ABATEMENT

The results of the watershed investigation indicate that abandoned deep mines are the principal source of acid mine drainage in the Babb Creek Watershed. Results show that 97.2% of all measurable mine drainage discharges have deep mine sources.

Abatement techniques which eliminate sources of acid mine drainage have a more significant long-term impact on receiving streams at less cost than those methods which treat the acid discharges. Abatement plans for the six mining complexes place emphasis on known procedures which prevent uncontaminated ground water from coming in contact with acid-forming materials in abandoned deep mines. Where the cost effectiveness of such procedures appear prohibitive other alternatives have been considered. One or more of the following abatement procedures are included in abatement plans for each mining complex. I

Deep Mine Inundation

Inundation of underground mine workings is accomplished by creating an impermeable barrier around the lower levels of the mine, thus impounding water in the mine and reducing the oxidation of pyritic materials. Success is dependent upon the ability of all material, behind which water will be impounded, to withstand hydraulic pressure. Once such a barrier is in place, a mine pool tap-off should be drilled into underground workings from a surface elevation which will permit an automatic overflow from the mine pool when the maximum pool elevation is reached. The bore hole should be cased and of sufficient size to accommodate the maximum recharge flow into the mine from surface and ground water sources. Tap-offs should be located as far from the lower levels of the mine as possible. This insures that the overflow is released from a portion of the mine pool where contamination from acid-forming materials is minimal.

A. Conventional hydraulic double bulkhead seals at deep mine entries:

In areas where overburden is not severely fractured and surrounding parent material is of a stable impermeable nature, inundation may be accomplished by installing double bulkhead seals in mine entries. Hydraulic heads up to 200 feet may be attained provided all entries are closed and no leakage occurs in adjacent areas. Seals should be keyed into the roof, floor and sides of the entries and grout injected into all weak and fractured material near the seal and the outcrop perimeter. Seals at entries which have mine discharges should be constructed with mine pool draw-off valves to control unexpected increases in hydraulic pressure. Plumbing for the valves, extending through both the outer and inner walls, should be installed near the base of the seal. This facility could also be used to control the mine discharge during construction. See Figure VI, page 39.

B. Sealing trench: Hydraulic seals at the entries of deep mines form only a small part of the continuous barrier needed to effectively inundate a mine. The major portion of the barrier is made up of geological strata and natural material near the outcrop of the coal seam mined. When these strata are broken it is not likely that inundation will be successful unless an impermeable barrier is placed along the lower levels of the mine. A sealing trench is somewhat analogous to an inverted subsurface dam with a continuous impervious core. The trench should be excavated to a minimum depth equal to the desired hydraulic head and all material segregated as it is removed. The coal seam and/or old workings are removed and impervious material compacted from below the coal seam up along the highwall side of the trench to a point where natural consolidated material is encountered. In some cases it may be necessary to extend the impervious core up to the surface if all overburden is broken. The bottom of the trench should be wide enough to allow heavy equipment to maneuver and the width of the core should be at least 10 feet or wide enough to allow heavy equipment compaction. An illustration of a typical cross section of a sealing trench is given in Figure VII, page 40.

C. Clay pack seals: Deep mine entries can be sealed with compacted clay or impervious material in situations where only a low hydraulic head is anticipated. The installation of a clay seal is similar to that of a sealing trench with the excavation limited to the area around a mine opening. It is important that all loose material be cleared away from the opening so that the clay can be well compacted against undisturbed overburden. Under optimum conditions, a clay pack seal can be expected to hold up to 30 feet of head pressure.

II Daylighting Deep Mines

The term daylighting refers to the process of stripping out underground mines. Daylighting can be an effective acid mine drainage abatement procedure when pollution control practices are carried out and the stripped area reclaimed in accordance with an approved plan.

The cost of daylighting must be directly related both to the amount of abatement that can be achieved and to the value of recoverable coal. Daylighting becomes feasible when production cost, including costs of surface and mineral rights, overburden removal and site reclamation are equal to or less than expected monetary returns. Accurate, up-to-date mine maps should be available and adequate test boring conducted in order to evaluate the potential of this process at any given site.

III Acid Mine Drainage Neutralization

A lime neutralization treatment plant is an alternate abatement procedure that can be considered when the possibility of eliminating certain A.M.D. discharges is remote. Neutralization can be practical in cases where the quantity of A.M.D. to be treated is relatively small and the iron concentrations of those discharges is less than 200 mg/L. Sludge disposal can become a problem if A.M.D. with high concentrations of iron must be treated.

Where possible, a treatment plant should be located where a gravity-fed collection system can combine more than one acid mine discharge. Water entering the plant should be collected in a holding pond large enough for a 1/2 hour retention time in order to equalize flow into the plant. If the pH of the water is constant (less than a 1 point fluctuation) flow into the plant can be monitored with a flowmeter or float gauge (weir) which will regulate an automatic limer. In those cases where pH fluctuation is more than 1.0, a pH electrode should be substituted for the flowmeter/float gauge system. Placed above the limer no gelatinous hydroxide precipitates should accumulate on the electrode if the pH is below 4.5; however, it will be necessary to periodically clean and standardize the electrode.

A plant designed to neutralize acid mine drainage to a pH range of 6.0 to 8.0 must settle out precipitates which are primarily gelatinous ferric hydroxide. The solubility of ferric hydroxide is such that it will precipitate at a pH of 4.5 or higher. Small concentrations of ferrous iron are found in most samples of A.M.D. Because ferrous hydroxide will not precipitate unless the pH is above 10.0, aeration is needed to oxidize the ferrous iron to the ferric form.

After aeration the treated water flows into settling lagoons with storage capacity for 1 day retention. During this period the sludge settles to the bottom of the lagoon and, as it accumulates, is pumped into drying beds where it is dewatered and later removed to a disposal site. Water from the sludge drying beds is recycled to the settling lagoons before it is released into the receiving stream. After the neutralization cycle is completed a flow cell pH meter can be used to monitor the effluent from the plant. The electrodes in a flow cell pH meter are designed so that they can function properly should some coating accumulate. A schematic diagram of the components of an acid mine drainage treatment plant is shown in Figure VIII, page 41.

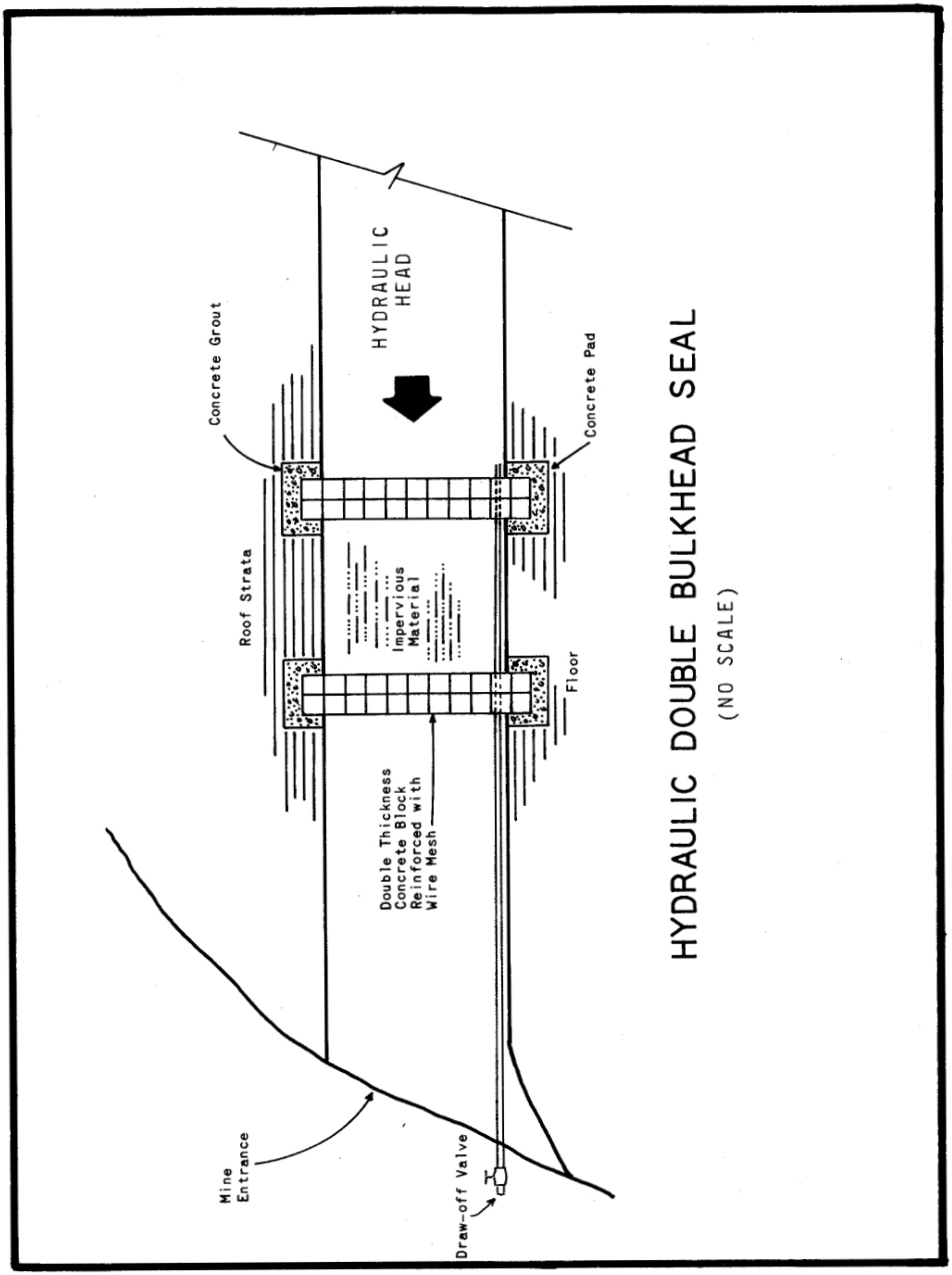
IV Stream Neutralization

Stream neutralization is a measure to improve water quality until abatement plans at acid mine drainage sources can be implemented, after which it could supplement abatement plans. This can be accomplished by any type of lime introduction, but limestone gabions placed in the stream bed offer the possibility of greatest stream improvement at lowest cost given the irregular flow pattern of streams under consideration.

