered of sufficient merit were studied in detail. This section describes such plans.

Preliminary consideration was given to developing abatement plans in each of three categories:

1. Abatement plans based solely on preventive measures 2.

Abatement plans based solely on treatment measures

3. Abatement plans based on various combinations of preventive and treatment measures

Comments relative to these three categories and the individual abatement plans presented in this section are set forth in the following:

1. Based on investigations described in this report and previous experience, it would be prohibitively expensive and totally impractical to develop an abatement plan comprised solely of preventive measures in an area as large as the project area and with its physical conditions.

2. For abatement plans consisting of preventive measures supplemented by treatment measures, estimates of acid mine drainage reductions attributable to the preventive measures were made on the basis of estimated increases in runoff coefficients, volumes of surface water kept from deep mine workings, and similar factors. In the preliminary design of treatment measures, due allowance was made for acid mine drainage reductions attributable to preventive measures.

3. Treatment measures were designed to meet the present Department of Environmental Resources mine drainage discharge limitations.

4. Based on investigations described in this report and previous experience, a number of preventive measures were considered uniquely applicable to project area conditions. These preventive measures were used in some of the abatement plans presented.

5. In the development of abatement plans, consideration was given in certain cases to abating all mine drainage discharges and in others only some

discharges. Plans were studied that would reduce project area mine drainage pollution from 85 to 100 percent. In the abatement plans in which somewhat less than a 100 percent reduction was to be attained, every effort was made to concentrate on those discharges contributing 85 percent of the project area iron and acid loads.

Each of the abatement plans studied in detail is described below:

ABATEMENT PLAN I

Basic Intent: Collect and treat at one site 18 mine drainage discharges whose quality is poorer than natural waters found within the project area. The collection system construction will eliminate Discharge Point 25.

Preventive measures: None

Collection System and Treatment Measures:

a. Twelve flow equalization basins located to serve groups of mine drainage discharges; design maximum flow.

b. 63,220.feet of conveyance sewers six to 30 inches in diameter; design for twice wet-weather flow.

c. 11,100 feet of lined channels; design maximum flow.

d. One treatment plant-Swatara Creek 13,500 feet south-southwest from Tremont; design wet-weather flow.

Estimated acid mine drainage volume affected and reductions in project area design average pollution loads attributable to the abatement plan are as follows:

Volume - 100%; 4.25 mgd
Iron - 85% (to 1 mg/ 1); 0.10 tons per day
Acid - 100%; l.86 tons per day

ABATEMENT PLAN II

Basic Intent: Collect and treat at one site major mine drainage Discharge Points 4, 11, 19, and 24 not meeting current Department limitations. Collection system construction will eliminate Discharge Point 25.

Preventive Measures: None

Collection System and
Treatment Measures:

a. Four flow equalization basins located near each of the four major discharges; design maximum flow.

b. 26,575 feet of conveyance sewers six to 30 inches in diameter; design for twice wet-weather flow.

c. l,000 feet of lined channels; design maximum flow.

d. One treatment plant - Swatara Creek 2,000 feet downstream from the point where it receives Panther Creek; design wet-weather flow.

Estimated acid mine drainage volume affected and reductions in project area design average pollution loads attributable to the abatement plan are as follows:

Volume - 86%; 3.64 mgd
Iron - 81 % (to 1 mg/l); 0.09 tons per day
Acid - 93%; 1.73 tons per day

ABATEMENT PLAN III

Basic Intent: Control of mine drainage pollution by construction of preventive and treatment measures; eliminate acid mine drainage at Discharge Points l, 3, 7, 8, 12, 15, 24, 25, 46, and 47; reduce acid mine drainage at Discharge Points 4, 11, and 30 in the project area as well as at the Middle Creek and Otto Colliery overflows outside the project area; collect and treat in one system Discharges 4, 11, and 19, of which 4 and 11 were reduced by preventive measures.

Preventive Measures: Clear 750 feet of stream channel and construct 4,430 feet of lined stream channels; construct 8,120 feet of surfacewater diversion ditches; restore 322.5 acres within 17 improperly restored strip mines; restore 1.0 acre of two test pits or proving areas; construct l,800 feet of unlined and 11,475 feet of lined channel to carry runoff; construct one grout curtain 730 feet long; clear and seal one rock tunnel; neutralize one rock dump; neutralize one strip mined area; move 21,000 cubic yards of refuse.

