SECTION III

BEECH CREEK WATERSHED: RESULTS OF INVESTIGATIONS

GENERAL DESCRIPTION

The Beech Creek Watershed (Watershed) is a mountainous wooded area covering approximately 170 square miles in northern Centre and southwestern Clinton Counties within which is located a portion of the Pennsylvania bituminous coal field. The western end of the Watershed is drained primarily by the North and South Forks of Beech Creek. The North and South Forks join to form Beech Creek, which drains the remaining major portion of the Watershed. Beech Creek terminates at the eastern end of the Watershed near Beech Creek Borough, where it flows into Bald Eagle Creek.

The manufacture of brick is currently the major industry within the Watershed with operations being conducted at a plant in Clarence, and on a part-time basis at a plant in Monument. Until a few years ago, the manufacture of brick was considerably more extensive with additional operations being conducted in Orviston and Monument. Several clay deep and strip mines were formerly active within the Watershed. At present only two clay strip mines are active, furnishing clay to the Clarence plant. Coal mining is the second largest industry in the Watershed. Considerable amounts of pulpwood are continuously removed from the Watershed. Truck and dairy farming is conducted in the downstream portion of the Watershed lying within Bald Eagle Valley. Most of the Watershed is forested and is open for public hunting of large and small game. Some public trout fishing is available in several streams tributary to the middle and lower reaches of Beech Creek, and the upper reaches of Beech Creek South Fork.

Watershed population is currently estimated at 3,070 with approximately 1,350 persons residing in Snow Shoe and Beech Creek Boroughs. Employment opportunities within the Watershed are limited. An estimated 210 persons are employed in brick plants and 35 in coal strip mining. Considerable employment opportunities in industry, hospitals, educational centers, and commercial establishments exist in communities such as Lock Haven, Bellefonte, and State College, all of which are located outside the Watershed.

For nearly a century before World War II, extensive deep mining was conducted in the Watershed. Deep mining has now ceased but, depending upon the coal market, could be conducted again. Major strip mining began in the Watershed about the time World War II started and is now the only method used. Four stripping operations, accounting for an annual production of approximately 250,000 tons, are currently being conducted in the Watershed. Based on available information, strip mining will continue at a significant rate in the Watershed for the foreseeable future. Although reserves exist in several areas of the Watershed, coal available under current economic conditions to both strip and deep mining operations is confined largely to the southwestern portion, extending from the vicinity of Snow Shoe Borough and Clarence Village northeastward to the vicinity of the abandoned town of Kato. MD has been discharged into Beech Creek and other Watershed streams since shortly after mining began.

The major source of MD pollution reaching Bald Eagle Creek is the Beech Creek Watershed. Although some minor inactive coal mining operations arc located in areas tributary to its headwaters, Bald Eagle Creek contains negligible concentrations of iron and is quite alkaline at its confluence with Beech Creek. On the other hand, Beech Creek just upstream from its confluence with Bald Eagle Creek contains negligible concentrations of iron but is acidic. Normally, all Beech Creek acidity is neutralized within a short distance downstream from its confluence with Bald Eagle Creek. Consequently, Bald Eagle Creek under normal conditions has little or no evidence of MD pollution at its confluence with the Susquehanna River West Branch approximately 15 miles to the northeast at Lock Haven. The Susquehanna River West Branch is acidic upstream from its confluence with Bald Eagle Creek, but becomes alkaline downstream because of the influence of Bald Eagle Creek and other tributaries. At present, bass and muskellunge are found in Bald Eagle Creek both above and below its confluence with Beech Creek, and public fishing is extensive along its length. The Department, however, fears that a low flow condition in Bald Eagle Creek created by regulated discharge from the newly constructed Foster J. Sayers Reservoir, coupled with a high discharge rate from Beech Creek, could adversely affect aquatic life in Bald Eagle Creek downstream from its confluence with Beech Creek.

Little or no acquatic life exists in Beech Creek or creeks forming its headwaters except for the headwaters of Beech Creek South Fork. Aquatic life does exist, however, in certain Watershed streams tributary to Beech Creek, particularly in its middle and lower reaches.

Sproul State Forest encompasses about 271,140 acres within Centre and Clinton Counties. Approximately 30,400 acres are within the Watershed. The Pennsylvania Department of Forests and Waters plans to encourage expansion of the present recreational, hunting, and fishing aspects of this forest. Interstate Route 80, recently completed across Pennsylvania, makes Sproul State Forest more accessible to a larger number of persons. Although only a small percentage of Watershed AMD originates on State Forest lands, the abatement of MD pollution within the Watershed is expected to make the State Forest more conducive to an expanded recreational program. The Corps of Engineers has proposed as the result of its Susquehanna River Basin study that Beech Creek from Pancake to Orviston be designated a wild stream, and that from Orviston to its mouth, Beech Creek be designated a recreation stream. The Corps has further proposed that Beech Creek South Fork be designated a trout fishing stream. In addition, the Corps has proposed an impoundment for recreation and fishing on the Swamp Branch of Big Run, located within the Watershed south of Pennsylvania Route 144.

Proposed Appalachian Strip Mine Reclamation Project No. 2, a joint Federal-Commonwealth undertaking that consists of the reclamation of approximately 175 acres of poorly restored strip mines within Sproul State Forest, is located approximately 0.6 mile east of Kato along the northern side of the Orviston and Kato Road. The Project was proposed by the Commonwealth to the Appalachian Regional Commission in July 1965 and subsequently received the Commission's approval. Although construction has not begun, completion is scheduled for the latter part of 1971. The Project area is expected to be restored to a desirable grade and replanted in trees suitable for growth in the soil conditions that will exist when regrading is completed. In addition to strip mine reclamation, a lookout will be created that will command a scenic view of several ridges and valleys.

The locations of the Watershed, boroughs, villages, and other geographic features referred to in this section are shown on Plate I.

GEOLOGIC CONSIDERATIONS

AMD in the Watershed is caused by numerous natural and man-made subsurface and surface conditions. Defining these conditions and the manner in which they are interrelated is an essential first step in determining the causes of AMD and subsequently developing abatement plans. This section describes geochemical considerations pertinent to MD discharge conditions encountered in the Watershed.

The types of rocks laid down in the Watershed millions of years ago, and the conditions then existing under which vegetable matter was deposited and decayed, bear significantly on current Watershed stream quality. Sediments were deposited in one or the other of two environments: aerobic or anaerobic. Vegetable matter accumulating on the land surface or in well aerated water was oxidized. In this environment the organic matter was ultimately converted to water and carbon dioxide, and iron present reached the ferric state. Many sedimentary rocks with a reddish cast can be observed in exposed outcroppings throughout the Watershed.

On the other hand, vegetable matter deposited in stagnant water decayed, after quickly depleting dissolved oxygen, by a slow process of anaerobic distillation. In this oxygen poor environment anaerobic and facultative bacteria functioned. Needed oxygen was extracted from oxygen-bearing materials including sulfates, with hydrogen sulfide being produced as an end product. Hydrogen sulfide reacted with soluble iron compounds to form disulfide, which precipitated as pyrite. Where sufficient amounts of organic matter were available, coal was eventually formed in association with the pyrite. Where smaller amounts of organic matter were deposited, not sufficient to form coal, pyrite was precipitated in the sediment. This latter circumstance is evident in the Watershed where AMD is found seeping from fill material used in the construction of Interstate Route 80. Therefore, in addition to being associated with the mining of coal in the Watershed, AMD is also encountered in areas where excavations have been made in sedimentary rocks in which no coal exists.

Conglomerates, sandstones, and shales are the major rock types found throughout most of the Watershed. Minor amounts of coal, clay, and limestone cover small portions of the Watershed. Generally, streams draining areas underlaid with conglomerates, sandstones, and shales will have (1) a very low solids content, (2) a pH less than 7.0, and (3) trace amounts of various metals including iron. The relatively low pH of these streams is attributable to their low buffering capacity, showing the effects of atmospheric carbon dioxide and organic acids from decaying vegetable matter. Iron concentrations result mostly from pyrite found in Watershed sandstones.

MAJOR SUBSURFACE CONDITIONS BEARING UPON THE FORMATION OF ACID MINE DRAINAGE

This section describes the major subsurface conditions causing AMD. The information used in defining these conditions was obtained from aerial photographs, mine maps, individuals knowledgeable about the Watershed, and field investigations. Aerial photographs of the Watershed were furnished by the Department. The few mine maps available were obtained from governmental and private sources. Detailed mine maps covering substantial Watershed areas were apparently discarded years ago by the original mining companies. Coal operators and other knowledgeable individuals were contacted as additional sources of information. Field investigations were made by Gannett Fleming Corddry and Carpenter, Inc. to (1) verify information and data obtained from other sources and (2) secure additional information and data as necessary to supplement those available from other sources.

Approximately 14 percent, or 23 square miles, of the Watershed is underlaid with coal. This coal is deposited in seven seams: the Mercer, Brookville, Clarion, Lower Kittanning, Middle Kittanning, Upper Kittanning, and Lower Freeport. Acid-producing materials are associated in varying degrees with the Mercer, Brookville, Clarion, Lower Kittanning, Middle Kittanning, and Upper Kittanning seams. Within the Watershed the Middle and Upper Kittanning seams are separated by only a few feet. Since the Middle and Upper Kittanning seams were deep and strip mined simultaneously, they will be considered in this report as one seam and will be identified as the Middle and Upper Kittanning seam. Although available information indicates that all coal seams were originally deposited throughout most of the Watershed, a number of seams have been eroded to the extent that they are now found only on the peaks of a few hills. Exhibit A presents the names by which coal seams are identified in this report and the names used by various groups to identify them.

The major geologic structure in the Watershed is a syncline trending in an eastwest direction with its axis passing through Clarence Village and the abandoned town of Kato approximately five miles to the east. The syncline rises and falls along its axis, alternately exposing and burying coals. From a high point near Orviston, the syncline plunges eastward out of the Watershed into Tangascootack Creek basin and westward toward Clarence where it reaches its greatest depth within the Watershed. Consequently, in this area of Clarence the largest number of coal seams remain and the most extensive mining has been done. A second minor syncline exists in the northeastern portion of the Watershed but terminates a few miles west of the eastern Watershed boundary. Coal seams gradually rise from the major synclinal axis toward the north and south. A few miles on either side of the major synclinal axis the coal measures are eroded to such an extent that there is little or no coal remaining toward the northern and southern extremities of the Watershed. The synclinal axis and typical configurations of Watershed coal seams are shown on Plate II.

