AUDENRIED TUNNEL

The Audenried Tunnel drains the western end of the mined Basin coal measures at a point approximately 3 miles west of Kelayres. The tunnel heads N 87° E for a distance of approximately 16,150 feet. Only the initial 1,300 feet could be mapped because the remaining portion was partially filled with impassable debris and contained bad air. Clearing of the tunnel to enable examination and mapping was undertaken by the Department in 1971 but was terminated at 1,300 feet when the removal of debris and the difficulty of maintaining satisfactory ventilation became major obstacles.

The tunnel was driven at a location close to the synclinal axis of the Basin. The bedding within the observed portion strikes N 70-80° W and dips gently approximately 9° North. For most purposes, the bedding can be considered to be striking parallel to the tunnel heading and almost flat-lying. Bedrock consists of interbedded thin to medium-bedded red shales, sandy shales, and sandstones of the Mauch Chunk Formation. The shale varies from clayey to silty in composition. It is soft and weathered near the tunnel portal and becomes progressively more sound with depth. The shale is broken but most joints are small and tight. The sandy shale varies from a coarse-grained shale to a very fine-grained sandstone. It is hard and blocky, and jointing is tight. The sandstone beds are hard, medium-grained, and medium-bedded. These beds are composed of impure quartz sediment, and they exhibit few joints and fractures. Sandstone predominates in a zone from 1,000 to 1,200 feet from the portal. Rock in the first 350 feet of the tunnel is poor. Full timbering was placed throughout this distance. For the next 150 feet, timber supports were required, but timber lining was not necessary. From this point, the rock improves in quality with depth. The last 600 feet of the examined portion of the tunnel are in relatively sound rock with no faults or fracture zones, but with tight jointing.

After the Department ceased clearing operations in 1971, Gannett Fleming Corddry and Carpenter, Inc., was asked if a sufficient length of the tunnel had been exposed to determine the feasibility of constructing a seal, and if so, whether a seal could be located and designed for construction within the cleared 1,300 feet. In its March 29, 1972, response to these questions, Gannett Fleming concluded that no suitable site for a seal exists within the exposed 1,300 feet and that no definitive determination of the feasibility of constructing a seal at a greater depth could be made without additional information. Toward this end, a minimal drilling program was suggested to aid in these decisions and to possibly establish limits for additional clearing.

Neither the suggested drilling nor additional clearing has been conducted. This report has been prepared in the recognized absence of definitive information in this area.

A 1931 report of the Glen Alden Coal Company describes in general terms the conditions encountered when the Audenried Tunnel was driven. The report mentions a fissure, 8,499 feet inside the portal, that produced almost 800 gallons of water per minute. The potential for leakage along this fracture, or other fractures within the uncleared portion of the tunnel, cannot be evaluated from available information. The report describes the rock penetrated from the portal to 8,499 feet as being interbedded red shales and sandstones except for 29 feet of conglomerate. The remaining tunnel length is said to be in conglomerate and sandstone. This report suggests the strong possibility of a fault at 8,499 feet. No conclusion can presently be reached regarding the orientation or condition of this fracture, or its effect on sealing of the tunnel.

While it is believed that the Audenried Tunnel can be sealed at some point to create a permanent pool within the Basin, additional information is required to reach a positive conclusion.

QUAKAKE TUNNEL

The Quakake Tunnel drains the eastern end of the mined Basin coal measures through Spring Mountain at a point south of the Borough of Beaver Meadows. The tunnel trends from its mouth approximately N 60^0 W for about 3,900 feet, where it intercepts mine workings in the Lykens vein. The tunnel had been cleared of debris by the Department and was accessible for mapping between its portal and the Lykens vein mine workings.

The tunnel portal is in badly fractured red shale of the Mauch Chunk Formation. Extensive timbering was required for support in this area. Younger red and gray shales and sandstones, with occasional thin beds of conglomerate, are penetrated deeper in the tunnel. Sandstones of the Pottsville Formation begin about 1,450 feet from the portal. These grade into mostly conglomerate between 1,800 and 2,000 feet. From this point to the first gangway at 3,900 feet are interbedded red and gray shales, sandstones, and some conglomerates. The conglomerates occur from 2,100 to 2,200 feet; 3,300 to 3,400 feet; and 3,650 to 3,850 feet. The bedding strikes generally N 68-80° E and dips 30 to 55 degrees to the northwest. Minor folding causes the dip to vary along a synclinal axis at approximately 1,900 feet, and at an anticlinal axis about 2,800 feet, inside the tunnel. Several thrust faults with minor displacement were observed. Movement along these faults appears to have been small, and there are no extensive broken or brecciated zones. The faults are oriented almost parallel to the strike of the bedding, and they do not appear to represent a potential leakage problem through the mountain.