The water quality of Babb Creek at Morris before its confluence with Wilson Creek (station CI-4a, average pH--5.6, net acidity--1152 lbs./day), may indicate that if sufficient stream neutralization can be achieved upstream it may allow a significant portion of the creek to support aquatic life.

Details of a "Stream Improvement Plan" are offered on pages 84-91.

FIGURE VI



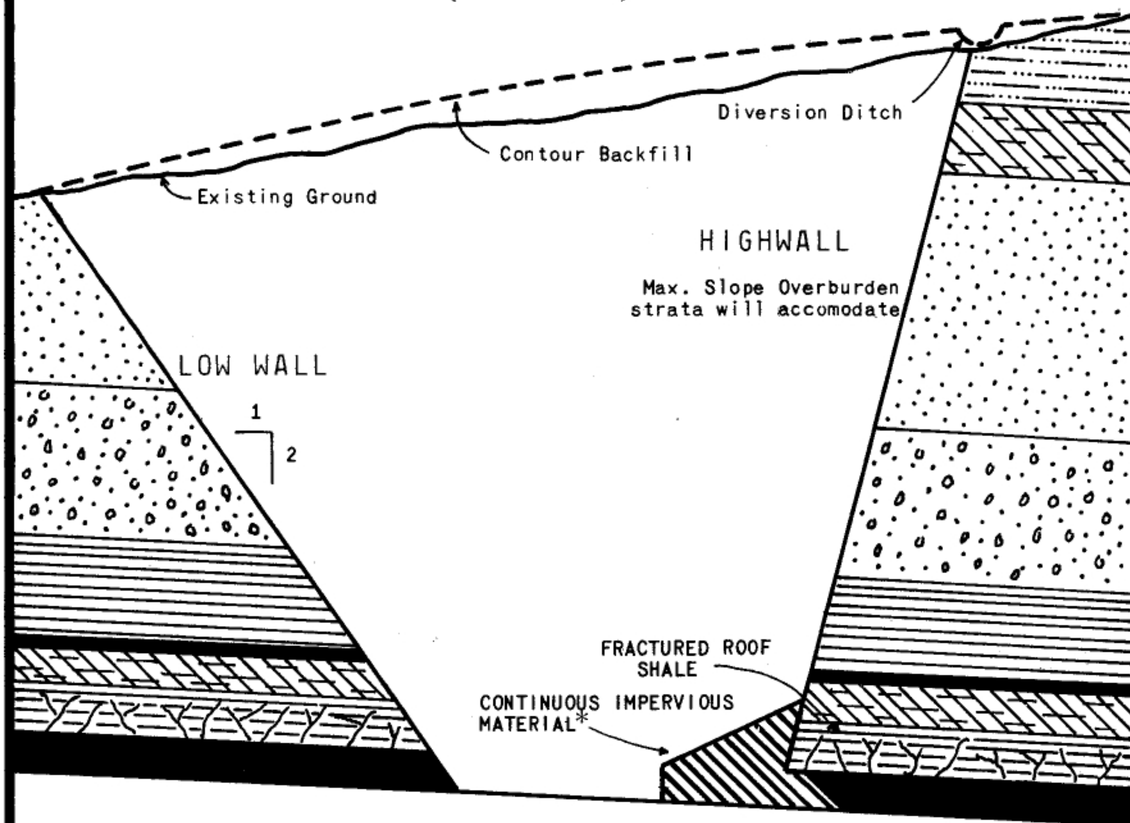
HYDRAULIC DOUBLE BULKHEAD SEAL

(NO SCALE)

FIGURE VII

TYPICAL CROSS-SECTION FOR SEALING TRENCH

(NO SCALE)

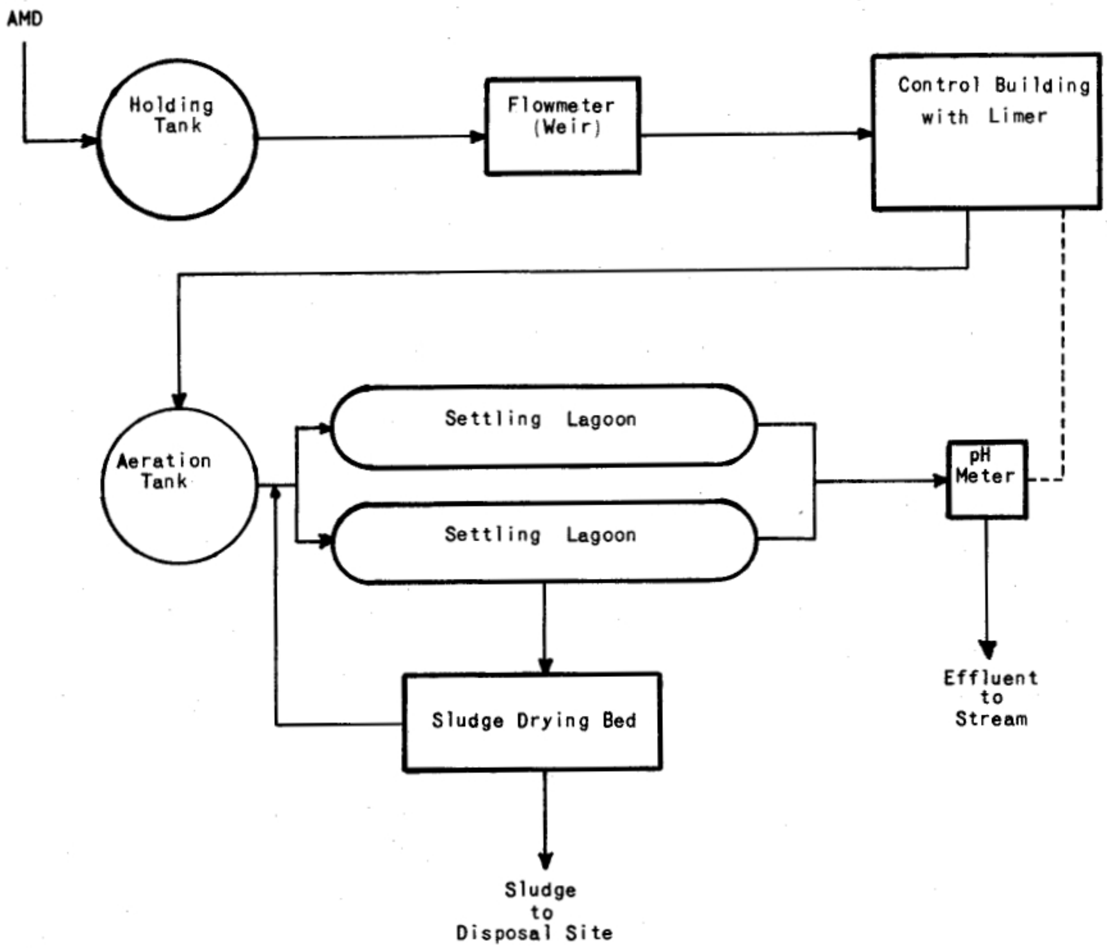


CONTINUOUS CLAY PACK INVERTED DAM

*COMPACTED IMPERVIOUS MATERIAL TO EXTEND ABOVE FRACTURED STRATA

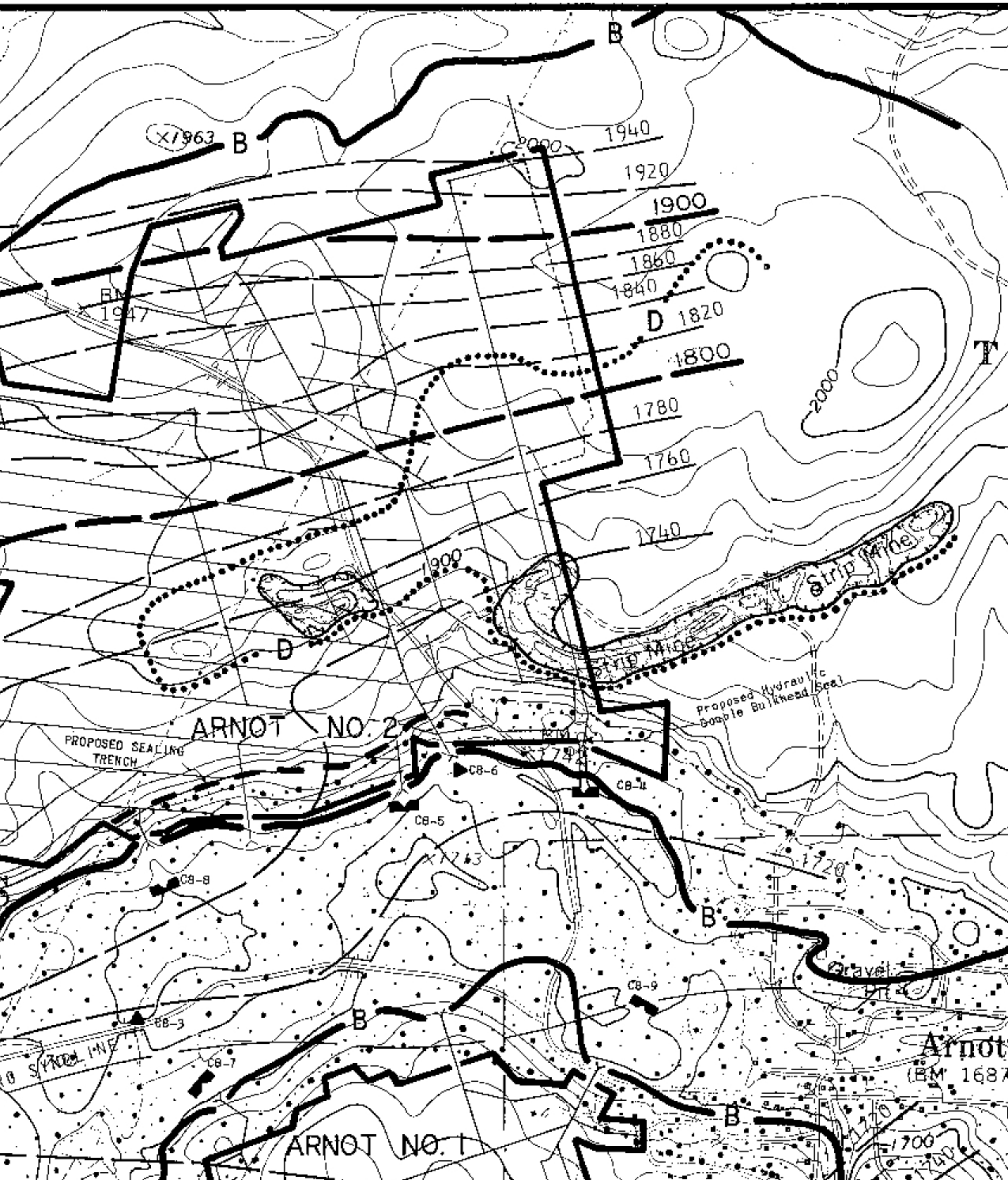
FIGURE VIII

TYPICAL TREATMENT PLANT



LIME NEUTRALIZATION - AERATION - DEWATERING
SLUDGE REMOVAL PROCESS

OF ARNOT MINING COMPLEX



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THE ARNOT MINING COMPLEX - PLATE IV

The Arnot Mining Complex, located approximately 3 miles southwest of Blossburg, once supported one of the largest mining communities in Tioga County. At the turn of the century the Blossburg Coal Co. operated as many as seven separate deep mines near Arnot. Most of the mineral rights were later sold to the Northwest Mining and Exchange Corp. This corporation granted a lease to Norman Guy in 1947-49 which resulted in two stripped areas near Arnot that were not reclaimed. Jones and Brague Mining Co. of Blossburg, Pa. now owns mineral rights in the Arnot area, but presently there is no active mining (surface or sub-surface) going on within the Complex.