The most extensive deep mining was done in the Brookville seam, followed by the Lower Kittanning, Middle and Upper Kittanning, and Lower Freeport seams. Although deep mining was conducted in the other seams, it was considerably less extensive than in these five seams. Since most deep mining was done in coal beds below the then existing ground-water table, care was taken to allow gravity drainage of mine waters. This was accomplished by taking advantage of the natural dip of the seams toward the synclinal axis. Deep mining was planned to take full advantage of this dip and to provide gravity discharge of MD. In addition, gobbing was common throughout the Watershed. Within the Watershed, therefore, surface and ground waters entering deep mine workings may flow for considerable distances over and through acid-producing material before eventually being discharged into Watershed streams as AMD. As deep mining progressed to deeper areas from which gravity drainage could not be obtained, mine waters were removed by a system of underground tunnels and pumps. When deep mining was discontinued, three mine water pools formed in areas of the mine workings formerly drained by pumping. The first of these is located in a small area southwest of Cherry Run Village lying on the north limb of the syncline in the Brookville seam. A second and much larger pool extends along the bottom of the synclinal trough in the Brookville workings from Cherry Run Village to Little Sandy Run. A 1,000 foot wide barrier pillar separates the second pool from the third pool, which continues eastward along the synclinal trough in the Brookville workings to the vicinity of Sandy Run. These three pools are relieved mostly by artesian-type discharges that have erupted through the overlying strata. Ground and surface waters entering underground workings in the Watershed therefore flow directly to MD discharge points, or become impounded in one of the three mine water pools and overflow from them.

All coal seams within the Watershed lie near the ground surface. The Brookville seam, the lowest to be extensively deep mined, reaches a maximum depth of approximately 150 feet below ground level. The underground voids created by deep mining have caused extensive fissuring of the overburden throughout Watershed deep-mined areas, principally that area overlying the deep-mined portions of the Brookville seam. In some areas the overburden has subsided into these underground voids. This fissuring and subsidence significantly reduce surface runoff from affected areas and increase ground and surface-water entry into inactive deep mine workings, thereby increasing the severity of the AMD problem.

The extent of Watershed deep mining, the location of deep mine entries, and other features discussed in this section are noted on Plates III-A and III-B.

EXTENT OF SUBSURFACE AREA DRAINING INTO OR OUT OF THE WATERSHED

In certain areas along the perimeter of the Watershed, precipitation becoming part of the ground water is conveyed both into and out of the Watershed. This condition is encountered where deep mine workings pass under the Watershed divide. In two well-defined areas one mile west of Snow Shoe Borough, deep mines in the Middle and Upper Kittanning and the Lower Freeport seams dip toward the north and convey ground waters into the Watershed from a combined area of approximately 144 acres located south of the Watershed topographic divide. Based on available information, in a small area of approximately 13 acres located three miles northwest of Snow Shoe Borough, deep mine workings in the Brookville, Lower Kittanning, and Middle and Upper Kittanning seams also apparently convey ground waters into the Watershed from west of the Watershed topographic divide. In a fourth well-defined area about two miles northeast of Monument Village, deep mines in the Mercer seam dip toward the east and convey ground waters out of the Watershed from an area of approximately 18 acres to the Tangascootack Creek basin. The extent of the subsurface area contributing to Watershed MD discharges is shown on Plates III-A and III-B.

MAJOR SURFACE CONDITIONS BEARING UPON THE FORMATION OF ACID MINE DRAINAGE

Defining the subsurface and surface conditions contributing to the formation of AMD was the first essential step in determining the causes of AMD and the subsequent development of abatement plans. This section describes the major surface conditions causing AMD. Sources of information used in defining the subsurface conditions causing AMD were also used in defining the surface conditions causing AMD.

An estimated 33 percent, or eight square miles, of the area within the Watershed underlaid with coal has been affected by active and inactive coal and clay strip mines. The largest quantities of strip mined coal have been removed from the Brookville seam. Strip mining within the Watershed has been and is currently being performed at a significant rate in the Brookville, Clarion, Lower Kittanning, and the Middle and Upper Kittanning seams. Limited strip mining has been performed in the Mercer and Lower Freeport seams. An estimated four percent, or seven square miles, of the Watershed has been disturbed by currently inactive coal and clay strip mines; 0.5 percent, or 0.8 square mile, by currently active strip mines.

As a result of past inadequate restoration, some strip mines in the Watershed serve as catch basins, which collect in varying degrees direct precipitation, surface runoff, and ground water. Considerable volumes so collected appear to enter deep mine workings through fissures in the bottoms of the strip mines or through connections created when strip mines cut directly into deep mine workings. Where no connections exist that allow water to flow from strip mines to inactive deep mine workings, water flows from the strip mines directly to surface streams. Waters collected in strip mines have contact with acid-producing materials located therein or in connecting deep mines.

Past practices used for the disposal of deep and strip mine refuse material on the Watershed surface have also resulted in the creation of AMD discharges. All this refuse in varying degrees is acid-producing and therefore causes AMD during wet weather.

The extent of Watershed strip mining, both inactive and active, and the locations of significant deposits of refuse and other geographic features are shown on Plates III-A and III-B.

WATER FLOW ROUTES INTO AND THROUGH DEEP MINE WORKINGS

After major subsurface and surface conditions causing AMD within the Watershed were established, water flow routes into and through deep mine workings were determined. Specific points at which surface and ground waters enter deep mine workings had to be located before AMD abatement measures could be planned in an effective and integrated manner. Water flow routes through underground workings also had to be traced before MD design volumes and quality could be established and before estimates could be made of AMD reductions attributable to the construction of preventive measures. This section describes the major points of interconnection between the ground surface and deep mine workings, and water flow routes through the deep mine workings.

The major points of connection between the ground surface and inactive deep mine workings in the Watershed are summarized below:

1. Deep Mine Entries:
   Ninety-one deep mine entries were located within the Watershed, including 86 drifts, four shafts, and one slope. The majority of deep mine entries were driven into the Brookville and Lower Kittanning seams, while the rest were driven into the Mercer, Clarion, Middle and Upper Kittanning, and Lower Freeport seams. Five deep mine entries, a relatively small number, provide access for surface waters to abandoned deep mine workings. Exhibit B describes the physical features of each deep mine entry. The locations of all deep mine entries are noted on Plates III-A and III-B.

2. Subsidence Areas:
   Thirty-nine areas where the ground surface has subsided into underlying deep mine workings exist in the Watershed. In the largest number of cases, the overburden has subsided into the Brookville seam. For the balance, subsidence has been into the Mercer, Lower Kittanning, Middle and Upper Kittanning, and Lower Freeport seams. Exhibit C presents additional descriptive information relative to subsidence areas. The locations of subsidence areas are noted on Plates III-A and III-B.

3. Stream Infiltration Areas:
   Two separate stretches of stream bed over which surface streams infiltrate in varying degrees into underlying deep mine workings are located in the Watershed. This condition was created by deep mining beneath stretches of stream bed. Both stream infiltration areas provide access for surface waters to the Brookville seam. Exhibit D presents additional descriptive information pertaining to stream infiltration areas. The locations of stream infiltration areas are noted on Plate III-A.

4. Strip Mines:
   One hundred eighty-eight strip mines exist in the Watershed, 10 of which are clay mines. Presently five coal strip mines and two clay strip mines are active. The majority of surface operations have mined the Brookville, Clarion, and Lower Kittanning seams. The balance have mined the Mercer, Middle

and Upper Kittanning, and Lower Freeport seams. Seventy strip mines provide varying degrees of access for surface waters to abandoned deep mine workings by direct connections or infiltration, or both. Exhibit E presents additional descriptive information pertaining to strip mines. The locations of all strip mines are noted on Plates III-A and III-B.

The information and data set forth in this section and in Exhibits B, C, D, and E relative to water flow routes through deep mine workings are based on the investigations described in this report. In reviewing this information and these data, it should be borne in mind that gobbing practices, the pulling of pillars during deep mine operations, and roof falls since the cessation of deep mine operations may have blocked, restricted, or altered the water flow routes through deep mine workings noted in Exhibits B, C, D, and E. The extent to which this may have occurred is extremely difficult to determine, but apparently the major underground flow routes are carrying huge volumes of water 30 to 40 years after abandonment of the deep mines.

A majority of the surface area underlaid with deep mines in the Watershed has been extensively fissured. In addition to the specific points of connection between the ground surface and deep mine workings located during the investigations, surface and ground waters also have access to deep mine workings in the deep-mined area of the Watershed through fissured overburden.

MINE DRAINAGE DISCHARGE POINTS

Locating MD discharge points was also essential in defining the current extent of MD pollution as well as the type and extent of abatement measures applicable to the Watershed. At the beginning of the investigations described in this report, the Federal Water Quality Administration and the Pennsylvania Departments of Mines and Mineral Industries and Health were contacted and all available Watershed MD volume and analytical data in the files of these agencies were reviewed. The Federal Water Quality Administration had located in the winter of 1966-1967 approximately one half of the MD discharge points ultimately found during field investigations conducted by Gannett Fleming Corddry and Carpenter, Inc. At each MD discharge point located by Federal Water Quality Administration personnel, one instantaneous flow measurement was made and one grab sample was collected for analysis. Records of the Department of Mines and Mineral Industries and the Department of Health have few MD volume and quality data. Furthermore, the use of data from these records was limited because of their age and the difficulty in correlating the data with specific MD discharge points. The relatively small amount of MD volume and analytical data that could be utilized from the files of these agencies, however, tends to substantiate the results of the gauging, sampling, and analytical program.