Estimated acid mine drainage volume affected and reductions in project area design average pollution loads attributable to the preventive measures are as follows:

Volume - 82% Iron
- 48% Acid - 29%

Collection System and Treatment Measures:

a. Three flow equalization basins located near each of three major discharges; design maximum flow.

b. 15,775 feet of conveyance sewers six to 15 inches in diameter; design for twice wet-weather flow.

c. 900 feet of lined channel; design maximum flow.

d. One treatment plant - Swatara Creek 2,500 feet east of Newtown; design wet-weather flow.

Estimated acid mine drainage volume affected and reductions in project area design average pollution loads attributable to the treatment measures are as follows:

Volume - 13 %
Iron - 48% (to 1 mg/l) Acid
- 68%

Estimated acid mine drainage volume affected and reductions in project area design average pollution loads attributable to the abatement plan are as follows:

Volume - 95 % ; 4.04 mgd
Iron - 96%; 0.109 tons per day
Acid - 97%; 1.82 tons per day

Estimated acid mine drainage volume affected and reductions in design average pollution loads outside the project area attributable to the abatement plan are as follows:

Volume - 0.814 mgd
Iron - 0.0924 tons per day
Acid - 0.451 tons per day

ABATEMENT PLAN IV

Basic Intent: Control mine drainage pollution by construction of preventive and treatment measures; eliminate acid mine drainage at Discharge Points l, 3, 4,7, 8, 12, 15, 19, 24, 25, 46, and 47; reduce acid mine drainage at Discharge Points 11 and 30 in the project area and at the Middle Creek and Otto Colliery overflows outside the project area; collect and treat Discharge 11 which was reduced by preventive measures.

Preventive Measures: Clear 750 feet of stream channel and construct 4,430 feet of lined stream channels; construct 8,700 feet of surface-water diversion ditches; restore 380.7 acres within 18 improperly restored strip mines; restore l.0 acre of two test pits or proving areas; construct 2,110 feet of lined channel to carry runoff; construct one grout curtain 730 feet long; clear and seal one rock tunnel; move 513,000 cubic yards of refuse into strip mines; neutralize one rock dump; neutralize one strip mined area; move 21,000 cubic yards of refuse.

Estimated acid mine drainage volume affected and reductions in project area design average pollution loads attributable to the preventive measures are as follows:

Volume - 92%
Iron - 98% Acid -
93%

Collection System and
Treatment Measures:

a. One flow equalization basin; design maximum flow.

b. l,050 feet of conveyance sewer eight inches in diameter; design for twice wet-weather flow.

c. 450 feet of lined channel; design maximum flow.

d. One treatment plant-Swatara Creek 2,000 feet upstream from its crossing by U.S. Route 209; design wet-weather flow.

Estimated acid mine drainage volume affected and reductions in project area design average pollution loads attributable to the treatment measures are as follows:

Volume - 3%
Iron - 0% Acid -
4 %

Estimated acid mine drainage volume affected and reductions in project area design average pollution loads attributable to the abatement plan are as follows:

Volume - 95 % ; 4.04 mgd
Iron - 98%;0.111 tons per day
Acid - 97%; 1.82 tons per day

Estimated acid mine drainage volume affected and reductions in design average pollution loads outside the project area attributable to the abatement plan are as follows:

Volume - 0.766 mgd
Iron - 0.0854 tons per day
Acid - 0.426 tons per day

COST ESTIMATES FOR ACID MINE DRAINAGE ABATEMENT PLANS STUDIED IN DETAIL

Various considerations associated with each abatement plan studied in detail were evaluated before selecting the plan to be recommended for construction. Cost was a major consideration. Accordingly, project and total annual costs were estimated and compared. These cost estimates, based on present price levels, are set forth in this section.

The costs associated with each of the plans studied in detail are summarized in the following:

Abatement Plan	Project Cost	Total Annual Costs: Average Over Initial 30 Years	Total Annual Costs: Average Over Next 270 Years	Total Annual Costs: Average Over 300 Years
I	$ 6,980,000	$ 766,000	$ 416,000	$ 475,000
II	3,440,000	460,000	302,000	318,000
III	5,740,000	563,000	166,500	200,800
IV	9,950,000	824,000	79,800	149,000

DISCUSSION OF ACID MINE DRAINAGE ABATEMENT PLANS STUDIED IN DETAIL

The principal factors considered in evaluating the abatement plans studied in detail are discussed below:

ABATEMENT PLAN I

The basic intent of this plan is the abatement of all 19 mine drainage discharges that do not meet current Department of Environmental Resources limitations and whose quality is poorer than natural ground water found within the project area. This is achieved by means of a collection and treatment system in which 18 discharges are collected and treated and one discharge is eliminated by the construction of the collection system. This plan gives positive control and more predictable results than subsequent plans involving preventive measures. For all practical purposes, the entire pollution load is abated by this plan. A reduction in acid mine drainage pollution cannot be attained until the collection and treatment system is constructed.