Two abandoned underground mines and an abandoned strip mine are partially. within the watershed boundary. The two underground mines are situated on the divide between Lick Creek, a tributary of Babb Creek and Johnson Run, a tributary of the Tioga River. The axis of the Blossburg Syncline is coincident with the valley floor.

Arnot No. 1 Mine, on the Bloss coal bed, is situated on the southern flank of the syncline. Mining was in a southerly direction to the rise from the valley floor to a level about 200 feet above the valley. The mapped periphery of the mine is an area of approximately 393 acres. Most of the drainage from the Arnot No. 1 Mine does not discharge to the Babb Creek Watershed. With negligible exceptions, the discharge is alkaline and would pose little concern to Babb Creek reclamation. During warm weather months this water is used as a public water supply for the village of Arnot and plans are now being implemented to make it a year-round source. The local Sportsman's Club has built a fish hatchery which also uses this discharge as a water source.

Arnot No. 2 Mine was also developed on the Bloss coal, but was mined to the rise on the northern flank of the Blossburg Syncline from the valley floor. Approximately 620 acres of the Bloss coal, averaging about 30" in thickness were mined. Five drift entries have been located, three of which are discharge points for mine drainage at elevations of between 1710 and 1720 feet. In general, the drifts were excavated or driven into bedrock through a veneer of end moraine glacial deposits on the valley wall. These deposits locally obscure bedrock and are overlaid or mixed with slope talus just above the valley floor.

Two abandoned strip mines covering approximately 20 acres are present on the Seymour coal in the vicinity above the Arnot No. 2 Mine. No other coals were mined in this part of the complex.

Typical bedrock composition above the Bloss coal in the vicinity of Arnot is illustrated in Figure II of the Geology section of this report. The bedrock, comprised of dark, sandy shale and/or sandstone layers approximately 10-30 feet thick above the Bloss, was neither strongly weathered nor badly broken where observed in the valley.

As shown by structure contours on the Bloss coal plotted in Plate' IV, the mine workings rise to the north about 200 feet at a rate of 2% close by the entry, steepening to about 10% near the outcrop at the northern boundary of development. Bedrock overburden ranges from approximately 20 feet to more than 160 feet locally. No surface evidence of mining subsidence was found.

Table C represents a condensed summary of water analysis applicable to the Arnot Mine Complex. Three entries to the Arnot No. 2 Mine have discharges. Of the total 1.28 million gallon flow from the mine, the easternmost entry (station C8-4) releases 50% of the total discharge, but only slightly more than 16% of the total acid load (652.2 lbs./day) from the mine. The discharge from this entry flows into the Tioga River Watershed.

The other entries (C8-5 and C8-8) drain into the Babb Creek Watershed. For the complete monthly water analysis and loading data at each mine drainage discharge station see Appendix C, p. 123. Location descriptions of the reconnaissance water sampling stations along with the 12-month water sampling and flow measuring stations are given in Appendix A, p. 98. Water analysis for those stations is listed in Appendix B, p. 106.

TABLE C

	STATION	FLOW MGD	pH	ACIDITY LBS./DAY	ALKY. LBS./DAY	TOTAL FE LBS./DAY	FERROUS LBS./DAY	SULFATE LBS./DAY
Arnot	C8-4	.645	4.8	107.0	58.3	1.60	.37	910.8
No. 2	C8-5	.214	3.4	122.3	0	2.38	.28	282.4
Mine	C8-8	.423	3.4	422.9	0	4.55	.37	613.6
TOTAL		1.282		652.2	58.3	8.53	1.02	1806.8
Arnot	C8-7	.027	5.6	2.2	3.4	.02	0	20.9
No. 1 Mine	C8-9	.557	6.0	26.4	90.0	1.03	.05	364.1
TOTAL		.584		28.6	93.4	1.05	.05	385.0

ABATEMENT:

Arnot No. 1 Mine: Drainage at stations C8-7 and C8-9.

Water quality data indicate that this mine is not a source of acid mine drainage. This information, combined with the fact that water from the mine (monitored at station C8-9) is used as a public water supply, is the basis for recommending that no abatement procedures be implemented at the Arnot No. 1 Mine at this time.

Arnot No. 2 Mine: Pollution sources at C8-5 and C8-8 and drainage at station C8-4.

Inundation: For complete inundation of this mine a head of 200 feet near the lower level of the mine would have to be developed. There is, however, some concern that rooms near the entries may not have sufficient barriers to maintain the anticipated head. In light of this possibility, an alternative trench seal is considered as a means of inundating a portion of the mine.

A sealing trench would consist of a cut approximately 3200 feet long excavated to an average depth of 60 feet to bring it below the Bloss vein. All overburden would be segregated and impervious material compacted against the highwall mineral seam and old workings. Pollution forming material would be placed above the impervious barrier and clean spoil compacted in the upper portion of the trench. Clean fill and topsoil would be regraded over the surface, a diversion ditch constructed along the highwall side and the area (14.2+ acres) replanted. (See Figure VII, page 40.)

Such a sealing trench or continuous clay pack inverted dam constructed from the drift at the west end of the mine (station C8-8) to the entry at C8-6 could be expected to maintain a hydraulic head pressure of 60 feet. A mine pool with a top water elevation at 1780 feet would inundate approximately 50% of the mine if the entry at station C8-4 is also sealed. A conventional hydraulic double bulkhead seal (see description, page 35 and Figure VI, page 38) would maintain the anticipated head if anchored in stable material and the area near the entry injected with grouting. A mine pool draw-off valve could be installed in the seal to control excessive build-up of hydraulic pressure. However, topography does not permit the effective placement of a mine pool overflow at elevation 1780.

In order to monitor the rise in water elevation and obtain water samples, tap-off holes should be drilled into mine headings behind the trench seal. Exploratory bore holes needed for final design of the trench seal could be used for tap-offs in many instances.

Estimated construction cost of sealing trench with surface revegetation (includes exploratory boring):	$ 560,900.00
Estimated construction cost of one (1) hydraulic double bulkhead seal with grouting:	20,000.00
Access road improvement:	2,900.00
TOTAL	$ 583,800.00

Estimated recoverable coal:		1,470 tons
Cost effectiveness per lb. of acid/day*	$	1,491.95

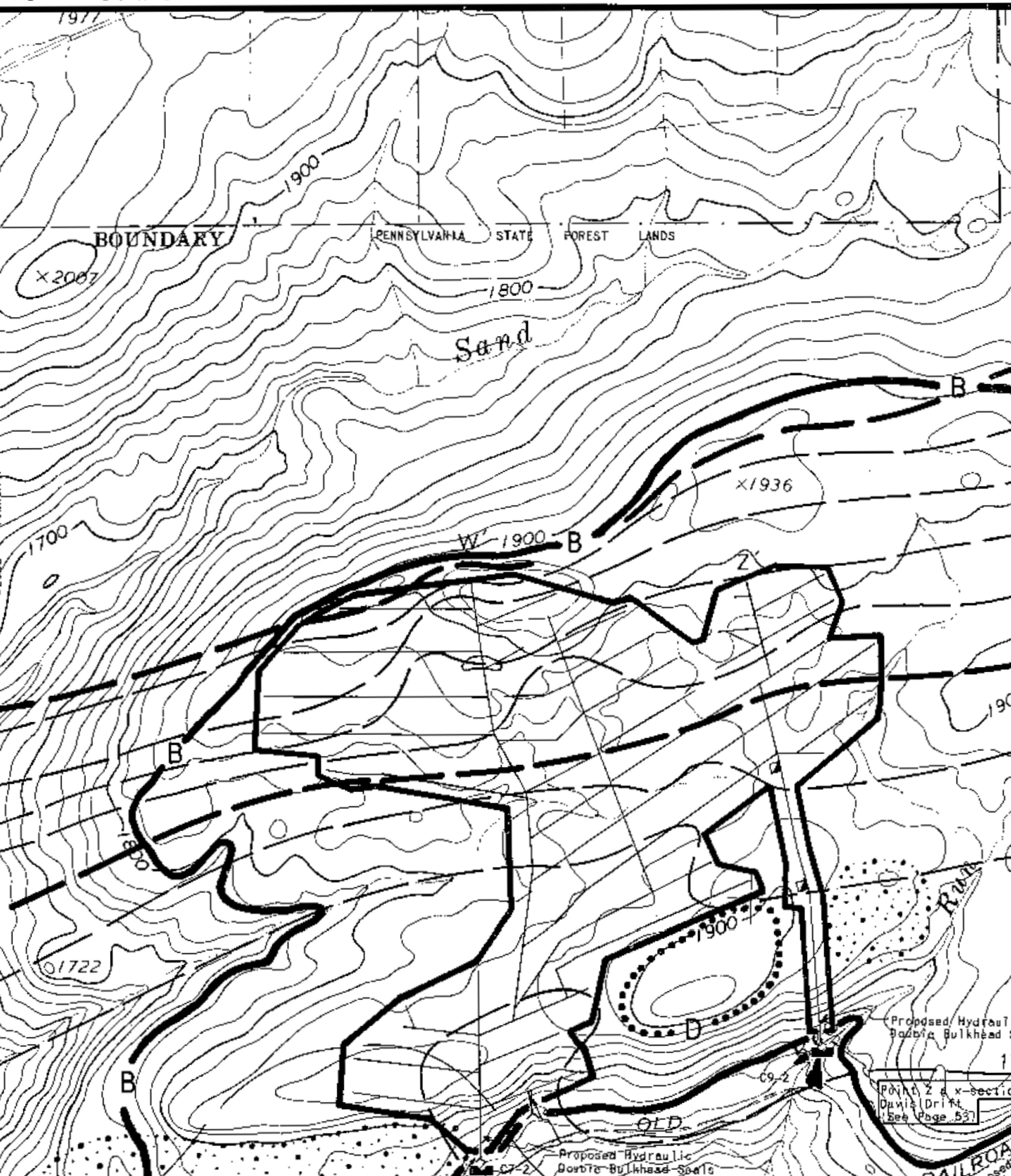
Neutralization: Arnot No. 2 Mine - Pollution sources C8-5 and C8-8. Because rooms near the entries of the Arnot No. 2 Mine may make the success of conventional hydraulic mine sealing speculative and because the cost of a trench seal may be excessive, the possibility of treating the acidic discharges at C8-5 and C8-8 has been considered. A plant located near the Monkey Drift (station C8-8), with a capacity of 1 MGD to accommodate maximum flow conditions, could treat both discharges. A narrative description and a diagram of the plant components can be found on page 37, Figure VIII, page 41.