As part of the field investigations, 184 Watershed MD discharge points were located, identified, and marked. MD discharges reported herein were located primarily during field investigations conducted from the fall of 1968 to the fall of 1969. Most of these discharges (145) flow to the North Fork of Beech Creek and its tributaries as well as to Sandy Run and its tributaries. Another 17 discharges were located on the south side of Beech Creek between Kato Village and Logway Run. The remaining discharges are scattered throughout the Watershed down to and including Twin Run. No discharges are located downstream from the confluence of Twin Run and Beech Creek. Discharges in addition to those observed probably exist under certain weather conditions not encountered during the field investigations. Findings, conclusions, and recommendations contained in this report are based solely upon discharge points observed from fall 1968 to fall 1969.

The MD discharge points located during the field investigations are summarized in the following:

1. Deep Mine Entries:
   MD is discharged to surface streams from 25 deep mine entries. Twenty-four entries provide gravity drainage from deep mine workings, and one serves as an overflow from an underground mine water pool. Of the 25 deep mine entries discharging MD, nine were driven into the Brookville seam, 11 into the Lower Kittanning, and the rest into the Mercer and Clarion seams. The locations of deep mine entries that discharge MD are noted on Plates III-A and III-B. Exhibits B and F present descriptive information pertaining to deep mine entries through which MD is discharged to surface streams.
2. MD Discharge Points Adjacent to Deep Mine Workings:
   Sixteen MD discharge points adjacent to deep mine workings with which there are no apparent direct interconnections exist in the Watershed. These discharge points are probably created by the seepage of mine waters to the ground surface from abandoned deep mine workings through unmined areas.

Apparently mine waters flow above the underclay from the deep mine workings to the ground surface where these waters appear as springs. The locations of these discharge points are noted on Plate III-A. Exhibit F describes these discharge points.

3. Underground Mine Water Pool Discharges:
   Fifteen MD discharge points relieving underground mine water pools exist within the Watershed. Two are overflows off the tops of pools, while the remainder are artesian flows through rock strata or boreholes to the overlying ground surface. Exhibit F describes the discharge points that relieve underground mine water pools. Their locations are noted on Plate III-A.

4. Strip Mines:
   MD from 134 strip mines drains through 168 discharge points. These discharge points pass not only MD resulting from direct precipitation, surface runoff, and ground water caught within the strip mine, but also MD from deep mine workings intercepted by stripping operations. Of these 134 strip mines, 50 are in the Brookville seam. The remainder are in the Mercer, Clarion, Lower Kittanning, Middle and Upper Kittanning, and Lower Freeport seams. For the rest of the strip mines (54) no discharge points could be established during the investigations. Exhibit F describes the discharge points that drain strip mines. The locations of strip mines and the discharge points that drain them are noted on Plates III-A and III-B.

5. Refuse Areas:
   Thirty-three refuse areas are located in the Watershed and apparently all discharge MD to some extent during and for a short period following wet weather. MD from 17 refuse areas was traced to 25 discharge points. The majority of these discharge points pass MD not only from refuse areas but from other sources as well. For the rest of the refuse areas, no discharge points could be established during the investigations. Exhibit G describes the discharge points that drain refuse areas and presents additional descriptive information relative to refuse areas. The locations of all major refuse areas are noted on Plates III-A and III-B.

6. Highway Fill Areas:
   In the southern portion of the Watershed a large highway fill area exists where Interstate 80 crosses the South Fork of Beech Creek. The fill material, obtained from adjacent highway cuts, is a hard gray sandstone containing large amounts of unstable pyritic concretions and disseminated specks. The oxidation products of this pyrite are now draining into the South Fork of Beech Creek through six MD discharge points. Exhibit F describes these discharge points. Their locations are noted on Plate III-A.

7. Miscellaneous MD Discharge Points:
   Five MD discharge points not covered previously include two natural springs flowing off the underclay of the Lower Kittanning seam, two discharges from test excavations in the Brookville seam, and one artesian flow from a deep well drilled in the strata below the coal measures. Exhibit F describes these discharge points. Their locations are noted on Plate III-A.

MINE DRAINAGE GAUGING, SAMPLING, AND ANALYTICAL PROGRAM

To define the current extent of MD pollution within the Watershed, the current volume and quality of MD discharges had to be established. Therefore, discharges from all 184 discharge points located during the field investigations were gauged, sampled, and analyzed from the fall of 1968 to the fall of 1969. At most discharge points covered during this program, nine instantaneous flow measurements and grab samples were obtained during dry, normal, and wet weather. All samples collected were analyzed for pH, iron, acidity, and sulfate. In addition, some samples were analyzed for aluminum, manganese, and total solids concentrations. The sporadic nature of MD discharges from refuse areas and time limitations prevented gauging and sampling of MD discharged from refuse areas to the same extent as other MD discharges.

Of the 184 discharge points located during the field investigations, 160 appear to continuously discharge MD. The remaining 24 discharge points appear to intermittently discharge MD. At 10 discharge points that appear to intermittently pass MD, no discharges were observed during the field investigations. Based on discharge conditions encountered during low, average, and high ground-water levels, combined Watershed MD volumes as well as major constituents and characteristics approximated the following:

	Ground-Water Levels		
	Low	Average	High
Volume - mgd	4.1	11.0	15.9
pH	3.0-3.5	3.0-3.5	2.8-3.3
Total Iron			
mg/l	28	26	27
tons per day	0.48	1.20	1.79
Acid (as $CaCO_3$)			
mg/l	395	397	418
tons per day	6.5	18.2	27.7

Exhibit H presents MD volumes, constituents, and characteristics measured at each discharge point during the gauging, sampling, and analytical program.

During the period covered by this program, yearly precipitation in the Watershed was approximately 10 percent less than the average yearly precipitation over the period of record. Likewise, total precipitation during the period affecting spring high flows (December 1968 through April 1969) was approximately 37 percent less than the December through April average over the period of record. Total Watershed precipitation during dry weather (August through October 1969) was approximately 17 percent less 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, MD discharge conditions for design purposes had to be established for each discharge point before abatement measures could be planned and their effectiveness estimated. This section describes the MD design volumes, constituents, and characteristics used in planning and evaluating the effectiveness of Watershed abatement measures.

Three conditions of MD 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 discharge conditions are described in the following:

Design Average
: Average daily MD volumes, constituents, and characteristics during a year of normal precipitation;

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

Design Maximum
: Maximum daily MD 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.

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

For design average conditions, MD volumes at discharge points range from 0 to 2,160 gpm, iron concentrations from 0.1 to 265 mg/l, and acid concentrations from 0 to 2,450 mg/l. Combined MD volumes as well as major constituents and characteristics used for design purposes are summarized in the following:

	Design Average	Design Wet Weather	Design Maximum
Volume - mgd	14.8	25.2	526
pH	3.3	3.0	3.7
Total Iron			
mg/l	26	27	23
tons per day	1.62	2.82	49.8
Acid (as $CaCO_3$)			
mg/l	400	420	350
tons per day	24.6	43.9	753

Exhibit I presents the assumptions and calculations used to establish combined design MD volumes. Exhibit J sets forth the MD design volumes, major constituents, and characteristics of discharges for each of the 184 discharge points located during the field investigations.

EVAPORATION-TRANSPIRATION LOSSES AND RUNOFF COEFFICIENTS

As part of the investigations described in this report, an attempt was made to verify certain hydrologic assumptions used to establish combined Watershed MD design volumes. Based on precipitation and runoff data collected by the Department, the evaporation-transpiration and runoff coefficient assumptions set forth in Exhibit I were checked.

Stream flow data were collected from May 1, 1969 through April 30, 1970 at stream gauging stations established by the Department on the South and North Forks of Beech Creek. The area tributary to the South Fork gauging station does not contain coal; the area tributary to the North Fork station has been subjected to considerable deep and strip mining. In addition, stream flow data were available for this time period for the permanent stream gauging station on Beech Creek at Monument Village.

Precipitation data were also collected during the same period at the United States Weather Bureau's permanent precipitation station at Clarence and at a second station established near Snow Shoe Borough. Because of various problems associated with operating and maintaining the Snow Shoe Borough station, precipitation data were incomplete and those collected appeared suspect. Therefore, precipitation data gathered at the Clarence station were used in estimating evaporation-transpiration losses and runoff coefficients in areas tributary to the three stream gauging stations. The locations of the stream gauging and precipitation stations are shown on Plate I.

From May 1, 1969 through April 30, 1970 precipitation equivalent to 41.91 inches of rain fell at the Clarence station. An estimated 56, 45, and 59 percent of the precipitation falling in Watershed areas tributary to the South Fork, North Fork, and Beech Creek stream gauging stations, respectively, flowed past these stations during the year as the result of surface- and ground-water discharges. The balance of the precipitation - 44, 55, and 41 percent - was lost to the atmosphere by evaporation and transpiration.

Measured stream flows at the South Fork, North Fork, and Beech Creek stream gauging stations were correlated with rainfall measured at the United States Weather Bureau's Clarence station during wet weather. The Rational Method, in which $Q = CiA$, was used to determine runoff coefficients. These terms are defined as follows: Q is the rate of runoff in cubic feet per second; C is the runoff-rainfall ratio; i is the rainfall intensity in inches per hour; and A is the area in acres off which the runoff occurs. Calculated runoff coefficients in Watershed areas tributary to the South Fork, North Fork, and Beech Creek stream gauging stations varied from 0.01 to 0.55, 0.02 to 0.45, and 0.01 to 0.51, respectively. The higher runoff coefficients were experienced during February and April, when melting snow contributed to surface-water discharges. Runoff coefficients averaged 0.18, 0.15, and 0.14, respectively.

Based on limited precipitation and stream flow data accumulated from May 1, 1969 through April 30, 1970, MD design volumes based on the evaporation-transpiration and runoff coefficient estimates set forth in Exhibit I appear reasonable for preliminary design purposes.

PRESENT MINE DRAINAGE DISCHARGE LIMITATIONS OF THE SANITARY WATER BOARD

One set of conditions used in the development of abatement plans for the Watershed was that of bringing various MD discharges under design average, wet weather, and maximum conditions into compliance with present SWB 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 MD discharge limitations have at present been established for the Watershed.