The project and long-term costs of Abatement Plan I are greater than those for Abatement Plan II. The differential in the project cost is due to the more extensive collection system required to convey the additional mine drainage discharges to the treatment plant. The higher long-term cost of this plan is also related to the operation, maintenance, and periodic replacement of the more extensive collection system required. Approximately 86 percent of the project cost is attributable to the collection facilities in this plan versus approximately 74 percent in Abatement Plan II.

ABATEMENT PLAN II

The basic intent of this plan is the abatement of five significant mine drainage discharges, which constitute 93 percent and 81 percent of the acid and iron pollution load, respectively, to the project area. This is achieved by means of a collection and treatment system in which four discharges are collected and treated and one discharge is eliminated by the construction of the collection system. This plan gives positive control and more predictable results than abatement plans incorporating preventive measures. A reduction in acid mine drainage pollution cannot be attained until the collection and treatment system is constructed.

The project cost of Abatement Plan II is less than for any of the other abatement plans studied in detail. The long-term cost is considerably higher than that of abatement plans incorporating preventive measures. This is due to the high annual operating and maintenance costs and periodic replacement of the collection and treatment facilities.

ABATEMENT PLAN III

This plan combines preventive measures with treatment measures to provide a reduction in the acid and iron pollution load to the project area of 97 and 96 percent, respectively. In addition, it provides a reduction to the pollution loads at two additional mine drainage discharge points outside the project area that have been affected by surface and underground mining in the project area. Approximately 29 percent of the project area acid pollution load is abated by preventive measures, with the remaining 68 percent collected and treated at one treatment plant. Stage construction of this plan is limited to the portion of the plan -using preventive measures.

The project cost is lower than that for Abatement Plan IV and slightly lower than the Abatement Plan I project cost. The long-term cost is considerably higher than that for Abatement Plan IV but lower than that for Abatement Plans I and II. The degree of reliability of this plan must be considered less than that of abatement plans employing collection and treatment measures only.

ABATEMENT PLAN IV

This plan provides for approximately the same reduction in the acid and iron pollution load to the project area as Abatement Plan III. Of the total acid load to the project area, 97 percent is reduced by this plan, which is comprised of reductions of 93 percent by preventive measures and four percent by treatment measures. An iron load reduction of 98 percent is achieved by preventive measures. As in Abatement Plan III, the pollution load from two discharge points outside the project area is reduced.

Since pollution load reductions are achieved mainly by preventive measures, the project cost for this plan is higher than for any of the other abatement plans studied in detail. The long-term cost is the lowest of all four abatement plans. This is due to the minor amount of annual operating and maintenance costs required for such a system. Stage construction of the preventive measures could be undertaken with this plan and the effect of each stage evaluated. The degree of reliability for this plan is less than for the other three abatement plans because of the extensive preventive measures proposed.

RECOMMENDED ACID MINE DRAINAGE ABATEMENT PLAN

Based on the long-term cost, the degree of reliability with which results can be predicted, flexibility to enable stage construction, an evaluation of preventive and treatment measures, reduction in project area pollution loads, and resultant stream quality, Abatement Plan IV is recommended for construction in the project area. The plan is comprised of 17 preventive measures, as well as one collection and treatment system. The abatement measures that would be constructed as parts of the recommended abatement plan are shown on Plate IV. The recommended order for implementing this plan is as follows:

l. Remove silt and debris from drainage channel of Discharge Point 24; remove rock, silt, and debris within Blackwood Tunnel; and construct reinforced concrete seal near south end of Blackwood Tunnel.

2. Remove refuse from a portion of R-2; and restore S-14 as well as portions of 5-12 and S-18 using refuse to meet partial fill requirements.

3. Reconstruct Stream Channel F-F' for an unnamed tributary of Swatara Creek; and construct surface-water diversion ditches for S-15 and S-16.

4. Reconstruct Stream Channel D-D' and clear unlined Channel D'-E for an unnamed tributary of Swatara Creek; regrade, replant, and construct surface-water diversion ditches for a portion of S-12; restore S-13.

5. Reconstruct Stream Channel C-C' for Swatara Creek.

6. Reconstruct Stream Channel B-B' for Swatara Creek; regrade and replant a portion of S-6; provide lined Channel J-J' for surface-water runoff from S-6 to Swatara Creek.

7. Restore S-21 and S-23 as well as a portion of S-22; reconstruct Stream Channel H-H' for an unnamed tributary of Swatara Creek; construct surface-water diversion ditches for S-21 and S-22.