On the basis of this preliminary study, it appears possible to place an effective seal in the conglomerate between 1,800 and 2,000 feet from the portal. In this area, the rock is hard and massive with only a few minor fractures. These factors do not appear to present serious leakage or physical strength impediments.

FUTURE DISCHARGE LOCATION

If both the Audenried and Quakake Tunnels can be sealed with no major Basin leakage occurring, it is believed that water will rise in the underground mine complexes drained by the tunnels until one continuous underground pool is formed. The lowest point of major interconnection that will permit free passage of water between the deep mine complexes is +1432. At this elevation, a rock tunnel, which served as a main haulageway in the Spring Mountain Mine, interconnected all veins between its southern workings presently drained by the Audenried Tunnel and its northern workings presently drained by the Quakake Tunnel.

Other interconnections occur at higher elevations in the Wharton and Mammoth vein workings between the Spring Brook and Spring Mountain Mines, as well as between the Spring Mountain Mine and the Coleraine and Beaver Meadow Mines in the Wharton, Mammoth, and Primrose veins. The latter two veins have actually been strip mined between the Spring Mountain and Coleraine Mines. These strip mines remain unbackfilled to a depth of approximately +1475.

The controlling interconnections between the mines drained by the Audenried Tunnel and those drained by the Quakake Tunnel are shown schematically in Exhibit A.

The ultimate pool elevation cannot be predicted with precision. From a study of available information, it appears that leakage at low Basin elevations will likely be minimal, and the pool level will approach the surface in the vicinity of Beaver Meadows Borough near the headwaters of Beaver Creek at an elevation of approximately +1550. As this elevation is approached, springs may develop, and some minor initial erosion of overburden may occur. Major relief will probably occur through deep mine workings that were mined to the surface in this area. However, the exact level, location, and seasonal fluctuation in the rate of discharge from the overflow are indeterminate.

DESIGN VOLUMES, CONSTITUENTS, AND CHARACTERISTICS OF PROPOSED MINE POOL OVERFLOW

If the pool level can reach an elevation of approximately +1550, it is estimated that 70 percent of the Basin deep mining will be inundated. A marked improvement will eventually occur in the overflow quality as compared to the present-day quality of the Audenried and Quakake Tunnel discharges. The initial overflow from the pool may be slightly alkaline for a short time as the first flush comprised essentially of surface water is released. Then, for some time, the overflow will deteriorate. This deterioration will be caused by the dissolving of the oxidation products on the exposed faces of pyritic materials within the deep mine workings as the pool rises above current drainage levels. Ultimately, as the pool level is stabilized, stratification of the waters contained in the pool will occur, with the more acid waters being contained in the lower levels. Surface water entering the pool will eventually displace the acid water in the upper pool levels. This displacement will be accompanied by improved overflow quality since further oxidation of the Basin's pyritic materials will be limited to those not inundated.

The worst quality pool overflow will likely occur within the first year after an overflow occurs. For purposes of evaluating the results of mine sealing, design quality and flow estimates have been prepared for three time periods: first year average, third year average, and thirtieth year and after average. These are presented in the following:

Design Conditions	Estimated First Year Average	Estimated Third Year Average	Estimated Thirtieth Year And After Average
Average			
Volume - mgd	35	35	35
pH Range	3.0-3.6	3.5-4.0	4.0-5.9
Acid (as $CaCO_3$)			
mg/1	550	100	40
tons/day	80.3	14.6	5.8
Iron			
mg/1	25	15	5.0
tons/day	3.6	2.2	0.7
Wet-Weather			
Volume - mgd	44	44	44
pH Range	3.0-3.6	3.5-4.0	4.0-5.9
Acid (as $CaCO_3$)			
mg/1	450	75	30
tons/day	82.5	13.8	5.5
Iron			
mg/1	20	10	4.0
tons/day	3.7	1.8	0.7
Maximum			
Volume - mgd	602	602	602
pH Range	3.5-4.0	4.0-5.9	4.0-5.9
Acid (as $CaCO_3$)			
mg/1	200	50	30
tons/day	502	126	75
Iron			
mg/1	15	5	3
tons/day	37.7	12.6	7.5

EFFECT OF NEW BASIN POOL ELEVATIONS

The inundation of the Basin deep mine workings to an elevation of approximately +1550 will preclude further mining below this elevation. Recovery of remaining coal from the existing mine workings below this elevation would be difficult and costly. Any remaining coal measures above this elevation could still be mined.