MINE DRAINAGE DISCHARGES IN COMPLIANCE WITH PRESENT DISCHARGE LIMITATIONS OF THE SANITARY WATER BOARD

Only three existing MD discharges meet all current SWB limitations for the design average, design wet weather, and design maximum conditions. For design average conditions three discharges meet all current SWB limitations, for design wet weather conditions five discharges meet all SWB limitations, and for design maximum conditions seven discharges meet all SWB limitations. Discharges meeting all current SWB limitations account for only one-tenth of one percent of Watershed pollution loads. The number of discharges meeting the pH, iron, and acid SWB limitations are listed below:

	Design Average	Design Wet Weather	Design Maximum
pH	10	10	11
Total Iron	114	115	138
Acid (as $CaCO_3$)	6	7	7

Scattered throughout the Watershed are an additional 20 discharges that are of marginal quality when compared to SWB limitations. For the three design conditions, these discharges meet two of the three discharge limitations and are of generally good quality. Under design average conditions these 20 discharges account for less than one-half of one percent of total Watershed pollution loads.

ANALYTICAL PROCEDURES

Analytical procedures used for determining the quality of MD discharges and Watershed streams were taken from several sources. The procedures used for pH, acidity-alkalinity, sulfate, and total solids determinations were taken directly from the 12th Edition of "Standard Methods for the Examination of Water and Wastewater," published in 1965. Atomic absorption procedures were used for determining total iron, manganese, and relatively high aluminum concentrations. Atomic absorption procedures are set forth in "FWPCA Methods for Chemical Analysis of Water and Wastes," published by the United States Department of the Interior in 1969. For relatively low aluminum concentrations, under two mg/l, the procedure used is set forth in "Analytical Chemistry," Volume 28, published by the American Chemical Society in 1956.

When reviewing and interpreting the acidity-alkalinity analytical results listed in this report, it is noted that analytical procedures for determining the acidity or alkalinity of a sample have varied over the years. The procedure in the 12th Edition of "Standard Methods for the Examination of Water and Wastewater" was adopted by the SWB in 1966 as set forth in the Board's "Rules and Regulations." This procedure results in certain Watershed discharges and streams with pH values as high as 7.5 being reported as acidic. On the other hand, if the acidity-alkalinity analytical procedure used by the Department of Health before 1966 had been utilized, a number of discharges and streams reported as acidic would have been alkaline.

EXTENT AND EFFECTIVENESS OF PAST MINE DRAINAGE PREVENTIVE MEASURES

Field investigations and other available information indicate that the federal Works Progress Administration constructed approximately one dozen air seals in various deep mine entries into the Lower Kittanning seam in the 1930's. These air seals have not proven to be effective primarily because of the shallow cover over the Lower Kittanning seam. In many cases the ground surface in the immediate area of the air seal has collapsed around the seal, completely obscuring it from view. Extensive fissuring of the overburden has allowed air to enter the abandoned deep mine workings thereby defeating the purpose of the air seals. None of the MD discharges from air sealed deep mine entries met SWB limitations.

Exhibit B notes the deep mine entries at which past attempts at air sealing could be definitely identified.

MAJOR MINE DRAINAGE VOLUME, IRON, AND ACID CONTRIBUTORS

During the investigations considerable variation was observed in the volume as well as in the tons of iron and acid contributed by MD discharge points. The number of discharge points contributing various percentages of total Watershed MD volume, iron, and acid for design average conditions are summarized below:

	Approximate Percentage of Total Watershed MD Volume, Iron, and Acid					
	30	50	75	90	99	100
Volume						
mgd	5.2	7.4	11.1	13.3	14.7	14.8
no. of MD Discharges	3	6	24	57	125	184
Total Iron						
tons per day	0.47	0.75	1.22	1.47	1.61	1.62
no. of MD Discharges	1	2	5	13	65	184
Acid						
tons per day	7.7	13.3	18.3	22.1	24.3	24.6
no. of MD Discharges	2	4	12	32	95	184

Exhibits K, L, and M present a tabulation in order of magnitude of all discharge points and percentages of total Watershed volume, iron, and acid represented by each under design average conditions.

WATERSHED STREAM LOADS

Relatively few MD discharge points are contributing the majority of Watershed AMD. Moreover, the discharge points contributing most AMD are clustered in certain areas within the Watershed. To further delineate those areas from which AMD originates, AMD being contributed to Beech Creek from each of its tributaries was determined. This further delineation of the origin of AMD within the Watershed was made so that subsequent abatement plans could be more realistically developed and evaluated. The major AMD loads being contributed to Beech Creek from various tributaries are listed below:

	MD Discharges		Volume		Total Iron		Acid	
	No.	Approx. % of Total	GPM	Approx. % of Total	lbs/ day	Approx. % of Total	lbs/ day	Approx. % of Total
Beech Creek North Fork	92	50	3,824	37	1,488	46	17,288	35
Tributary L	1	0.5	108	1	3	0	1,140	2
Sandy Run	53	30	4,539	44	1,668	51	26,090	53
Tributary R	4	2	118	1	16	0.5	827	2
Logway Run	2	1	210	2	39	1	728	2
Big Run	5	3	839	8	9	0.5	1,709	3
Totals	157	86.5	9,638	93	3,223	99.0	47,782	97

The rest of the MD volume, iron, and acid contributions to Beech Creek come from seven tributaries and nine discharges that flow directly to Beech Creek.

Under design average conditions, approximately 81 percent of the Watershed AMD volume, 97 percent of the iron, and 88 percent of the acid originate from the discharge points located in the Beech Creek North Fork and Sandy Run basins. Approximately 93 percent of the AMD volume, 99 percent of the iron, and 97 percent of the acid originate from the discharge points located in the Beech Creek North Fork, Sandy Run, Tributary L, Tributary R, Logway Run, and Big Run basins. Exhibit N lists for the three design conditions MD loads being contributed to Beech Creek from each tributary and from MD discharges that flow directly into Beech Creek. Exhibits O and P list for the three design conditions MD loads being contributed to Beech Creek North Fork, and Sandy Run, respectively. The locations of all streams and discharge points are noted on Plates III-A and III-B.

The following presents a comparison of the number of discharge points contributing various percentages of Watershed MD volume, iron, and acid under design average conditions, and the number of such discharges tributary to those streams noted in this section:

	Approximate Percentage of Total Watershed MD Volume, Iron, and Acid				
	30	50	75	90	99
Volume					
Number of MD discharges throughout Watershed producing the listed percentages	3	6	24	57	125
Number of these same MD discharges tributary to Beech Creek North Fork and Sandy Run	3	5	18	42	97
Number of these same MD discharges tributary to Beech Creek North Fork, Sandy Run, Tributary L, and Tributary R	3	5	19	44	99
Number of these same MD discharges tributary to Beech Creek North Fork, Sandy Run, Tributary L, Tributary R, and Logway Run	3	5	20	45	101
Number of these same MD discharges tributary to Beech Creek North Fork, Sandy Run, Tributary L, Tributary R, Logway Run, and Big Run	3	6	23	49	106
Iron					
Number of MD discharges throughout Watershed producing the listed percentages	1	2	5	13	65
Number of these same MD discharges tributary to Beech Creek North Fork and Sandy Run	1	2	5	12	51
Number of these same MD discharges tributary to Beech Creek North Fork, Sandy Run, Tributary L, and Tributary R	1	2	5	12	55
Number of these same MD discharges tributary to Beech Creek North Fork, Sandy Run, Tributary L, Tributary R, and Logway Run	1	2	5	13	56
Number of these same MD discharges tributary to Beech Creek North Fork, Sandy Run, Tributary L, Tributary R. Logway Run, and Big Run	1	2	5	13	59

	Approximate Percentage of Total Watershed MD Volume, Iron, and Acid				
	30	50	75	90	99
Acid					
Number of MD discharges throughout Watershed producing the listed percentages	2	4	12	32	95
Number of these same MD discharges tributary to Beech Creek North Fork and Sandy Run	2	4	10	25	75
Number of these same MD discharges tributary to Beech Creek North Fork, Sandy Run, Tributary L, and Tributary R	2	4	11	28	79
Number of these same MD discharges tributary to Beech Creek North Fork, Sandy Run, Tributary L, Tributary R, and Logway Run	2	4	11	29	81
Number of these same MD discharges tributary to Beech Creek North Fork, Sandy Run, Tributary L, Tributary R, Logway Run, and Big Run	2	4	12	30	85

STREAM QUALITY CRITERIA

In addition to the MD discharge limitations previously presented, the SWB, upon recommendation of the Bureau of Sanitary Engineering (Bureau) of the Department of Health, has adopted general and specific stream quality criteria for all surface streams in the Bald Eagle Creek Basin, of which Beech Creek is a part. The stream quality criteria are based upon the anticipated use of Bald Eagle Creek 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) fishing and water contact sports; (4) power; and (5) treated waste assimilation.

The Board's general stream quality criteria apply to all streams in the Watershed 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 Board are as follows:

pH	Not less than 6.0 or greater than 8.5.
Dissolved oxygen	Minimum daily average 6.0 mg/l; no value less than 5.0 mg/l.
Total iron	Not to exceed 1.5 mg/l.
Temperature	Not to exceed 58° F or natural temperatures, whichever is greater.
Dissolved solids	Not to exceed 500 mg/l as a monthly average value; not to exceed 750 mg/l at any time.
Bacteria (coliforms/100 ml)	For the period 5/15 to 9/15 of any year - not 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 20 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 Bureau further recommended to the SWB that MD from abandoned mines be controlled throughout the entire Watershed as part of an overall plan of abatement. Based on discussions with Bureau personnel, the SWB would apparently not require the treatment of all MD discharges from abandoned workings to the extent necessary to meet SWB limitations. The basic intent of the SWB appears to be that of initially protecting the major Watershed streams. To achieve this end, the SWB would apparently require the elimination, reduction, and/or treatment of MD discharges to the extent necessary to remove MD pollutants primarily responsible for degradation of major streams. If in the opinion of the SWB the removal of additional MD pollutants appeared warranted, the SWB would so indicate.

STREAM SAMPLING AND ANALYTICAL PROGRAM

An important aspect of the investigations was that of determining existing stream quality in Beech Creek and its major tributaries. Knowledge of current Watershed stream quality was considered essential for evaluating abatement plans.