8. Restore S-9 and construct grout curtain across S-9.

9. Reaffect S-3 by excavating deep mine workings above underground pool elevations, and restore entire affected area.

10. Restore S-4, S-5, S-8, and S-17; construct surface-water diversion ditches for S-7.

11. Restore S-19; construct surface-water diversion ditches for S-20.

12. Periodically apply alkali over strip mined areas contributing to Discharge Point 24.

13. Remove refuse from a portion of R-3 encroaching on Panther Creek.

14. Restore S-11; and construct surface-water diversion ditches for S-10.

15. Restore S-2 east of 1-81 and construct lined channel through S-2 to convey surface-water runoff from I-81.

16. Periodically apply alkali on R-l.

17. Restore S-l.

18. Construct collection facilities and treatment plant at Discharge Point 11.

The recommended plan will reduce one as well as abate 13 of the 19 discharge points considered to comprise the project area pollution load. In addition, this plan will accomplish reductions in pollution loads at two major discharge points located outside the project area. Flows at these two discharge points had been increased by past mining within the project area.

Project cost and unit cost information for the preventive and treatment measures comprising the recommended plan is summarized in the following:

		Total Annual Costs Per Ton of Acid Removed		
	Project Cost	**Average Over Initial 30 Years**	**Average Over Next 270 Years**	**Average Over 300 Years**
Preventive Measures	$ 9,730,000	$ 962	$ 25	$ 112
Treatment Measures	220,000	2,190	1,990	2,010

Exhibit L presents information by project on estimated acid mine drainage pollution abated and associated costs for the preventive and treatment measures comprising the recommended plan. Exhibit M shows by project the mine drainage discharge points affected by the preventive and treatment measures comprising the recommended plan.

ANTICIPATED QUALITY OF PROJECT AREA STREAMS AFTER IMPLEMENTATION OF RECOMMENDED ABATEMENT PLAN

Information and data on the anticipated quality of project area streams follow:

l. Good Spring Creek- Swatara Creek tributary entering but not considered a part of the project area:

As a result of implementing the recommended plan, a considerable volume of water will be excluded from one major mine drainage discharge point that is situated within the Good Spring Creek watershed. This should have no significant change in stream quality at the mouth of Good Spring Creek due to the large volumes of mine drainage remaining. If current raw sewage discharges are collected, and treated, and the effluent is discharged directly to Swatara Creek, it is anticipated that stream pH and alkalinity would be depressed in Good Spring Creek.

2. Black Creek- Tributary of Swatara Creek within the project area having no mine drainage discharges:

It is anticipated that current water quality will not change with implementation of the recommended plan.

3. Project area tributaries of Swatara Creek having mine drainage discharges, specifically Panther Creek and two unnamed tributaries:

Implementing the recommended plan will eliminate a considerable volume of mine drainage from two discharge points. Based upon current water quality, Panther Creek is not visibly affected at the sampling station by these discharges. It is anticipated that Panther Creek will have a pH of 5.9, average iron concentration of 0.4 mg/l, and average acid concentration of 10 mg/l.

It is expected that one of the two unnamed tributaries, known locally as Polly's Run and measured at Stream Sampling Station T-2, will be improved in quality, largely as the result of flow augmentation in its upper and middle reaches. The augmentation will be accomplished by collecting and conveying good quality water across mined areas to the stream. Through this procedure the water will be prevented from infiltrating into underlying deep mine workings and becoming part of the underground pool overflow outside of the project area. The pH of Polly's Run is expected to average 5.5 and go as low as 4.2. The maximum iron concentration is expected to be 2.2 mg/l, with an average of l.3 mg/l. Average acidity is expected to be 34 mg/l.

The remaining unnamed tributary sampled at Stream Sampling Station T-l is not affected by the recommended plan, and its quality will remain unchanged.

4. Swatara Creek within the project area:

Swatara Creek throughout its reaches will be improved in quality by flow augmentation from surface and ground-water formerly infiltrating into underground mine water pools discharging outside the project area, and by elimination of or substantial reductions to 14 mine drainage discharge points located within the project area. It is expected that Swatara Creek itself will approach natural ground-water quality in its reaches above its confluence with Good Spring Creek. The average pH range is expected to be 5.0 to 5.7, with a minimum of 4.2. Iron concentration on the average will be 0.5 mg/ 1, with a maximum of 1.1 mg/l. Average acidity is expected to be 15 mg/l, with a maximum of 30 mg/l.