Estimated construction cost of neutralization plant:	$	50,400.00
Estimated operating costs (1 year):	$	6,460.00
Estimated cost of sludge drying and disposal:	$	3,230.00
TOTAL 1ST YEAR COST:	$	60,090.00
Cost effectiveness per lb. of acid/day (1st year):	$	110.20

Surface Reclamation: Approximately 19.7 acres of unreclaimed strippings in the Seymour vein lay above the Arnot No. 2 Mine. These are portions of the 1939 Norman Guy permit and they are on State Forest Land. Both areas have revegetated themselves and no evidence of acid run-off was found. Because no relationship between these strippings and acid mine drainage is apparent, their reclamation cannot be justified at this time.

Computation based on a 60% estimated reduction of the acid load referable to the mine. It does not represent cost-less-value of recoverable coal. 652.2 lbs./acid/day x .60 = 391.3.

NG COMPLEX



1977
1900
BOUNDARY
PENNSYLVANIA STATE FOREST LANDS
×2007
1800
Sand
B
×1936
1700
W'
1900
B
Z'
B
1800
190
Run
1900
D
1722
Proposed Hydraul
Double Bulkhead S
C9-2
Point Z & x-sectio
Davis Drift
(See Page 53)
OLD
B
Proposed Hydraulic
Double Bulkhead Seals
C7-2
RAILROA

THE KLONDIKE COMPLEX - PLATE V

The Klondike Mine is located in Bloss Township approximately 2.4 miles west of Arnot. The mine was originally operated by the Blossburg Coal Co. and later by the Northwest Mining and Exchange Corp. until it was abandoned in 1930-35. Although known locally as "The Klondike Mine" the official name is recorded as "The Maple Hill Mine".

Access to the mine is along an abandoned railroad siding once owned by the Erie Railroad which ran from Morris to Arnot and connected to the now abandoned main line in Blossburg. Access is limited in the winter months.

Approximately 270 acres of Bloss coal was mined at the Klondike Mine. The coal was mined up dip on the north flank of the Blossburg Syncline as shown in Plate V and the cross-section in Figure IX. The coal bed is relatively flat-lying in the southern half of the mine, rising gently at a rate of 2 percent or less from the entries. Northward the coal rise is sharply increased. Mine records indicate an average rise of 6 percent in that sector of the mine. However, local dips of 25 degrees are indicated. Overall rise of the mine workings above the entries is on the order of 160 feet. There is no evidence that any other coal seam was mined. The mineral rights in this area are now owned by the Jones and Brague Mining Co. of Blossburg, Pa. and the surface is State Forest Land.

There are three drift entries into the Klondike Mine, two of which are discharge points for acid mine drainage. Flowing drifts were closed with air seals shortly after the mine was abandoned. (See stations C7-2 and C9-2, Map No. 3A.) The drift at station C9-2 may have been a watercourse known locally as "The Davis Drift". Mine maps do not show mining along the Davis Drift for a distance of 1200 feet. The flow from this entry goes directly into Red Run, a tributary of Lick Run. Mine drainage from station C7-2, the main entry for the Klondike Mine, runs in a well-defined channel along the east side of a spoil pile and into Lick Run at a point 800+ ft. downstream from the confluence of Red Run and Lick Run. The average combined flow of the two discharges is 0.670 million gallons per day with an acid load of 686.9 pounds per day. This is approximately 24% of the acid load flowing into Babb Creek above Morris and 6.4% of the total acid load within the Watershed.

TABLE D

	STATION	FLOW MGD	pH	ACIDITY LBS./DAY	ALKY. LBS./DAY	TOTAL FE LBS./DAY	FERROUS LBS./DAY	SULFATE LBS./DAY
Klondike	C7-2	.462	3.1	564.7	0	35.25	0.64	1303.8
Mine	C9-2	.208	3.4	122.2	0	4.72	0.32	231.6

Complete monthly water analysis and loading data for each station are given in Appendix C, p. 122 and p. 125.

ABATEMENT

Inundation: Topographic conditions above the Klondike Mine are illustrated by cross-sections (Figure IX). Mine maps do not show development close to the crop line and the overlying strata appears undisturbed, therefore, inundation is possible. A theoretical head pressure exceeding 150 feet would be required for complete inundation. Broken and weathered strata are assumed to be present in thinner cover (40 feet or less) found in the northern portion of the mine. Evaluation of these conditions indicate that a head of 65 feet is realistically obtainable. A 65 foot high mine pool (mine elevation 1790) would permit inundation of approximately 60 percent of the workings, and should eliminate 75 percent or more of the pollution referable to the mine. Hydraulic double bulkhead seals installed in the main entry (station C7-2) and in the Davis Drift (station C9-2) would shut off the existing flow of A.M.D. from the mine. The drift 500+ ft. east of the main entry that presently is not a discharge point should also be sealed. The circumference of each seal, as well as any weaker strata adjacent to it, should be injected with grout to protect the integrity of the impoundment. A narrative description of the hydraulic double bulkhead seal is given on page 35. Figure VI, page 39 shows a typical crosssection of this type of seal.

Proof boring to determine site conditions at the proposed seal location should be done during the design phase of the plan implementation. Some of the bore holes drilled into the mine working can be cased and later used for a mine pool tap-off once inundation is complete. A more ideal location for mine pool tap-off would be at a mine elevation of 1790 where the pool will be stagnate and the water less contaminated; however, the cost effectiveness for the excavation and/or the lateral boring required in order to reach this mine elevation cannot be projected at this time.

Surface Reclamation: Although there has been no surface mining done in the Klondike Complex, two spoil piles near the main entry and the Davis Drift should

Estimated construction cost of three (3) hydraulic double bulkhead seals with grouting:	$ 60,000.00
Access road improvement (includes bridge crossing at Red Run):	$ 20,100.00
TOTAL	$ 80,100.00
Cost effectiveness per lb. of acid/day*:	$ 155.48

Cost effectiveness computed on expected 75% reduction of daily acid load from mine discharges at station C7-2 and C9-2. 686.9 lbs. acid/day x .75 = 515.2.

be graded and revegetated. Examination of the flora below the spoil piles indicate that they do not contribute significantly to the pollution of Lick Creek; however, grading and revegetation of the piles would help any hidden downward percolation into the subsoil which, though suspected, cannot be demonstrated at this time.[l] See mine waste piles shown at stations C7-2 and C9-2, Plate VI.

Estimated construction cost of grading, covering and revegetating 7.2 acres @ $2,000.00/acre:	$ 14,400.00