The Federal Water Quality Administration, the Department of Mines and Mineral Industries, and the Department of Health were contacted, and all their Watershed stream quality data were reviewed. As part of the field investigations conducted by the Federal Water Quality Administration during the winter of 1966-1967, one or more grab samples were obtained at the mouths of certain tributaries of, and at several locations along, Beech Creek. Fairly complete laboratory analyses were performed on these samples. Records of the Departments of Health and of Mines and Mineral Industries generally contain very little data on Watershed stream quality. One exception is that during the past eight years the Department of Health has accumulated some stream quality data at the mouth of Beech Creek and in Bald Eagle Creek upstream and downstream from its confluence with Beech Creek. Beech Creek stream quality data collected by the Department of Health over the past several years have been incorporated into the stream quality data presented in this report.

As part of the field investigations conducted by Gannett Fleming Corddry and Carpenter, Inc., stream sampling stations were established at (1) the mouths of all major Beech Creek tributaries and other points along the tributaries as considered advisable, and (2) several locations along Beech Creek. Forty-two sampling stations were established, 37 on tributaries of Beech Creek and five on Beech Creek itself. Samples were collected at each of these 42 stations from the fall of 1968 to the fall of 1969. At most stations nine grab samples were obtained under dry, average, and wet-weather runoff conditions. During a portion of the sampling program, Logway Run was being treated by a coal operator who was conducting an active strip mine operation in its headwaters. The reported Logway Run sampling results show stream quality during periods when treatment was not being accomplished. The locations of all sampling stations are noted on Plate I.

Specific stream quality criteria such as pH, total iron, and dissolved solids are applicable to Watershed streams when considering MD discharges. All stream samples collected were analyzed for pH, total iron, acidity, and sulfate, whereas some were analyzed for aluminum, manganese, and total solids concentrations. No effort was made during the investigations to determine the dissolved oxygen, temperature, or coliform bacteria content of streams. Dissolved oxygen was not considered to be a critical criterion since ferrous iron in MD discharges was found to be insignificant. Temperature was not felt to be a critical consideration since the presence or absence of mining would have little effect on stream temperatures. Any coliform bacterial population in Watershed streams would not be attributable to MD discharges.

For 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 WATERSHED STREAMS

The average quality of waters observed at Beech Creek sampling stations from the fall of 1968 to the fall of 1969 is summarized below:

	Stream Sampling Stations on Beech Creek	
	Upstream Portion	Downstream Portion
pH	3.7-3.8	4.1-4.2
Total Iron - mg/l	2.2-3.7	0.3-0.4
Acid (as $CaCO_3$) - mg/l	59-74	43-48

Based on analytical data, Beech Creek does not meet the SWB pH criterion and is acidic. Low pH values of 3.3 and 3.7, respectively, were noted in the upstream and downstream portions of Beech Creek. The SWB iron criterion is met in the lower reaches of Beech Creek but not in its upper reaches. Maximum iron concentrations of 6.5 mg/l were noted in the upstream portion and 0.6 mg/l in the downstream portion. Based on available information and additional limited analytical data, other constituents and characteristics do not appear at present to be of major sanitary significance.

The average quality of waters observed at sampling stations located on Beech Creek tributaries is summarized in the following:

	Stream Sampling Stations on Beech Creek Tributaries (1)			
	Mined Areas		Non-Mined Areas	
	MD Discharges Noted (2)	No MD Discharges Noted (3)	Coal Present (4)	Coal Not Present (5)
pH	2.9-6.5	5.2-6.6	6.2	6.1-6.5
Total Iron-mg/l	0.1-35	0.1-0.2	0.3	0.1-0.2
Acid (as $CaCO_3$)-mg/l	13-542	17-22	21	18-19

(1) Including North and South Forks
(2) 19 tributaries; active mining and/or processing on six
(3) Four tributaries; no active mining or processing
(4) One tributary; no MD discharges noted
(5) Three tributaries

A brief discussion of information and data on the quality of Watershed streams tributary to Beech Creek follows. Unless otherwise noted, all sampling stations were located at the mouths of tributaries.

1. Tributaries on which Mining or Processing Operations, or Both, Have Been or Are Being Conducted (Mined Areas):
   a. Tributaries on which MD Discharges Were Noted
      Downstream Portion of Beech Creek South Fork and Its Tributaries

Although Beech Creek South Fork at its mouth is of generally good quality, the South Fork and its tributaries deteriorate as the Interstate Route 80 crossing is approached. This deterioration is attributable to the fill material used in the construction of Interstate Route 80 and to a relatively small active coal processing operation. The average pH at the mouth of Beech Creek South Fork was 4.8, with a low of 4.7. The average acid concentration was 26 mg/l. The maximum iron concentration noted was 1.1 mg/l. Based on available information and additional limited analytical data, other stream constituents and characteristics do not appear at present to be of consequence. Near the Interstate Route crossing, the average pH in Beech Creek South Fork and its tributaries varied from 3.7 to 4.9, with a low of 3.5. Average acid concentrations varied from 63 to 164 mg/l. Average iron concentrations ranged from 0.9 to 2.0 mg/l, with a high of 3.3. Based on available information and additional limited analytical data, other stream constituents and characteristics do not appear at present to be of major sanitary significance.

Beech Creek North Fork and Its Tributaries

Except for the upstream reaches of Cherry Run, Beech Creek North Fork and its tributaries are of generally poor quality. The upstream portions of the North Fork are generally of poorer quality than the downstream portions. Average pH values throughout the North Fork basin ranged from 3.0 to 4.5, with a low of 2.7. Average acid concentrations ranged from 65 to 370 mg/l. Average iron concentrations varied from 1.7 to 35.3 mg/l, with a high of 51.5 mg/l. Based on available information and additional limited analytical data, other constituents and characteristics do not appear at present to be of major sanitary significance in the downstream portions of the North Fork. However, in its upstream portions the sulfate, total solids, aluminum, and manganese concentrations are of magnitude sufficient to justify further consideration.

Sandy Run and Its Tributaries

Sandy Run and its tributaries are of generally poor quality, with the downstream portions being significantly worse than the upstream portions. In the upstream portions of the Sandy Run watershed, average pH values ranged from 3.7 to 4.6, with a low of 3.0. Average acid concentrations ranged from 28 to 61 mg/l. Average iron concentrations ranged from 0.2 to 1.8 mg/l, with a high of 5.2 mg/l. Based on available information and additional limited analytical data, other constituents and characteristics do not appear at present to be of major sanitary significance. In the downstream portions of the Sandy Run watershed, average pH values ranged from 2.9 to 3.4, with a low of 2.8. Average acid concentrations varied from 114 to 542 mg/l. Average iron concentrations ranged from 7.5 to 31 mg/l, with a high of 50.9 mg/l. Based on available information and additional limited analytical data, sulfate, total solids, aluminum, and manganese concentrations are generally of a magnitude sufficient to justify further consideration.

Tributaries L and R

No sampling stations were established on these tributaries. Flows, except during runoff, are mostly from MD discharges within their basins.

The quality of these tributaries is poor, usually comparable to that of the MD discharges entering them.

Logway Run

The quality of Logway Run is poor. The average pH was 3.3, with a low of 2.9, and the average acidity was 312 mg/l. The average iron concentration was 12 mg/l, with a high of 24.2 mg/l. Based on available information and analytical data, sulfate, total solids, aluminum, and manganese concentrations are of magnitude sufficient to justify further consideration.

Big Run

Big Run at its mouth was found to be of generally good quality. The average pH was 5.2, with a low of 4.9. The average acid concentration was 23 mg/l. The maximum iron concentration noted was 0.1 mg/l. Based on available information and additional limited analytical data, other stream constituents and characteristics do not appear at present to be of consequence.

Twin, Three Rock, Two Rock, and Council Runs, and the Downstream Portion of Wolf Run

These tributaries at the sampling stations were found to be of generally good quality. Average pH values varied from 5.6 to 6.5, with a low of 4.6. Average acid concentrations varied from 13 to 20 mg/l. The maximum iron concentration noted was 0.3 mg/l. Based on available information and additional limited analytical data, other stream constituents and characteristics do not appear to be of consequence. Normal aquatic life including several species of minnow and trout was noted in Twin, Three Rock, Two Rock, and Council Runs.

b. Tributaries on which No MD Discharges Were Noted

Based on investigations described in this report, the upper portions of Wolf and Cherry Runs, and Monument and Hayes Runs drain Watershed areas that have been mined but within which no MD discharges were noted. All these streams at the sampling stations were of generally good quality. The average pH varied from 5.2 to 6.6, with a low of 4.4. Average acid concentrations ranged from 17 to 22 mg/l. The maximum iron concentration noted was 0.6 mg/l. Based on available information and additional limited analytical data, other stream constituents and characteristics do not appear to be of consequence. Normal aquatic life including several species of minnow and trout was noted in the upper portion of Wolf Run as well as in Monument and Hayes Runs.

2. Tributaries on which Coal Is Present but Has Not Been Mined, and on which No Coal Exists (Non-mined Areas):

Based on investigations described in this report, Rock Run drains a Watershed area in which coal is present but has not been mined. The upstream portion of Beech Creek South Fork, and Eddy Lick and Panther Runs drain Watershed areas not containing coal. All four of these tributaries were found to be of comparable quality. Average pH varied from 6.1 to 6.5, with a low of 4.6. Average acid concentrations ranged from 18 to 21 mg/l. The maximum iron concentration noted was 1.0 mg/l. Based on available information and additional limited analytical data, other stream constituents and characteristics do not appear to be of consequence. Normal aquatic life including several species of minnow and trout was noted in the upstream portion of Beech Creek South Fork.

As previously noted, the majority of Watershed MD pollution loads were attributable to relatively few MD discharges located in certain well defined and limited areas. The information and data set forth in this chapter further show that, except for Big Run, tributaries receiving most AMD loads - Beech Creek North Fork, Tributary L, Sandy Run, Tributary R, and Logway Run - are of the poorest quality. The Big Run sampling station was a substantial distance downstream from the MD discharges draining into the Run. This and the fact that the Big Run watershed area is fairly large account for the generally good quality of Big Run at its mouth.