It is believed that no significant surface subsidence attributable to the establishment of a pool within the Basin will occur. However, as determined from a study of limited mine map information, a portion of the Borough of Beaver Meadows may have been undermined close to the surface. Surface elevations in this area range from approximately +1560 to +1575. If the pool elevation reaches +1550 and mining has been accomplished in this area, minor subsidence could occur as the pool level initially rises or fluctuates seasonally. This problem could be lessened by controlled filling of the pool. After a stabilized pool elevation is reached, seasonal fluctuations could be reduced by eliminating potential restrictions in flow to the surface by drilling boreholes or excavating open channels into the deep mine workings.

EFFECTS OF MINE SEALING ON WATERSHED STREAMS

As a result of sealing the Audenried and Quakake Tunnels, all Basin mine drainage will discharge to the headwaters of Beaver Creek. This stream flows into Black Creek, then into the Lehigh River, and eventually into the Delaware River.

At present, Beaver Creek is mildly acid. It has no use other than to convey treated wastewater from Beaver Meadows Borough. Its streambed, for several miles downstream from the Basin, is badly silted with waste coal fines from past Basin mining operations. There are limited public road crossings over this stream. The mine pool overflow should have no adverse effect upon current uses of this stream.

However, by sealing the Audenried Tunnel, a major pollution source to Catawissa Creek will be eliminated. Coupled with the Department's other mine drainage abatement projects on this watershed, Catawissa Creek stream quality should be substantially improved and its acid load to the Susquehanna River significantly reduced.

The Quakake Tunnel discharges to Wetzel Creek, rendering it acid to its mouth. Elimination of this discharge will remove the entire present acid load to this stream. As a result, Wetzel Creek could be used for fishing and other recreational purposes.

Sealing of the Audenried Tunnel and transfer of its present discharge to the Delaware River would augment flow in the Delaware River. Since water shortages have occurred in the lower reaches of the Delaware River, augmentation of its flow is desirable.

EFFECTS OF MINE SEALING ON WATER SUPPLIES IN OR NEAR THE BASIN

There are no public water supply sources located within the Basin coal measures. However, outside the coal measures, both wells and reservoirs have been established within the watershed draining toward the mined areas. These sources are presently used both as public and private water supplies.

Each of the surface supplies is located, and finds its sources, at elevations well above the highest elevations of all coal measures. Sealing of the Audenried and Quakake Tunnels should in no way affect these sources.

Of the wells serving as private and public supply sources, those on the north side of the Basin are part of a large public system of wells and surface water reservoirs owned by the Hazleton Water Authority. In addition to the City of Hazleton, the Authority provides service to other nearby communities including the Borough of Beaver Meadows and the Villages of Jeansville, Junedale, Tresckow, Audenried, and Beaver Brook.

On the south side of the Basin, the Honeybrook Water Company services the Borough of McAdoo and the Village of Kelayres from wells located within these communities. In addition, the Consolidated Cigar Company's plant, located at the east edge of McAdoo, has several private wells that were drilled to provide water for its manufacturing process.

A preliminary examination of the well records and their locations leads to the conclusion that sealing the Audenried and Quakake Tunnels and allowing a mine water pool to reach a potential elevation of approximately +1550 will have no adverse effect upon the yield or quality of water pumped from these wells.

However, creation of an impoundment within the deep mine workings in the Basin could ultimately provide an important source for both public and private water supplies. It could immediately be used as a source of water for the coal preparation plants presently using surface impoundments.

Coal mining, both in this basin and adjacent basins, was the most significant factor in the establishment of the communities in and adjacent to the Basin. However, major deep mining was discontinued in the Basin more than 10 years ago because of the dwindling mineable coal reserves, reduced coal markets, and rising production costs. Consequently, the impact of Basin deep mining on the general area economy has appreciably decreased. The Basin economy has become more dependent on the diverse industries that have been established in the greater Hazleton area.

Strip mining continues, and considerable additional coal is being reclaimed from the large refuse banks in the Basin. Basin coal production during 1972 consisted of approximately 64,000 tons from strip mining and 135,000 tons from reworking refuse banks.