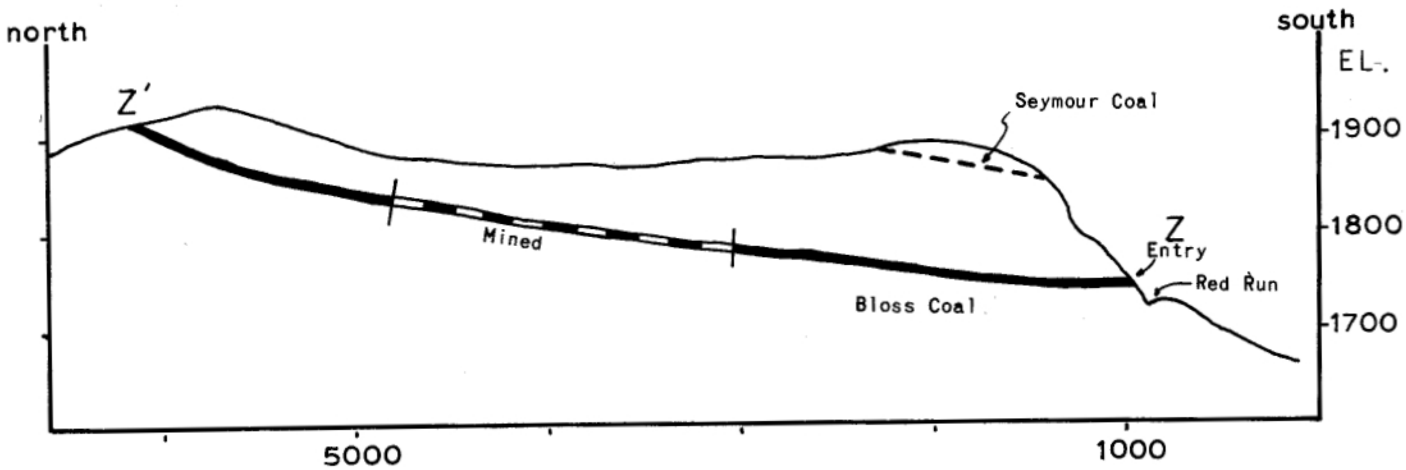
FIGURE IX

CROSS-SECTIONS AT ENTRIES

KLONDIKE MINE

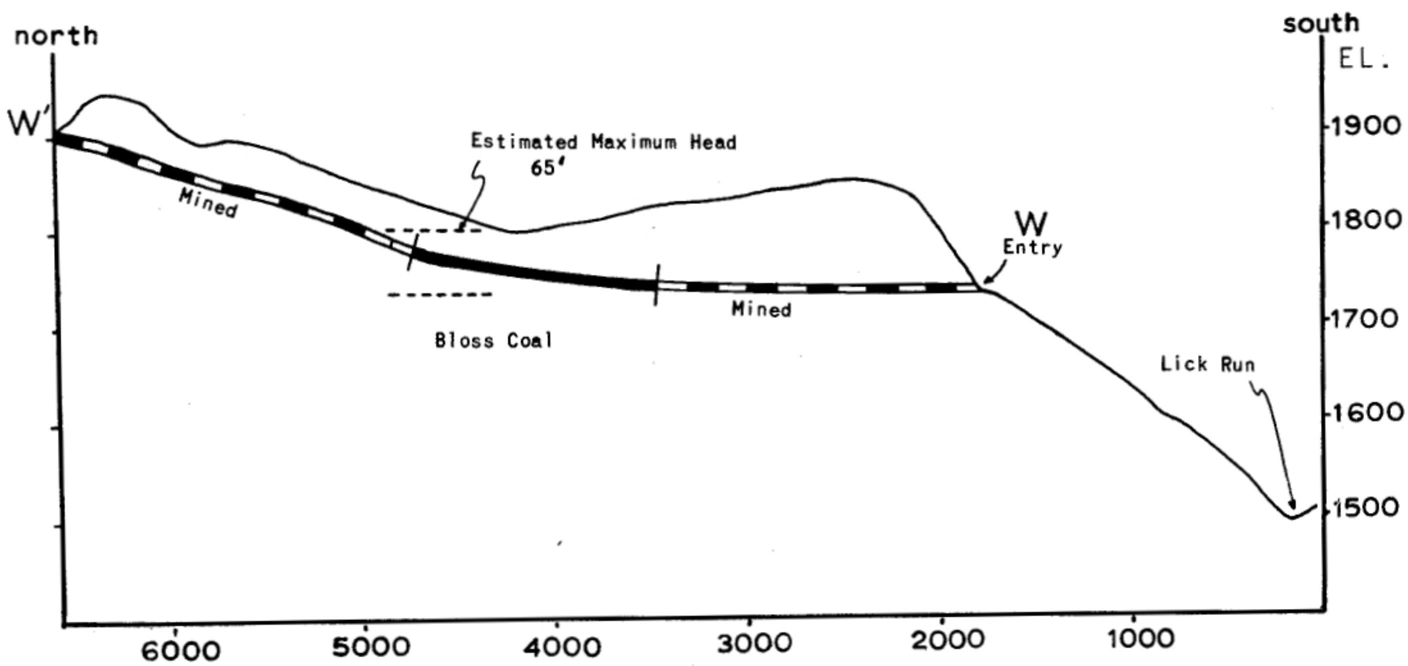
(MAPLE HILL MINE)

HORIZONTAL SCALE 1" = 1000 FEET
VERTICAL SCALE 1" = 200 FEET
VERTICAL EXAGGERATION X 5



DATUM 1650

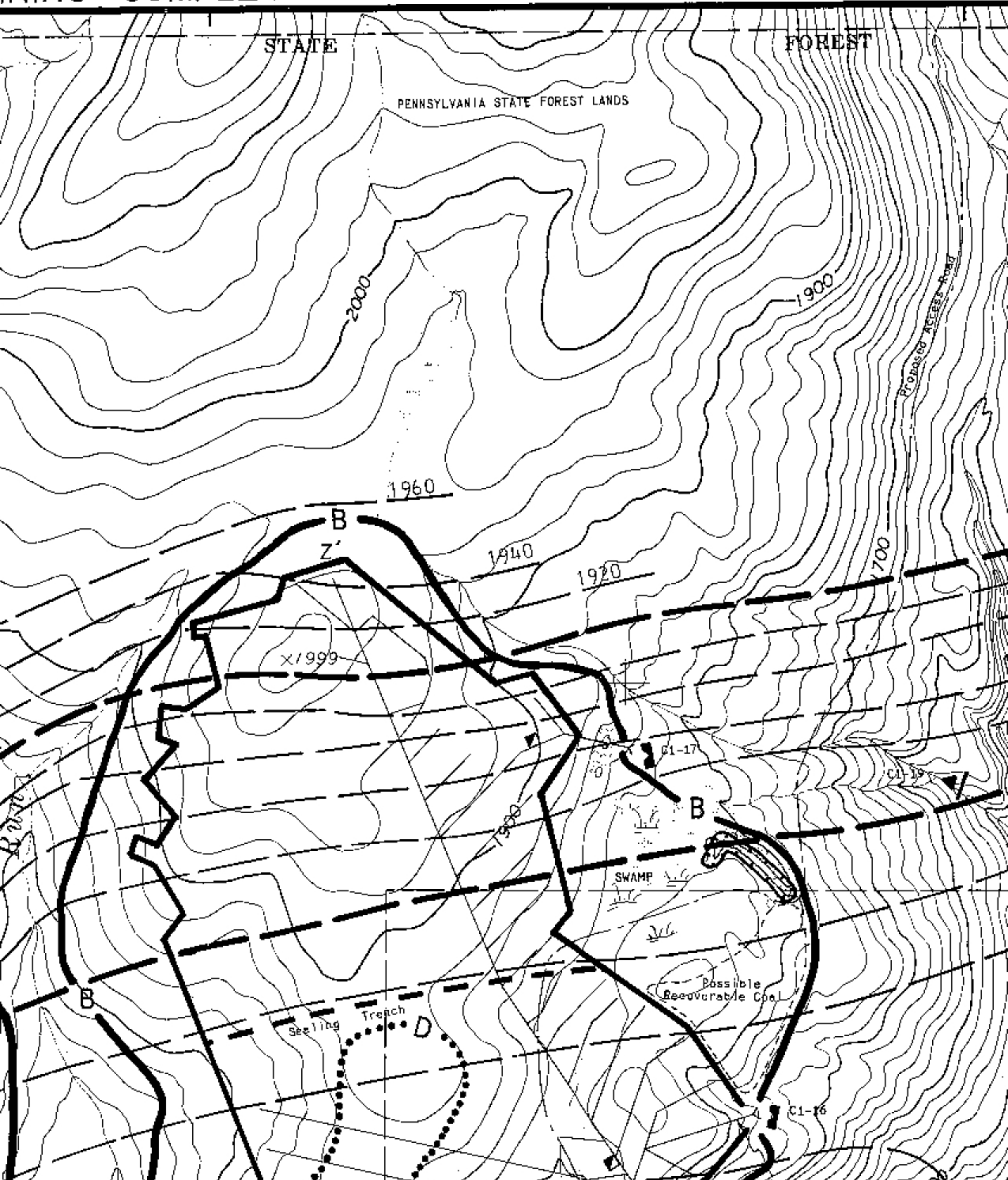
DAVIS DRIFT



DATUM 1450

MAIN ENTRY

INING COMPLEX



THE BEAR RUN MINING COMPLEX - PLATE VI

The Bear Run Complex is comprised primarily of the area of the Bear Run Mine and minor underground and surface mines on the Bloss coal which are marginal to, or interconnected with, the Bear Run mine workings. The mine is located approximately 0.5 miles west of the confluence of Babb Creek and Lick Creek and lies from 400 to 600 feet above the stream bed of Babb Creek.

As illustrated in Plate VI, the mined strata are situated to the north of the Blossburg Syncline axis. Here the Bloss coal (about 46" thick) rises gently northward, outcropping about 220 feet above the elevation of the principal mine entries. Up to 130 feet of strata, containing much sandstone, are present above the Bloss coal.

Little is known about the coals normally found above the Bloss seam. However, the Cushing and Morgan horizons apparently were tested. Lack of subsequent prospecting or other efforts suggests that these upper coals may be cut out, or not considered of potential value in the vicinity. The Seymour coal outcrop line shown in Plate VI is drawn on a persistent bench with a few minor seeps but no coal was seen.

The main entry for the Bear Run Mine is located on a narrow bench of the Babb Creek Valley's northwestern flank. From this point, the main heading extends in a northwesterly direction for approximately 6600 feet. Several major side headings extend toward the west for approximately 3000 feet. The entire mine periphery is an area of roughly 370 acres.

The mine was worked to the rise of the coal seam and where local dips occurred, pumps or siphons were used to maintain drainage. Deep mine operations were apparently discontinued about 1914-18. Later, several small strip mines were developed around the northern perimeter of the deep mine along the Bloss coal crop line. None of these strippings were extensive and no surface mining has been done since the early 1940's. In the late 1930's mine sealing was attempted on the main heading under the W.P.A. Federal program existing at that time.

The surface area involved with the Bear Run Mining Complex is now owned by the Commonwealth of Pennsylvania and is administered by the Bureau of Forestry of the Pennsylvania Department of Environmental Resources. The surface is primarily forested with second growth northern hardwood species and mature stands of aspen poletimber. Mineral rights are owned by the Jones and Brague Mining Co. of Blossburg, Pa.

The northern section of the mining complex is drained by Rattlesnake Run and several swampy areas which are tributaries of this stream. Rattlesnake Run empties into Babb Creek at a point above any major influx of acid mine drainage. Further south, several small intermittent streams provide drainage for the major portion of the undermined area. The western extremities of the Bear Run Mine lie within the Nickel Run watershed but no evidence of acid mine discharges entering Nickel Run was observed.

The major points of A.M.D. appear along the southeastern portion of the undermined area. There are four acid mine discharges from the Bear Run Mine: the largest (1134 lbs. of acid/day) at No. 1 entry (CI-14), and smaller discharges at No. 2 entry (C1-15), No. 3 (C1-16) and at Brown's Drift (CI-17). Table E presents the average daily loading for these discharges. Water analysis of Babb Creek above and below the primary A.M.D. influx from the No. 1 entry (CI-14) is listed in Appendix B, station C1-14a and station CI-IIa, page 104.

For complete monthly water analysis and loading data for all water sampling and flow measuring stations in the Bear Run Mining Complex, see Appendix C, pp. 119-120.