On the other hand, the rest of the tributaries sampled were in generally good condition when judged on the basis of quality at the sampling stations. With the exception of pH, all these tributaries for the most part met the SWB specific stream quality criteria. Although they drain 1) areas containing MD discharges, 2) mined areas containing no MD discharges, 3) non-mined areas in which coal is present, and 4) areas in which no coal is known to exist, there was no significant difference in their quality at the sampling stations. Tributaries draining non-mined areas in which coal is present and those draining areas in which no coal is known to exist occasionally did not meet the Board's pH criterion. In addition, these tributaries were at all times acidic. While the SWB iron criterion was met under all runoff conditions during sampling, iron was at all times present.

Exhibit Q lists the constituents and characteristics measured at each sampling station during the sampling and analytical program. The locations of all sampling stations are noted on Plate I. The locations of all streams are shown on Plates I, III-A, and III-B.

APPLICABLE ACID MINE DRAINAGE ABATEMENT MEASURES

Over the years numerous abatement measures capable of eliminating or reducing AMD have been proposed. Before development of abatement plans for the Watershed, abatement measures applicable to Watershed problems and conditions had to be established. This section describes the abatement measures considered applicable in the Watershed and subsequently used in developing abatement plans.

As part of the investigations described in this report, all known abatement measures considered to be theoretically sound were reviewed without regard to the extent of previous usage. The purpose of this review was to gather and tabulate pertinent information needed to determine applicability of abatement measures within the Watershed. Twenty-five abatement measures (18 preventive, four treatment, and three disposal measures) were covered by this review. Abatement measures and information pertaining to them are set forth in Exhibit R.

Eleven of the abatement measures were not considered applicable in eliminating or reducing MD pollution within the Watershed. This was due to subsurface and surface conditions, the anticipated degree of accuracy in predicting effectiveness, and relative treatment costs. Of the 14 considered applicable, 10 were eventually used in developing abatement plans. Four abatement measures considered applicable were not utilized because the other applicable abatement measures could be more appropriately used in the Watershed. The 10 abatement measures used in developing abatement plans are listed below:

Preventive Measures:

- Inundate Deep Mine Workings
- Reconstruct Stream Channels
- Construct Surface or Ground Water Diversion Ditches, or Both
- Restore Strip Mines
- Move Refuse into Strip Mines
- Eliminate Deep Mine Workings
- Excavate and Restore Subsidence Areas
- Close Deep Mine Entries
- Chemically Neutralize Contents of Strip Mines

Treatment Measure:

- Chemically Neutralize, Oxidize, and Settle Mine Drainage in Treatment Facilities

ACID MINE DRAINAGE ABATEMENT PLANS STUDIED IN DETAIL

Various abatement measures, separately or in combination, have the potential for eliminating MD pollution in the Watershed. All abatement measures considered applicable to problems and conditions of the Watershed were reviewed separately and in combination to develop by inspection techniques alternative abatement plans. 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 and with the physical conditions of the Watershed.

2. For abatement plans consisting of preventive measures supplemented by treatment measures, estimates of AMD 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 AMD reductions attributable to preventive measures.

3. Treatment measures were designed to meet the present SWB MD effluent requirements.

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

5. In the development of abatement plans, consideration was given in certain cases to abating all MD discharges and in others only some discharges. Plans were studied that would reduce Watershed MD pollution from 90 to 100 percent. In the development of abatement plans in which somewhat less than a 100 percent reduction was to be attained, every effort was made to concentrate on the most polluted tributaries and those discharges contributing 90 percent of the Watershed MD iron and acid loads. Preventive measures designed toward this end eliminated many additional MD discharges.

6. Collection systems initially intended to convey the major MD discharges not eliminated by preventive measures collected minor MD discharges located within 500 feet of the conveyance sewers. Resultant iron and acid reductions for abatement plans comprised of preventive and treatment measures were therefore equal to or greater than 90 percent.

7. All abatement plans included the collection and treatment of AMD discharges near the crossing of Interstate Route 80 and Beech Creek South Fork. These MD discharge points contribute a negligible fraction of the Watershed pollution loads, and Beech Creek South Fork at its mouth is of generally good quality. The only reason for collecting and treating such discharges was to complement the Corps of Engineers designation of the South Fork as a trout fishing stream.

Each abatement plan studied in detail is described below:

Abatement Plan I

Basic Intent: Collect and treat at one site all 181 MD discharges not meeting current SWB limitations.

Preventive Measures: None.

Collection System and Treatment Measures:

a. 575,950 feet of conveyance sewers six to 120 inches in diameter; Design maximum flow.
b. One flow equalization basin at treatment plant; Design maximum flow.
c. One treatment plant located on Beech Creek two miles downstream from Monument Village; Design wet-weather flow.

Estimated AMD volume affected and reductions in total Watershed design average loads attributable to the abatement plan are as follows:

Volume -	100% ; 14.8 mgd
Iron-	85% (to 4 mg/l); 1.37 tons per day
Acid -	100%; 24.6 tons per day

Abatement Plan II

Basic Intent: Collect and treat at four sites the 181 MD Discharges not meeting current SWB limitations.

Preventive Measures: None.

Collection System and Treatment Measures:

a. 427,210 feet of conveyance sewers six to 84 inches in diameter; Design maximum flow.

b. Four flow equalization basins, one at each treatment plant; Design maximum flow.
c. Four treatment plants - North Fork Beech Creek 1.4 miles downstream from Pancake Village, South Fork Beech Creek 2,000 feet downstream from Interstate Route 80 crossing, Beech Creek 2,000 feet. downstream from Kato Village, and Beech Creek two miles downstream from Monument Village; Design wet-weather flow.

Estimated AMD volume affected and reductions in total Watershed design average loads attributable to the abatement plan are as follows:

Volume	-	100%; 14.8 mgd
Iron	-	89% (to 4 mg/l); 1.44 tons per day
Acid	-	100%; 24.6 tons per day

Abatement Plan III

Basic Intent: Control of MD pollution by construction of preventive and treatment measures; eliminate AMD at 84 MD discharge points and reduce at 10 MD discharge points; collect and treat in three systems 78 MD discharges, including 10 from which AMD was reduced by preventive measures; 22 MD discharges not eliminated or treated consist of three meeting SWB limitations and 19 of marginal quality.

Preventive Measures: Reconstruct stream channels; construct surface or ground water diversion ditches, or both, at seven strip mines; restore in varying degrees 45 strip mines; move 13 refuse areas into strip mines; eliminate deep mine workings in two areas; excavate and restore three subsidence areas; close one deep mine entry; chemically neutralize one strip mine.

Estimated AMD volume affected and reductions in total Watershed design average loads attributable to the preventive measures are as follows:

Volume	-	44%
Iron	-	30%
Acid	-	47%

Collection System and Treatment Measures:

a. 187,580 feet of conveyance sewers six to 90 inches in diameter; Design maximum flow.
b. Three flow equalization basins, one at each treatment plant; Design maximum flow.

c. Three treatment plants - North Fork Beech Creek at Pancake Village, South Fork Beech Creek 2,000 feet downstream from Interstate Route 80 crossing, and Beech Creek two miles downstream from Kato Village; Design wet-weather flow.

Estimated AMD volume affected and reductions in total Watershed design average loads attributable to the treatment measures are as follows:

Volume - 50%
Iron - 62% (to 4 mg/l)
Acid - 52%

Estimated AMD volume affected and reductions in total Watershed design average loads attributable to the abatement plan are as follows:

Volume - 94%; 13.9 mgd
Iron - 92%; 1.48 tons per day
Acid - 99%; 24.4 tons per day

Abatement Plan IV

Basic Intent: Control of MD pollution by construction of preventive and treatment measures; eliminate AMD at 41 MD discharge points and reduce at four MD discharge points; collect and treat in one system 34 MD discharges including three from which AMD was reduced by preventive measures.

Preventive Measures: Reconstruct stream channels; construct surface water diversion ditches at three strip mines; restore in varying degrees 22 strip mines; move three refuse areas into strip mines; eliminate deep mine workings in one area; excavate and restore one subsidence area; close one deep mine entry; chemically neutralize one strip mine.

Estimated AMD volume affected and reductions in total Watershed design average loads attributable to preventive measures are as follows:

Volume - 38%
Iron - 29%
Acid - 45%

Collection System and Treatment Measures:

a. 115,530 feet of conveyance sewers six to 84 inches in diameter; Design maximum flow.
b. One flow equalization basin; Design maximum flow.
c. One treatment plant located on Beech Creek at Kato Village; Design wet-weather flow.

Estimated AMD volume affected and reductions in total Watershed design average loads attributable to the treatment measures are as follows:

Volume	-	41 %
Iron	-	62% (to 4 mg/l)
Acid	-	49%

Estimated AMD volume affected and reductions in total Watershed design average loads attributable to the abatement plan are as follows:

Volume	-	79%; 11.7 mgd
Iron	-	91%; 1.48 tons per day
Acid	-	94%; 22.9 tons per day

Abatement Plan V

Basic Intent: The same as Abatement Plan IV except that treatment is at three sites rather than at one site.

Preventive Measures: The same as for Abatement Plan IV.

Estimated AMD volume affected and reductions in total Watershed design average loads attributable to the preventive measures are as follows:

The same as for Abatement Plan IV.

Collection System and Treatment Measures:

a. 52,510 feet of conveyance sewers six to 60 inches in diameter; Design maximum flow.
b. Three flow equalization basins, one at each treatment plant; Design maximum flow.
c. Three treatment plants - North Fork Beech Creek at Clarence Village, South Fork Beech Creek 2,000 feet downstream from Interstate Route 80 crossing, and Sandy Run 4,000 feet upstream from its confluence with Beech Creek; Design wet-weather flow.

Estimated AMD volume affected and reductions in total Watershed design average loads attributable to the treatment measures are as follows:

The same as for Abatement Plan IV.

Estimated AMD volume affected and reductions in total Watershed design average loads attributable to the abatement plan are as follows:

The same as for Abatement Plan IV.

Abatement Plan VI

Basic Intent: Control of MD pollution by construction of preventive and treatment measures; eliminate AMD from 41 MD discharge points and reduce at four MD discharge points; collect and treat in two systems AMD from 36 MD discharges, including three from which AMD was reduced by preventive measures, interconnections constructed between abandoned deep mines used to convey a portion of AMD from North Fork basin to Sandy Run basin for treatment.