The general location of the Basin is shown on Plate I.

MINE DRAINAGE ABATEMENT PLANS STUDIED IN DETAIL

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

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

1. Abatement plans consisting of various preventive measures excluding mine sealing.
2. An abatement plan consisting of mine sealing only.

Comments relative to these two categories and the individual abatement plans are set forth in the following:

1. Abatement plans involving treatment measures were specifically eliminated from consideration as determined by the scope of work authorized by the Department.

2. On the basis of investigations described in this report and previous experience, it would be totally impractical and prohibitively expensive to develop an abatement plan comprised solely of preventive measures that would completely abate the mine drainage load from the Basin.

3. On the basis of investigations and previous experience, abatement plans involving preventive measures other than mine sealing were limited to diverting surface water presently draining into the Basin coal measures to streams outside the Basin, because of the large area and physical condition of the surface overlying the Basin coal measures.

4. The abatement plan involving the placement of impermeable seals in the Audenried and Quakake Tunnels was based on a geologic study of the Basin including an examination of the Quakake Tunnel rock structure and examination of only 1,300 feet of the Audenried Tunnel immediately inside its ad it.

5. Preliminary examination of the condition and nature of the rock in the Quakake Tunnel indicated that the placement of an effective seal in the tunnel is feasible.

6. Observations in the Audenried Tunnel regarding the placement of a seal are inconclusive because of the tunnel's significant length (14,850 feet) not accessible for study. It was assumed that a satisfactory seal location could be found between the tunnel entry and the mined coal measures. However, additional studies are required to reach a definitive conclusion.

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

ABATEMENT PLAN I

Basic Intent:

Control of mine drainage by the construction of surface drainage facilities along the western perimeter of the Basin coal measures to intercept and conduct point sources of surface water around or across the mined area, thereby reducing the contribution of water to the Audenried Tunnel discharge.

Preventive Measures:

Construction of 7,200 feet of lined channel and 4,200 feet of unlined channel, including provisions for 14 transition structures to accommodate point sources of water, as well as excavation and backfill of surface areas to establish the proper gradients.

The estimated mine drainage volume affected and reductions in the Basin design average pollutional loads attributable to the abatement plan are as follows:

	Design Average Discharge Reductions		
	Audenried Tunnel	Quakake Tunnel	Total
Volume - mgd	2.09	-	2.09
Acid - tons/day	3.05	-	3.05
Iron - tons/day	0.04	-	0.04
Percent	11.4	-	6

ABATEMENT PLAN II

Basic Intent:

Control of mine drainage by the construction of surface drainage facilities along the northern and southern perimeters of the Basin coal measures to intercept and conduct point sources of surface water around or across the mined area, thereby reducing the contribution of water to the Audenried and Quakake Tunnel discharges.

Preventive Measures:

Construction of 24,500 feet of surface water diversion ditches and 38,500 feet of lined channel, including provisions for 56 transition structures to accommodate point sources of water, as well as excavation and backfill of surface areas to establish the proper gradients.

The estimated mine drainage volume affected and reductions in the Basin design average pollutional loads attributable to the abatement plan are as follows:

	Design Average Discharge Reductions		
	Audenried Tunnel	Quakake Tunnel	Total
Volume - mgd	2.22	1.09	3.31
Acid - tons/day	3.19	1.07	4.26
Iron - tons/day	0.04	0.02	0.06
Percent	12	6.6	10.0

ABATEMENT PLAN III

Basic Intent:

Control of mine drainage by inundating existing deep mine workings in the Basin to the maximum practical level; eliminating existing Audenried and Quakake Tunnel discharges; and establishing an overflow point at a new location with ultimate improvement in water quality.

Preventive Measure:

Clear debris for a maximum of 8,000 feet within the Audenried Tunnel; construct impermeable reinforced concrete seals with acid-resistant liners and emergency relief valves in both the Audenried and Quakake Tunnels.

The estimated mine drainage volume affected and ultimate reductions in the Basin design average pollutional loads attributable to the abatement plan are as follows:

Volume	-0.0 mgd; 0%
Acid	- 37.0 tons/day; 86.5%
Iron	- 0.1 tons/day; 16.6% (increase)

COST ESTIMATES FOR 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 March 1973 price levels, are set forth in this section.