Assuming no abatement of mine drainage in the Good Spring Creek watershed other than that proposed in the recommended plan, the quality of Swatara Creek below its confluence with Good Spring Creek will show some improvement but will remain affected by the mine drainage pollution load in Good Spring Creek. The average pH is expected to be 5.0, with a minimum of 4.2. The iron concentration will average 1.0 mg/l, with a maximum concentration expected to reach 4.0 mg/l. Average acidity will be 35 mg/l, with an anticipated maximum concentration of 55 mg/l.

If current raw sewage discharges are collected, treated, and discharged directly to Swatara Creek in compliance with Department of Environmental Resources orders and with Department-approved plans, some alkalinity might be imparted to Swatara Creek. Any alkalinity that can be made available by such treatment facilities should be encouraged.

Exhibit N shows the expected constituents and characteristics of project area streams at each sampling station after implementation of the recommended plan.

PROJECT AREA ACTIVE MINES

Active coal mining continues in the project area on a limited scale. During 1970 there were two active strip mines and 10 active deep mines in the project area. These mines produced approximately 125,000 tons of coal in 1970. However, by the end of 1971 the number of active operations in the project area had dwindled to two strip mines, both conducted by the same operator, and two deep mines. These four operations accounted for approximately 60,000 tons of coal during 1970. All these operations have a limited life, which in most instances is estimated at less than five years. Each operation is in itself limited by the amount of coal remaining after earlier deep mining operations were completed, its quality, its accessibility, the extent of underground mine water pools, the extent and condition of past strip mining operations, and similar factors.

Based on available information and data, no active project area deep or strip mine has found it necessary to collect and pump mine water to the surface for discharge to project area streams. Any water developed by these limited active operations, which are all interconnected with past deep mining, follows established water flow routes into abandoned underground mine workings from which discharges exist.

If the active deep and strip mine operators are required to collect and treat their mine drainage, the resulting facilities would have an insignificant effect on project area mine drainage pollution. From an engineering standpoint, it would therefore be more practical to allow this water to flow into the underground mine workings for collection and 'treatment with the abandoned mine drainage discharges where necessary.

A reasonable and easily administered method by which active operators could bear their part of the responsibility for mine drainage abatement in the project area would be to pay the Department of Environmental Resources on the basis of coal tonnage produced. The Department could then use this money to implement abatement measures designed to eliminate mine drainage pollution in the project area and the entire watershed. The Department should therefore require payment of a fixed amount per ton of coal mined from each active operator in the project area. The amount should be consistent with that to be paid by active operators in other portions of the anthracite field.

OVERVIEW

Swatara Creek has been adversely affected by mine drainage pollution in its headwaters area. The Department of Environmental Resources is concerned with the abatement of this pollution, as mandated in Pennsylvania's Clean Streams Act, as well as with resultant stream quality improvement in the Susquehanna River. Based on the results of the investigations described in this report, Swatara Creek stream quality will be considerably improved following implementation of the recommended abatement plan. Susquehanna River stream quality will be enhanced to a lesser degree.

After implementation of the recommended plan, Swatara Creek in the project area is expected to virtually meet the Department's pH stream quality criterion, and to fully meet its iron stream quality criterion. Stream quality in the downstream reaches of Swatara Creek should also be improved by the elimination of considerable volumes of acid mine drainage in the project area. For all of Swatara Creek, some improvement in other constituents and characteristics associated with mine drainage should be accomplished. Therefore, it appears certain that implementation of the recommended plan will assist in accomplishing the Department's objective.

In addition, the recommended plan will (l) remove 98 and 97 percent of project area iron and acid loads, respectively, and (2) improve the present quality of Swatara Creek tributaries currently receiving acid mine drainage in the project area. Although under the recommended plan all project area streams would not meet all of the Department's specific stream quality criteria, there would not appear to be any water usage problem associated with this fact.

It is expected that implementation of the recommendations of the other two consulting engineering firms in their project areas will also enhance stream quality within their project areas as well as throughout Swatara Creek. The Department's objective of controlling drainage from abandoned mines throughout its headwaters area would probably be met, or at least a significant step will have been taken toward this end.

The recommended plan is amenable to stage construction. Therefore the anticipated effect of each stage on acid mine drainage loads and improvement in stream quality can be verified and evaluated. If, during the course of implementing the recommended plan, additional preventive or treatment measures are indicated, they could easily be accommodated.

As stated earlier, abatement plans for the two other project areas comprising the headwaters of Swatara Creek are being developed by other consultants. It is believed that serious thought should be given to combining the recommendations of all three firms into a master abatement plan designed to provide desirable stream quality throughout the watershed for the least cost.