Preventive Measures: The same as for Abatement Plans IV and V.

Estimated AMD volume affected and reductions in total Watershed design average loads attributable to the preventive measures are as follows:

The same as for Abatement Plans IV and V.

Collection System and Treatment Measures:

a. 21,215 feet of conveyance sewers six to 27 inches in diameter; Design for twice wet-weather flow.
b. 5,800 feet of open channel; Design maximum flow.
c. 2,350 feet of interconnections between deep mine workings; Design maximum flow.
d. Six flow equalization basins located to serve groups of MD discharges; Design maximum flow.
e. Two treatment plants - Sandy Run 4,000 feet upstream from its confluence with Beech Creek, and South Fork Beech Creek 2,000 feet downstream from Interstate Route 80 crossing; Design wet-weather flow.

Estimated AMD volume affected and reductions in total Watershed Design average loads attributable to the treatment measures are as follows:

Volume	-	41%
Iron	-	61% (to 4 mg/l)
Acid	-	49%

Estimated AMD volume affected and reductions in total Watershed design average loads attributable to the abatement plan are as follows:

Volume	-	79%; 11.7 mgd
Iron	-	90%; 1.46 tons per day
Acid	-	94%; 23.0 tons per day

Abatement Plan VII

Basic Intent: Control of MD pollution by construction of preventive and treatment measures; eliminate AMD at 48 MD discharge points and reduce at four MD discharge points; collect and treat in three systems 30 MD discharges including three from which AMD was reduced by preventive measures.

Preventive Measures: Reconstruct stream channels; construct surface-water diversion ditches at three strip mines; restore in varying degrees 22 strip mines; move five refuse areas into strip mines; eliminate deep mine workings in one area; excavate and restore one subsidence area; close one deep mine entry; chemically neutralize one strip mine; inundate selected deep mine workings.

Estimated AMD volume affected and reductions in total Watershed design average loads attributable to the preventive measures are as follows:

Volume	-	40%
Iron	-	30%
Acid	-	49%

Collection System and Treatment Measures:

a. 35,755 feet of conveyance sewers six to 24 inches in diameter; Design for twice wet-weather flow.
b. 5,000 feet of open channel; Design maximum flow.
c. Nine flow equalization basins located to serve groups of MD discharges; Design maximum flow.
d. Three treatment plants - North Fork Beech Creek at Clarence Village, Beech Creek South Fork 2,000 feet downstream from Interstate Route 80 crossing, and Sandy Run 4,000 feet upstream from its confluence with Beech Creek; Design wet-weather flow.

Estimated AMD volume affected and reductions in total Watershed design average loads attributable to the treatment measures are as follows:

Volume	-	39%
Iron	-	60% (to 4 mg/l)
Acid	-	45%

Estimated AMD volume affected and reductions in total Watershed design average loads attributable to the abatement plan are as follows:

Volume	-	79%; 11.8 mgd
Iron	-	90%; 1.47 tons per day
Acid	-	94%; 23.0 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. Information used in preparing the estimates is presented in Exhibit S.

Costs associated with each plan 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	102,000,000	8,130,000	3,740,000	4,180,000
II	41,000,000	3,670,000	1,960,000	2,130,000
III	50,000,000	4,000,000	1,110,000	1,400,000
IV	33,000,000	2,680,000	875,000	1,050,000
V	23,100,000	2,050,000	681,000	818,000
VI	22,700,000	1,880,000	516,000	652,000
VII	21,400,000	1,880,000	556,000	689,000

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 Plans I and II

The basic intent of both these plans is the collection and treatment of all MD discharges not meeting current SWB limitations. Abatement Plan I achieves this through one collection and treatment system, Abatement Plan II by four collection and treatment systems. In Abatement Plan II approximately 96 percent of the AMD pollution load reduction is achieved at two of the four treatment plants. These plans would give more positive control and more predictable results than subsequent plans incorporating preventive measures. Abatement Plan I would have to be constructed in its entirety before any reduction in AMD pollution would be realized.

The major reason for the project and long-term cost differential between Abatement Plans I and II is the considerably larger and longer conveyance sewer network required for Abatement Plan I. In Abatement Plan I the collection facilities account for approximately 98 percent of the project cost, in Abatement Plan II approximately 94 percent.

Abatement Plan III

Nearly all MD discharges not meeting current SWB requirements are eliminated, reduced, or treated in Abatement Plan III. To this extent, the plan accomplishes the same purpose as Abatement Plans I and II but does so with a combination of preventive and treatment measures. In Abatement Plan III the three collection and treatment systems are located in the upper portion of the Watershed. Approximately 99 percent of the AMD pollution load reduction by treatment is achieved at two of the three treatment plants. Preventive measures are used throughout the Watershed.

Approximately 57 percent of the project cost is attributable to preventive measures, 40 percent to the collection facilities. Of the total Watershed design average pollution load approximately 38 percent is eliminated by preventive measures and approximately 96 percent by the entire abatement plan. The reduction in pollution load by Abatement Plan III slightly exceeds the reductions by all other abatement plans. The stage construction of preventive and treatment measures could be undertaken with Abatement Plan III, and the effect of each stage on reduction in AMD loads and improvement in stream quality evaluated.

Abatement Plans IV and V

The basic intent of Abatement Plans IV and V and subsequent plans is to eliminate by preventive and treatment measures the pollution load from the 32 MD discharges contributing 90 percent of acid and the 13 contributing 90 percent of iron in the Watershed. The only difference between the two plans is that Abatement Plan IV has one collection and treatment system, whereas Abatement Plan V has three such systems. In Abatement Plan V approximately 99 percent of the AMD pollution load reduction by treatment is achieved at two of the three treatment plants. Preventive measures in Abatement Plans IV and V are quite different than in Abatement Plan III. Collection and treatment are confined to the upper portion of the Watershed. Preventive measures are used throughout the Watershed.

In Abatement Plan IV approximately 45 percent of the project cost is attributable to preventive measures, 51 percent to the collection facilities. In Abatement Plan V approximately 64 percent of the project cost is attributable to preventive measures, approximately 30 percent to the collection facilities. Both plans give the same reductions in total Watershed design average pollution loads: approximately 37 percent by preventive measures and approximately 92 percent by the entire plans.

The project and long-term costs for Abatement Plan V are considerably less than for Abatement Plan IV. The major reason for this cost differential is that considerably larger and longer conveyance sewers are required for Abatement Plan IV. Stage construction of preventive measures would be equally applicable to both plans, but stage construction of treatment facilities would be applicable only to Abatement Plan V.

Abatement Plan VI

The preventive measures of Abatement Plan VI are exactly the same as those for Abatement Plans IV and V. Abatement Plan VI has two collection and treatment systems. Approximately 99 percent of the AMD pollution load reduction by treatment is achieved at one of the two treatment plants. Collection and treatment are confined to the upper portion of the Watershed. In one of the collection and treatment systems, underground conveyance of AMD is an essential part of the collection facilities. Because of the unique feature of these collection facilities the results of Abatement Plan VI cannot be predicted with as high a degree of accuracy as for the other abatement plans. Preventive measures are used throughout the Watershed.

In Abatement Plan VI approximately 66 percent of the project cost is attributable to preventive measures and approximately 29 percent to the collection facilities. Of the total Watershed design average pollution load approximately 37 percent is eliminated by preventive measures and approximately 92 percent by the entire abatement plan. The stage construction of preventive and treatment measures could be undertaken with this plan and the effect of each stage evaluated.

Abatement Plan VII

The preventive measures comprising part of Abatement Plan VII are virtually the same as in Abatement Plans IV, V, and VI. Abatement Plan VII has three collection and treatment systems. Approximately 99 percent of the AMD pollution load reduction by treatment is achieved at two of the three treatment plants. Collection and treatment are confined to the upper portion of the Watershed. Preventive measures are used throughout the Watershed.

In Abatement Plan VII approximately 75 percent of the project cost is attributable to preventive measures and approximately 18 percent to the collection facilities. Of the total Watershed design average pollution load approximately 40 percent is eliminated by preventive measures and approximately 92 percent by the entire abatement plan. The stage construction of preventive and treatment measures could be undertaken with Abatement Plan VII and the effect of each stage evaluated.

The project costs for Abatement Plans V, VI, and VII are virtually the same. The long-term costs for Abatement Plans VI and VII are nearly equal and less than those for Abatement Plan V.

The reduction in total Watershed design average pollution loads by Abatement Plans IV, V, VI, and VII is virtually the same, as is the reduction by the preventive measures of these plans.

RECOMMENDED ACID MINE DRAINAGE ABATEMENT PLAN

Based on project and long-term costs, degree of reliability with which results can be predicted, flexibility to enable stage construction and evaluation of preventive and treatment measures, reduction in total Watershed pollution loads, and resultant stream quality, Abatement Plan VII is recommended for construction in the Watershed. This plan is comprised of construction in five complexes. The five complexes and various abatement measures that would be constructed therein as parts of the recommended abatement plan are shown on Plates IV-A and IV-B. The recommended order for implementing this plan is as follows:

1. Construct preventive measures in Complex A.
    a. Excavate and restore Subsidence Area B-20; reconstruct stream channels across AA and BB.
    b. Construct surface-water diversion ditches around or across Strip Mines S-8, S-55, and S-57; close Deep Mine Entry D-2.
    c. Restore Strip Mines S-41, S-110, S-115, S-119, S-121, and south portion of S-133; move Refuse Area R-19 into strip mine.

2. Construct preventive measures in Complex C.
    a. Eliminate deep mine workings behind Deep Mine Entries D-70 and 71 by excavation and restoration of the mined area.
    b. Inundate deep mine workings by constructing peripheral seal in deep mine workings adjacent to Strip Mines S-151, S-152, S-153, and S-154.
    c. Restore Strip Mines S-84, S-120, S-126, S-129, S-130, S-131, S-150, northern portions of S-128 and S-149, and northwest portion of S-153; move Refuse Areas R-20 and R-21 into strip mine.