TABLE E

STATION	FLOW MGD	pH	ACIDITY LBS./DAY	ALKY. LBS./DAY	TOTAL FE LBS./DAY	FERROUS LBS./DAY	SULFATE LBS./DAY
C1-14	0.598	3.1	1134.5	0	70.91	5.26	1591
C1-15	0.012	3.3	16.3	0	4.90	8.04	29
C1-16	0.129	3.2	194.8	0	22.07	0.09	254
C1-17	0.036	3.2	40.4	0	0.96	0.23	68
TOTAL	0.775		1386.0	0	98.84	13.62	1942

The net acid load from the Bear Run Mine (1386 lbs./day) is approximately 43% of the total load flowing into Babb Creek above Morris and 11% of the total acid load within the watershed.

ABATEMENT

Access Road Improvement and Relocation: The access road from the Leslie Reese farm, which runs in a southerly direction from its intersection with Pa. L.R. 58038, is the most feasible way to gain access to the Bear Run Mine. A recent timber sale on State Forest lands has improved a section of this road extending from the intersection southerly approximately 3000 ft. from Pa. L.R. 58038. The remainder of the existing road could be improved by grading, by improving drainage and relocating a section through the woods on a less severe grade. The roads should be extended southerly across Rattlesnake Run to a point east of the swamp. At this point the road would rejoin the existing road which runs along and then across the swamp. The road could be roughed in so that drilling equipment could be brought to the mine area and the road would gradually be improved as operations progressed.

A merchantable stand of aspen poletimber and some hardwood poletimber and light sawtimber covers a major portion of the land overlaying the mined area. It is recommended that this timber be put up for sale by the Department of Environmental Resources. The logical way to remove this timber would be across the improved access road mentioned in the preceeding paragraph. Part of the cost of constructing the access road could be paid for by the sale of this timber.

Inundation: Although a theoretical head pressure of nearly 200 feet would be required for complete inundation of the Bear Run Mine, evaluation of the topographic and geological conditions suggest that a head pressure of 55 feet could be obtained by sealing the 3 entries into the lower level of the mine. (See entries at stations C1-14, CI-15 and CI-16 - Plate VI.) Mine maps do not show underground mine workings close to the crop line near the main entry (CI-14) and the No. 3 drift (CI-15) nor does the overlying strata appear disturbed.

Although "air-type" seals were installed in the main entry (C1-14) and the No. 3 drift (CI-15) 40 years ago, it will be necessary to replace them with conventional double bulkhead hydraulic seals as part of the mine inundation effort. The, entry at CI-16 would also have to be closed with a similar type of hydraulic seal and all areas adjacent to these seals grouted in order to inundate the lower 50% of the mine. A mine pool with a top water elevation of 1780 would be created if a head pressure of 55 feet was developed. With 50% of the mine inundated it could be expected that 60% of the acid load from the mine would be eliminated.

The surface elevation of the air shaft along the main heading and the entry at Brown's Drift (station C1-17, elevation 1814) are all above the expected top water elevation of the mine pool; therefore they would not have to be sealed unless further inundation was required. An evaluation of conventional double bulkhead hydraulic seals is given on page 35. Figure VI, page 39 is a cross-sectional illustration of this type of seal in place.

Estimated construction cost of three (3) hydraulic double bulkhead seals with grouting:	$	60,000.00
Access road improvement:	$	15,400.00
TOTAL	$	75,400.00
Cost effectiveness per lb. of acid/day*:	$	93.39

Further inundation of the mine would require the placement of a subsurface barrier such as a sealing trench that would extend east and west across the center portion of the mine at elevation 1780. A sealing trench, or continuous clay pack inverted dam, would be excavated into the mine workings from a point just west of the swamp to the western limit of the mine. The trench would be approximately 3300 feet in length and have an average depth of 70 feet. A more detailed narrative description of this type of subsurface barrier is given on pp. 35 and 36. See Figure VII, p. 40 for a cross-sectional illustration of the sealing trench design.

The cost effectiveness of constructing a subsurface barrier as described could be prohibitive if the construction were not related to future permitted surface mining. It is estimated that up to 100 acre feet of recoverable coal lies within the 25+ acre area east and south of the swamp. It is also possible that coal could be recovered from the underground mined section west of this area.

The decision to include surface mining as part of the abatement plan for the Bear Run Complex should be based upon data obtained from preliminary test boring. Since there is a strong possibility that proceeds from stripping the

Cost effectiveness computed on expected 60% reduction of daily acid load from the 3 mine discharges at stations CI-14, CI-15 and C1-16. 1345.6 lbs. of acid/day x .60 = 807.4.

coal in this area could help to defray the costs of acid mine drainage abatement, the test boring could be correlated with the stripping plan of operations. It is estimated that it will be necessary to drill 40 to 50 test holes and that the average depth of these holes will be 61+ feet. Thus, approximately 2700 lineal feet of boring will be required.

Provisions to do proof boring for the design and installation of the double bulkhead hydraulic seals in the mine entries could be included in the test boring program.

In areas where enough recoverable coal is found to make surface mining profitable, and in areas where stripping may only be economically marginal, it is recommended that this be seriously considered as the means by which acid mine drainage abatement can be accomplished. Any surface mining should be done in a manner consistent with the overall abatement plan for the area. All final cuts that expose underground mine workings should be sealed along the highwall as they are backfilled in order to create a subsurface barrier similar to the sealing trench described above.

Surface Reclamation: There is one small, unreclaimed stripping on the Bloss crop line along the eastern side of the Bear Run Complex. This is a single cut located on the eastern edge of the swamp and north of the present access road. No acid mine drainage has been directly

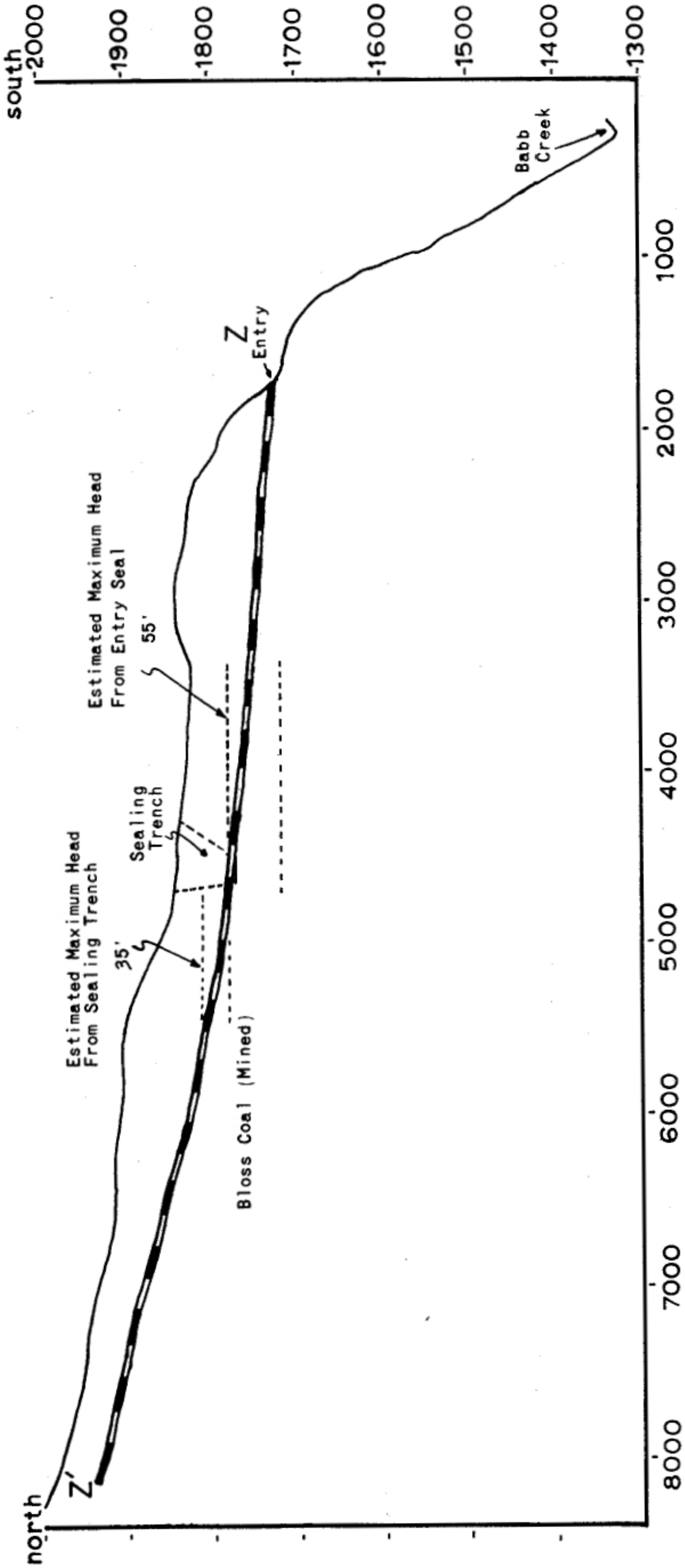
Estimated construction cost of sealing trench and surface revegetation at trench site:	$ 728,000.00
Estimated recoverable coal from trench site:	8,600 tons
Estimate of other recoverable coal at the Bear Run Complex:	180,000 tons

attributed to this stripping; however, backfilling and grading it to contour could become a part of other surface reclamation involved with the stripping and sealing trench proposal.

Reclamation of the spoil pile at the main entry (see analysis of spoil material, p. 22) could also be correlated with future surface mining. The spoil pile should be graded to the contour or possibly removed for fill at the strippings or the sealing trench. This would be feasible if the material were placed so that no ground water would filter through it. Any excess fill from the strippings or the trench could then be used as cover material at the spoil pile site. The area should then be fertilized and planted. A diversion ditch should be constructed along the upgrade side to prevent surface water from flowing over the restored area.