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

		Annual Costs		
Abatement Plan	Project Cost	Average Over Initial 30 Years	Average Over Next 270 Years	Average Over 300 Years
I	$244,600	$20,400	$ 5,000	$ 6,570
II	$942,500	$81,600	$32,100	$37,100
III	$937,000	$68,100	$ 1,200	$ 8,010

Project and long-term costs for this abatement plan are much lower than those for Abatement Plan II because of the much lesser extent of construction of surface water conveyance facilities. Although the project cost for Abatement Plan I is considerably lower than that for Abatement Plan III, its long-term cost is only slightly lower than that for Abatement Plan III even though it has higher operating and maintenance costs, as well as periodic replacement of its facilities.

ABATEMENT PLAN II

The basic intent of this plan is similar to that of Abatement Plan I except that it has been expanded to include the reduction of surface water entering deep mine workings from drainage areas lying outside all of the Basin coal measures. This is achieved by providing additional lined and unlined channels that will convey the surface water around and across practically all of the Basin mined areas. This plan also offers the same degree of control and predictability as Abatement Plan I. It achieves a flow and acid load reduction of about 12 percent from the Audenried Tunnel discharge, as well as a flow and acid toad reduction of about 6.6 percent from the Quakake Tunnel discharge. Stage construction of this plan can be accomplished, and the effect of each stage evaluated as described in Abatement Plan I.

The project and tong-term costs of this plan are greater than any other plan because of the much more extensive construction of surface water conveyance systems, together with higher annual operating and maintenance costs, and periodic replacement of the facilities.

ABATEMENT PLAN III

This plan provides for the complete elimination of the Audenried and Quakake Tunnel discharges through the placement of impermeable seals in each tunnel. Resulting impoundment of water in the Basin deep mine workings will inundate exposed coat measures to an elevation at which the impounded water will overflow to the Basin surface. It is predicted that this overflow will ultimately be of better quality than either of the two tunnel discharges. The degree of reliability of this plan is less than the other two plans because of inconclusive data currently available concerning the rock strata within and overlying the Audenried Tunnel, as well as its capability to support a mine seal. If such additional data can be obtained and if these data verify original premises, the degree of reliability of this plan will be considerably increased. It is estimated that 86.5 percent of the acid load from the Basin will be eliminated by this plan. A reduction of this magnitude in the acid load from the Basin cannot be achieved until the seals have been constructed and equilibrium conditions have occurred in the pool overflow.

The project cost for this plan is considerably greater than that for Abatement Plan I but is slightly less than that for Abatement Plan II. Its long-term cost is considerably lower than that for Abatement Plan II but slightly higher than that for Abatement Plan I. Its low long-term cost is mainly due to negligible operating and maintenance costs for such a system because of the estimated durability of the proposed mine seals.

RECOMMENDED ABATEMENT PLAN

Despite the low long-term cost associated with Abatement Plan III, together with substantial reductions in Basin pollutional loads and resultant improvement in stream quality in both Catawissa and Wetzel Creeks, Abatement Plan III cannot be recommended for construction at this time. This is due to the uncertainty regarding the location of, and the effectiveness of placing, a seal in the Audenried Tunnel to serve its intended purpose.

Conversely, the overriding benefits associated with Abatement Plan III when compared to Abatement Plans I and II should not be discounted until it can be conclusively determined that an effective seal cannot be placed in the Audenried Tunnel.

It is recommended, therefore, that the following program be implemented:

1. A core drilling program, as outlined in Exhibit G, that would provide the minimum additional amount of geologic information deemed necessary to establish the feasibility of placing an effective seal in the Audenried Tunnel. This information would also establish finite limits for possible additional clearing of Audenried Tunnel for the purpose of geologic mapping.

2. If feasibility of placing an effective seal is established, Abatement Plan III is recommended for construction.

3. If feasibility of placing an effective seal is not established, Abatement Plan I is recommended for construction.

Project and unit cost information for the recommended alternative plans is summarized in the following:

	Project Cost	Annual Cost Per Ton Of Acid Removed: Average Over Initial 30 Years	Average Over Next 270 Years	Average Over 300 Years
Abatement Plan I	$244,600	$18.30	$4.50	$5.90
Abatement Plan III	$937,000	$ 5.13	$0.09	$0.59

Exhibit H presents information on estimated mine drainage abated and associated costs for each recommended alternative abatement plan.

Abatement measures that would be constructed as part of the recommended alternative plans are shown on Plate III.