3. Construct preventive measures in Complex E.
    a. Neutralize the contents of Strip Mine S-184.

4. Construct preventive measures in Complex D.
    a. Restore Strip Mines S-159, S-166, S-167, S-168, and portions of S-160 and S-161 located on south side of Orviston-Kato Road; move Refuse Areas R-29 and R-30 into strip mine.

5. Construct collection facilities and treatment plant in Complex A.

6. Construct collection facilities and treatment plant in Complex C.

7. Construct collection facilities and treatment plant in Complex B.

The recommended abatement plan includes the complete or partial restoration of Strip Mines S-119, S-149, and S-167. Portions of these strip mines are or have recently been active. However, the manner and extent of restoration do not appear to be to the degree recommended for pollution abatement. Some additional restoration of these strip mines has therefore been included in the recommended plan.

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	$16,100,000	$264	$ 0.28	$ 26.56
Treatment Measures	5,300,000	188	141	145

Exhibit T presents information by complex on estimated AMD pollution abated and associated costs for the preventive and treatment measures comprising the recommended plan. Exhibit U shows by complex the MD discharge points affected by the preventive and treatment measures comprising the recommended plan.

The Department has initiated a Quick Start AMD abatement project in the vicinity of MD Discharge Points 170 and 171, which currently discharge directly to Beech Creek. Pollution discharges at MD Discharge Points 170 and 171 will be eliminated by regrading Refuse Area R-31, covering it with soil, planting it, and constructing appropriate surface-water diversion ditches around it. This project is expected to be completed during the first half of 1971.

ANTICIPATED QUALITY OF WATERSHED STREAMS
AFTER IMPLEMENTATION OF
RECOMMENDED ABATEMENT PLAN

The average quality of waters anticipated at the Beech Creek sampling stations after implementation of the recommended abatement plan is summarized below:

	Stream Sampling Stations on Beech Creek	
	Upstream Portion	Downstream Portion
pH	6.0-6.2	6.4-6.6
Total Iron -mg/l	0.3-0.4	0.2-0.3
Acid (as $CaCO_3$) - mg/l	18-20	16-18

The entire length of Beech Creek on the average would meet SWB pH and iron stream quality criteria but continue to be slightly acidic. The downstream reaches of Beech Creek would meet SWB pH and iron criteria under all conditions of discharge. Anticipated minimum pH and maximum iron concentration would be 5.5 and 1.2, respectively, in the upstream portion of Beech Creek. Other constituents and characteristics would not be of major sanitary significance in Beech Creek.

The average quality of waters anticipated at sampling stations on Beech Creek tributaries after implementation of the recommended abatement plan is summarized in the following:

	Stream Sampling Stations on Beech Creek Tributaries (1)			
	Mined Areas		Non-Mined Areas	
	MD Discharges Noted (2)	No MD Discharges Noted (3)	Coal Present (4)	Coal Not Present (5)
pH	3.7-6.6	5.2-6.6	6.2	6.1-6.5
Total Iron -mg/l	0.1-2.0	0.1-0.2	0.3	0.1-0.2
Acid (as $CaCO_3$) - mg/l	12-66	20	20	10-20

(1) Including North and South Forks
(2) 19 tributaries; active mining or processing or both, on six
(3) Four tributaries; no active mining or processing
(4) One tributary; no MD discharges noted
(5) Three tributaries

Information and data on the anticipated quality of Watershed streams tributary to Beech Creek follow:

1. Tributaries on which Mining or Processing Operations, or Both, Have Been or Are Being Conducted
   a. Tributaries on which MD discharges Were Noted
      Downstream Portion of Beech Creek South Fork and Its Tributaries
         Stream quality in the downstream tributaries will remain unchanged; stream quality in the downstream portion of the South Fork will be improved by the recommended treatment measures. Average pH at the

mouth of Beech Creek South Fork is expected to be 6.2, with a low of 5.6 anticipated. The average acid concentration to be expected is 16 mg/l. Iron concentrations are expected to average 0.2 mg/l, with a high of 0.6 mg/l anticipated. Other stream constituents and characteristics are not expected then to be of consequence. As Interstate Route 80 crossing is approached, the average pH in Beech Creek South Fork can be maintained in a favorable range by controlling alkalinity of the effluent from the treatment facility at Complex B. Other stream constituents and characteristics are not expected to be of major sanitary significance.

Beech Creek North Fork and Its Tributaries

Stream quality will considerably improve throughout Beech Creek North Fork from construction of the recommended preventive and treatment measures. The upstream portions of the North Fork and its tributaries will have average pH values ranging from 4.0 to 5.5, with lows of 3.6 anticipated. Acidities will average from 20 to 32 mg/l. Iron concentrations will average from 0.2 to 0.7 mg/l, with highs of 2.0 mg/l anticipated. Beech Creek North Fork from the vicinity of Clarence Village to its mouth is expected to have average pH values from 4.6 to 5.0, with a low of 4.0 anticipated. Average acidities will range from 18 to 22 mg/l. Iron concentrations are expected to vary from 0.4 to 0.7 mg/l, with a high of 2.0 mg/l anticipated. This entire downstream stretch of Beech Creek North Fork could be maintained as an alkaline stream by controlling lime additions at the treatment facilities comprising a portion of Complex A abatement measures. Throughout Beech Creek North Fork, other constituents and characteristics are not then expected to be of major sanitary significance.

Sandy Run and Its Tributaries

Stream quality in the upstream portion of Sandy Run and its tributaries will remain unchanged. Upon construction of the recommended preventive and treatment measures, stream quality in the downstream portion of Sandy Run and its tributaries will be considerably improved. In the downstream portion of the Run and its tributaries pH values are expected to range from 4.6 to 6.5, with occasional lows of 4.0 anticipated. Average acidities will range from 16 to 30 mg/l. Iron concentrations will be 0.2 to 0.6 mg/l, with occasional highs of 2.0 mg/l anticipated. Other constituents and characteristics are not then expected to be of major significance.

Tributaries L and R

Stream quality along the entire lengths of Tributaries L and R will be improved by the recommended preventive measures. The average pH at the mouth of each tributary is expected to be 5.2, with a low of 4.4 anticipated. Acidity is expected to average 30 mg/l. The average iron concentration is expected to be 0.2 mg/l, with a high of 0.6 mg/l anticipated. Other constituents and characteristics are not then expected to be of major sanitary significance.

Logway Run

Stream quality along the entire length of Logway Run will be improved by the recommended preventive measures. The average pH at the mouth is expected to be 5.2, with a low of 4.4 anticipated. Acidity is expected to average 20 mg/l. The average iron concentration will be 0.2 mg/l, with a high of 0.6 mg/l anticipated. Other stream constituents and characteristics are not then expected to be of major sanitary significance.

Big Run

Stream quality along the entire length of Big Run and its Middle and East Branches will be improved by the recommended preventive measures. The average pH at the mouth of Big Run is expected to be 6.6, with a low of 6.2 anticipated. Acidity is expected to average 10 mg/l. The maximum iron concentration is expected to remain 0.1 mg/l. Other stream constituents and characteristics are not then expected to be of consequence.

Twin, Three Rock, Two Rock, and Council Runs, and the Downstream Portion of Wolf Run

The recommended abatement plan does not include any abatement measures on these streams. These streams are expected to retain their generally good quality.

b. Tributaries on which No MD Discharges Were Noted

The recommended abatement plan does not include abatement measures on the upper portions of Wolf and Cherry Runs, or on Monument or Hayes Runs. These streams are expected to maintain their generally good quality.

2. Tributaries on which Coal Is Present but Has Not Been Mined and on which No Coal Exists (Non-mined Areas)

The recommended abatement plan does not include abatement measures on Rock Run, the upstream portion of Beech Creek South Fork, Eddy Lick, or Panther Runs. These streams are expected to maintain their generally good quality.

The information and data presented in this report show that upon implementation of the recommended abatement plan, streams now receiving the major AMD loadings - Beech Creek North Fork, Tributary L, Sandy Run, Tributary R, Logway Run, and Big Run - will be improved in quality. Although these streams will not then meet SWB pH and iron criteria under all conditions of discharge, the improvement in quality will be substantive.

All Watershed streams draining areas where abatement measures are to be constructed are expected to remain acidic. With very few exceptions, the acidity in these streams after the recommended plan is implemented will be comparable to the natural acidity found in Watershed streams draining areas where (1) no MD discharges were noted, (2) coal is present but has not been mined, and (3) no coal is present. The reported natural acidity in these three classes of streams can be attributed to geochemical considerations and analytical methodology.

Exhibit V lists the pH, iron, and acid-alkalinity concentrations anticipated at each stream sampling station following implementation of the recommended plan. The locations of all sampling stations are shown on Plate I. The locations of all streams are shown on Plates I, III-A, and III-B.

OVERVIEW

Bald Eagle Creek downstream from its confluence with Beech Creek has in the past apparently been of relatively good quality. The Department is concerned that future water quality in Bald Eagle Creek downstream from its confluence with Beech Creek could under certain flow conditions be seriously degraded because of limited release of water from Foster J. Sayers Reservoir. Based on results of investigations described in this report, Beech Creek upon implementation of the recommended abatement plan will be of such quality that degradation of Bald Eagle Creek by AMD originating from within the Watershed will be highly improbable. When the recommended plan is implemented, the entire length of Beech Creek on the average is expected to meet the SWB pH and iron stream quality criteria. The downstream reaches of Beech Creek will probably meet the SWB pH and iron criteria under all discharge conditions. Furthermore, for all of Beech Creek other constituents and characteristics would not then appear to be of major sanitary significance. Therefore, all indications are that the recommended plan will accomplish the Department's major objective.

In addition, the recommended plan will (1) remove 90 and 94 percent of total average Watershed iron and acid loads respectively, and (2) significantly improve the current stream quality of Beech Creek tributaries receiving the major AMD loads. Although under the recommended plan various tributaries would still not meet the SWB specific stream quality criteria, there would not appear to be any immediate urgency or problem associated with this fact. Considering the anticipated stream quality in Beech Creek, the further objective of controlling MD from abandoned workings throughout the entire Watershed would probably be met or, as a minimum, a significant step made toward this end.

The recommended abatement plan is amenable to stage construction. Therefore, the anticipated effect of each stage on reductions in AMD 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 (or both) are indicated, such could easily be accommodated.