Estimated construction cost of backfilling and planting 4.4 acres of unreclaimed stripping @ $1,250.00/acre:	$ 5,500.00
Estimated construction cost of grading*, covering and revegetating 5.2 acres of mine refuse @ $1750.00/acre:	$ 9,100.00
TOTAL	$ 14,600.00

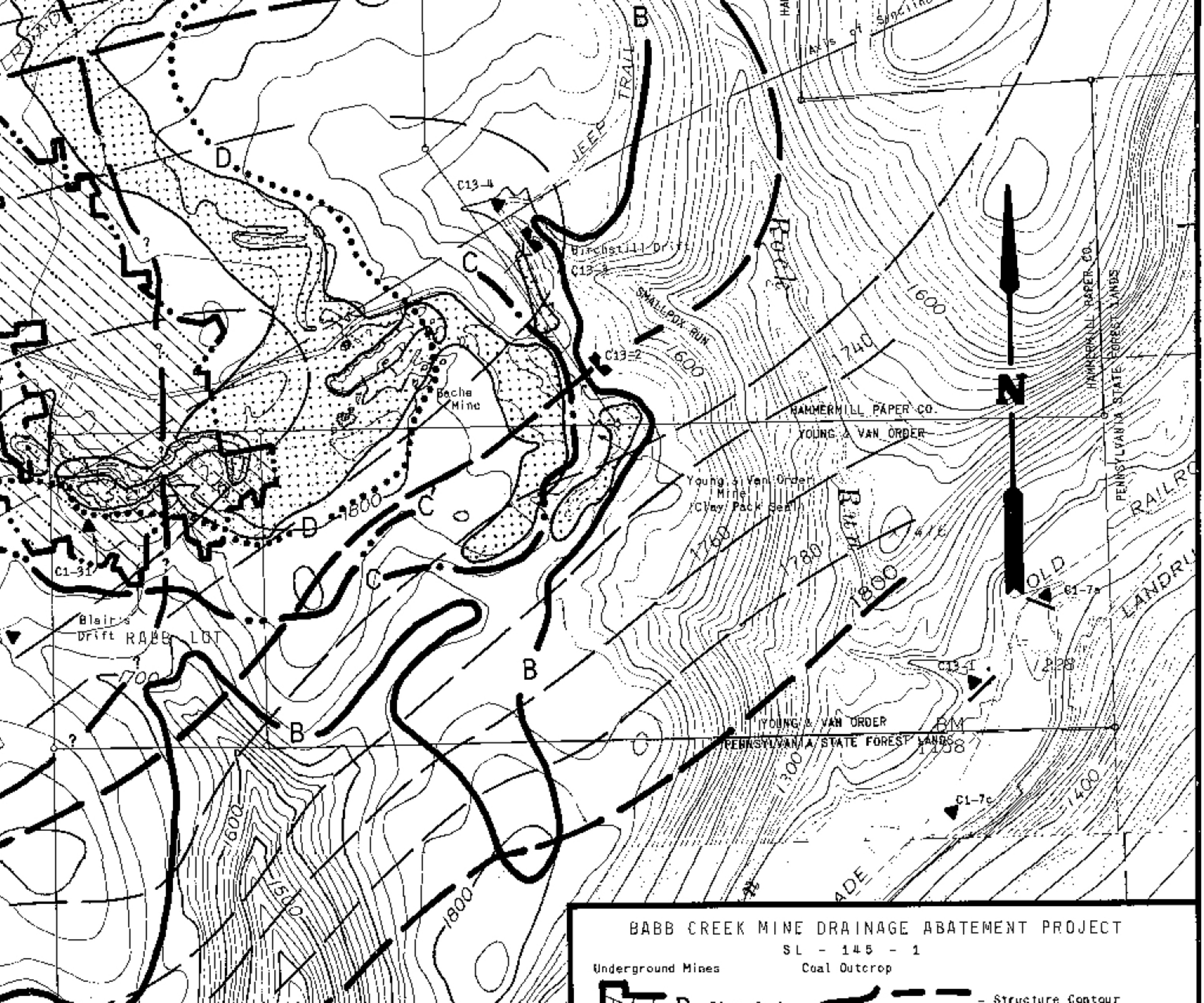
FIGURE X



CROSS-SECTION AT MAIN ENTRY

BEAR RUN MINE

Horizontal Scale 1" = 1000'
Vertical Scale 1" = 200'
Vertical Exaggeration X 5



BABB CREEK MINE DRAINAGE ABATEMENT PROJECT
SL - 145 - 1
Underground Mines
Coal Outcrop
Structure Contour
HAMMERMILL PAPER CO.
PENNSYLVANIA STATE FOREST LANDS
YOUNG & VAN ORDER
Young & Van Order Mine (Clay Pack Seam)
Bache Mine
Birchstill Drift
Blair's Drift
BABB LOT
JEEP TRAIL
SMALLPOX RUN
Rock Run
OLD LANDRUM RAILROAD GRADE
Axis of Syncline
N
C13-4
C13-3
C13-2
C13-1
C1-31
C1-7a
C1-7c
1600
1740
1760
1780
1800
1700
1500
1400
1300
B
C
D

THE ANTRIM MINING COMPLEX - PLATE VII

The Antrim Mining Complex is located near the village of Antrim in Duncan Township. The coals in the Antrim Complex are preserved on the plateau in a shallow basinal structure along the axis of the Blossburg Syncline. The syncline is situated north of Babb Creek and parallels that creek between Wilson Creek and Rock Run. Here the coals are more than 450 feet above the base drainage of Babb and Wilson Creeks. In the absence of adequate mine maps of the main Antrim Mine, the structure of the Bloss coal, shown on the geologic map - Plate II and in Plate VII, has been interpreted from fragmental boring records, photogeologic study and tracing of coal benches in the field.

Locally as much as 180 feet of strata are preserved in the axis of syncline above the Bloss (B) coal. (See Geology Section, Figure III for characteristic columnar sections.) The strata contain other economic coals which have been mined by both surface and underground extraction methods, including the Cushing (C), Morgan (C') and Seymour (D) coals.

The coals between the Bloss and Seymour horizons (Cushing and Morgan) are mapped only locally and are thought to be lenticular and highly variable throughout the Complex.

The mines at Antrim were operated by the Fall Brook Coal Co. from 1872 until the early 1900's when they were abandoned. In 1940 the Antrim Coal Co. reopened the No. 1 Drift but local miners relate that mining was limited to pillar removal.

The Antrim Mine: The largest mine at Antrim, and the primary source of acid mine drainage in the Complex, extends eastwardly from the main entry (Antrim No. 1 Drift-station B1-14) located just south of the village. Conversations with miners at Antrim have produced accounts of the operation of the mine, but the total area of the mine is not known. They have stated that both the Bloss and Cushing coals were mined and drawn out through the No. 1 and No. 2 Drifts.

Flow data at the mines point of discharge (station B1-14, 2.341 MG/ day) indicates that roughly 1360 acres are drained and channeled through this watercourse. (See Estimates of Deep Mined Areas, page 28.) This flow carries an average acid load of 3768.6 lbs./day which is 34% of the total acid load from all sources within the watershed.

The Backswitch Mine: The other discharge point of acid mine drainage at Antrim is located on the railroad backswitch north of the village (station B1-16). There is evidence that this mine is connected with the Antrim No. 2 Drift but, without adequate mine maps, the exact relationship has not been determined. The flow from the Backswitch Mine averages 0.158 MG/day with an acid load of 274.5 lbs./day..

The Cope Mine: A small mine known locally as the Cope Mine is the only other known source of acid mine drainage that flows into Wilson Creek from the east. It is located east of Devil's Elbow on the south fork of Wilson Run, a tributary of Wilson Creek. There are two drift entries at this mine. One is a discharge point for acid mine drainage (station BI-24). The other Sampling and Flow Measuring Station monitors a spring-fed flow that runs through a small spoil pile (B1-2"5). The combined flow at these two locations averages 0.080 MG/day with 25.6 lbs. of acid per day.

The Rock Run Mines: Two miles east of Antrim on the western flank of the Rock Run hollow are several small mines known collectively as the Rock Run Mines. Some apparently were "farmer's drifts" or small individual operations, two of which are sources of acid mine drainage which flows into Smallpox Creek, a tributary of Rock Run._ The discharge points are designated as Sampling and Flow Measuring Stations C13-2 and C13-3. (See Plate VII.)

Drainage from the Young and VanOrder Mine is monitored at station C13-2 and has an average daily flow of 0.065 MG/day and an acid load of 362.4 lbs./ day. The other discharge comes from what is known locally as the Birchstill Drift (station C13-3), and averages a flow of 0.021 MG/day with an acid load of 67.5 lbs./day. The two discharges combine to account for 14% of the acid load attributing to mine sources which flow into Babb Creek above Morris.

Surface mining: Surface mining has disturbed roughly 500 acres throughout the Antrim Complex. Stripping operations have taken place over the years, the largest and most recent being that of the Jones and Brague Mining Co. of Blossburg, Pa. (1958-1970). Most of the stripping has been reclaimed and, with the exception of small isolated areas, revegetation is progressing satisfactorily.

Table F presents a loading summary for the discharges in the Antrim Mining Complex. Monthly water analysis and loading data for each station are listed in Appendix C.

TABLE F

STATION	FLOW MGD	pH	ACIDITY LBS./DAY	ALKY. LBS./DAY	TOTAL FE LBS./DAY	FERROUS LBS./DAY	SULFATE LBS./DAY
B1-14	2.341	3.2	3768.6	0	170.21	19.48	8288.0
B1-16	0.158	3.1	274.5	0	6.38	0.23	808.8
B1-24	0.018	3.8	9.3	0.05	0.30	0.19	12.3
B1-25	0.072	4.5	16.3	3.30	0.23	0.14	44.0
C13-2	0.065	3.2	362.4	0	8.16	1.92	1147.4
C13-3	0.021	3.4	67.5	0	1.02	0.45	49.1

Estimated construction cost of 2 hydraulic double bulkhead seals, grouting and proof boring:	$ 37,000.00
Estimated construction cost of placing impermeable barrier in pre-act stripping, backfilling, grading and vegetation:	$ 44,000.00
TOTAL	$ 81,000.00
Cost effectiveness per lb. of acid/day:*	$ 28.66

The Backswitch Mine: Pollution source B1-16..

A mine pool of 40 feet in the Antrim Mine would not inundate any portion of the Backswitch Mine even though the possibility exists that the two mines are interconnected. To inundate the Backswitch Mine and abate the discharge from this area, the watercourse at station BI-16 should be sealed as well as three other drift entries in the southern perimeter of the mine which are presently dry. (See Backswitch Mine-Plate VII.)

Inundation: Miners at Antrim have stated that portions of the mine are already inundated. This may be possible since the elevation of the watercourse at station BI-16 (1740) is above the structure of the Bloss coal as it is thought to exist. Therefore, it is possible that by creating a mine pool with a head pressure of 40 feet and a top water elevation of 1780, that a significant portion of the mine would become inundated.

The type of hydraulic seal used at these locations should depend upon results of proof boring that will determine the extent of mining near the crop line and the condition of the strata above the coal. Because coal was stripped along the Bloss crop line above the entry at station B1-16, the

Cost effectiveness computed on expected 75% reduction of daily acid load from mine discharge at station BI-14--3768.6 lbs. of acid per day x .75 = 2826.4.

placement of a hydraulic seal at this location should be north of the disturbed area. Grout curtains should be placed adjacent to all hydraulic seals where proof boring indicates they are necessary.

The Cope Mine: Drainage at stations BI-24 and B1-25.

Estimated construction cost of 4 hydraulic double bulkhead seals, grout curtains and proof boring:	$	72,000.00
Cost effectiveness per lb. of acid/day*:	$	327.87

The discharge flowing from the Cope Mine (station BI-24--.018 MG/day, 9.3 lbs. acid/day) does not appear to be of a sufficient magnitude to merit inundating the mine.

Water quality improvement in Wilson Run could be achieved by relocating the spoil pile at the mine to a well-drained site where it can be graded, covered with soil and planted. This will eliminate the degradation of spring water, sampled at station B1-27, which presently flows through the pile. The unpolluted spring water then should help to neutralize the discharge from

Estimated construction cost for removal of spoil pile, covering, grading and planting:	$	5,900.00
Cost effectiveness per lb. of acid/day**:	$	362.00

the mine after it reaches Wilson Run. (See water quality data for the mouth of Wilson Run, station B1-7, Appendix C, page 113.)

The Rock Run Mines: Pollution sources C13-2 and C13-3.

Mine maps for the Rock Run area are not available and local information is sketchy, but it is probable that surface mining has disturbed all or

*Cost effectiveness computed on 80% reduction of daily acid load from mine discharge at station BI-16--274.5 lbs. of acid/day x .80 = 219.6.

**Computed on complete elimination of pollution source at station B1-25 (16.3 lbs. of acid/day) with the removal of the spoil pile.

portions of both the Young and VanOrder Mine and the Bache Mine. It appears that the Bache mine entry has been stripped out completely, although drainage from the mine may be contributing to the flow monitored at station C13-2.

The other discharge in the Rock Run area originates from the Birchstill Drift, 1400+ feet north of the Young and VanOrder mine entry (station C13-3). The drift was exposed by a single stripping cut that has not been backfilled. Presently acid mine drainage from the drift is flowing from the north end of this cut.

The entry at the Young and VanOrder Mine should be excavated and a clay pack seal compacted into the opening to abate the discharge from this source.

Estimated construction cost:	$	5,400.00
Cost effectiveness per lb. of acid/day:	$	14.90

The open stripping cut through the Birchstill Drift should be excavated along the highwall, packed with an impermeable barrier and backfilled. The area should then be graded to the contour and planted.

Estimated construction cost:	$	15,250.00
Cost effectiveness per lb. of acid/day:	$	225.90

OMPLEX


1900
1880
1860
1877
1840
1820
1800
1780
1772
1760
1740
1720
1700
1600
1500
1400
1300
B1-21
B2-2
B2-1
B1-41
Creek
MORRIS TOWNSHIP
B
S
C
B1-23
MITCHELL MINE
MINE WASTE
B1-20
MAIN ENTRY
B1-29
B1-30
B1-31
Trench
Sealing
1690
1680
S. SIMONS
(Minerals)
B1-6
B1-5
Hydraulic Double
Bulkhead Seal
RATTLER
Basswood
HAMMERMILL PAPER
A2-7

THE ANNA S MINING COMPLEX - PLATE VIII

The Anna S Mine is located in Morris Township approximately 1.8 miles north of the village of Morris. The complex straddles the broad, poorly defined axis of the Blossburg Syncline and includes extensive mining on both flanks of the syncline. The mapped periphery of the mine, as shown on existing mine maps, is an area of approximately 742 acres.

The main mined Bloss coal bed is. variable both in characteristics and thickness. Reported mined thicknesses range from 38 to 46 inches; however the bed splits on the flanks of the syncline into two merchantable beds which are separated locally by as much as 12 feet of claystone and/or shale. In these places the aggregate thickness may exceed 6 feet. Sandstone and sandy shale appear to be the dominant overburden lithology throughout the complex.

A northwest-southeast trending fault traverses the southern portion of the complex as shown in Plate VIII. Local vertical displacements are on the order of 10 to 20 feet. Fracturing associated with the fault may limit choices for remedial abatement measures to the south of this fracture.

The Anna S Mine was opened in the late 1800's by the Fall Brook Coal Co. and was abandoned in 1937. Coal from the mine was transported to Antrim via the cable car system which ran east and west across Pa. T. R. 287. Mine waste was deposited in a large slide pile covering an area of approximately 10 acres and extending from the main entry to Wilson Creek, 400+ ft. below. There is no evidence that any coal other than the Bloss was mined.

Two major discharges of acid mine drainage flow from the mine. Drainage from the main entry (Sampling and Flow Measuring Station B1-20) averages .601 MG/day with an acid load of 1039 lbs./day. This flow drains into Wilson Creek via its own channel. The other major discharge is a waterway known locally as the Hunter Drift (Sampling and Flow Measuring Station Bl-5). This discharge has an average daily flow of .561 million gallons that contributes 1554 lbs. of acid/day to Basswood Run, a tributary of Wilson Creek. The combined flow at these stations accounts for 38% of the net acid load flowing into Wilson Creek and 23% of the net acidity from all sources within the watershed.

Two other discharge points of acid mine drainage are monitored at Sampling and Flow Measuring Stations Bl-22 and B1-23. These are two of seven drift entries into the Mitchell Mine which is situated in a 24+ acre area north of the Anna S Main Entry. Flow volume at Station B1-22 (.162 MG/day) could indicate that this watercourse channels drainage from the northeast portion of the Anna S Mine (See Estimates of Deep Mined Areas, p. 28).

North of the Anna S the limits of an underground mine, known locally as the Lindquist Mine, have been observed. No drainage from the mine was discovered during the study.

The only active mining presently under way in the watershed is being done in the area of the Lindquist Mine by the P. & M. Coal Co., Blossburg, Pa. (Mine Permit No. 4775 SM6, issued 11/17/75). The permit is for stripping the "D", "E" and Bloss coal veins and the present limit of operations are within the Eugene House tract. (See Plate VIII.)

An 18 acre Pre-act strip mine along the Bloss crop line from the Mitchell Mine north and then west to the Lindquist Mine has not been backfilled but has been planted with evergreens and reforestation is well established. No acid mine drainage referable to these strippings has been observed; although, because of their location, they must be considered basic to any proposed abatement plan for the complex.

Strip mines have been developed locally on the Cushing and Seymour coals on the southern side of the complex and on the west side of the Anna S Mine near the syncline axis. Here, approximately 95 acres were stripped by the Jones and Brague Mining Co. between 1963 and 1967. All of the strippings have been backfilled and planted with evergreens, although there are isolated sections where vegetation is still sparse.

Most of the area west of Plantation Road drains into Paint Run or its tributaries. Sampling and Flow Measuring Station A2-10 monitors a flow at the west side of a restored stripping. The discharge may originate from the southwest extremity of the Anna S mine workings. The flow averages .058 MG/ day and carries an acid load of 101.4 lbs./day.

Several pre-act strippings covering an area of approximately 20 acres between Hunter's Drift and the Anna S Main Entry have not been restored. Flow volume at station BI-31 averages .051 MG/day and has an acid load of 17.9 lbs./day. Other points of discharge in the area (Reconnaissance Sampling Stations BI-29 and B1-30) have flows only during heavy rainfall and were not deemed critical enough for continued monitoring. None of these discharges have established a well-defined channel of flow to Basswood Run and apparently are absorbed by the soil.

Table G is a summary of the 12-month average loading data for all mine drainage discharges in the complex. Complete monthly water analysis and loading data for each station is given in Appendix C.

A mine pool level control valve could be placed into a clay pack seal installed at the Jamestown Drift; a drift entry which presently is dry, located on the west side of the mine. The surface elevation at the drift (1698 feet) means very little hydraulic. head pressure should develop at this entry and the mine pool here would be relatively stagnant. (See Deep Mine Inundation, p. 34.)

Estimated construction cost of sealing trench with surface revegetation:	$ 423,500.00
Estimated construction cost of 1 hydraulic double bulkhead seal with grouting and 1 clay pack seal with mine pool level control valve:	$ 25,000.00
TOTAL	$ 448,500.00
Estimated recoverable coal:	9,000 tons
Cost effectiveness per lb. of acid/day:*	$ 197.40

The Anna S Mine: Pollution source A2-10.

The mine drainage at Water Sampling and Flow Measuring Station A2-10 is the only discharge referable to the Anna S Complex that flows into the Stony Fork Watershed. Although surface water run-off from the restored stripping near station A2-10 is evident during wet periods, the consistency of the flow may suggest that a considerable portion of the flow originates from the Anna S Mine. It is possible that surface mining exposed underground workings which drain the southern portion of the mine.

Abatement of this discharge may be accomplished by constructing a sealing trench along the southern and eastern perimeter of the northern portion of the restored stripping. Construction of the trench would consist of at least one

Cost effectiveness computed on expected 80% reduction of daily acid load from all discharges from the Anna S except station A2-10---2840.4 lbs. of acid/day x .80 = 2272.3. It' does not represent cost-less-value of recoverable coal.

cut 40 feet wide at the bottom, 1200 feet long and excavated to an average depth of 40 feet. Installation of the impervious barrier in the trench would be in the manner described earlier for the sealing trench in the northeastern portion of the mine. (Also see narrative description, pp. 35-36 and Figure VII, p. 40.) The purpose of the sealing trench near station A2-10 would not be to establish a mine pool behind this subsurface barrier, but rather to seal off drainage from the southern portion of the mine and channel it to the mine pool in the lower levels of the mine.

Surface Reclamation: The mine waste pile and yard area of the Anna S Mine covers

Estimated construction cost of sealing trench with surface revegetation:	$ 114,500.00
Cost effectiveness per lb. of acid/day:	$ 1,129.00

approximately 9.8 acres. The spoil pile lies on a steep hillside that drops into Wilson Creek. Birch trees are beginning to grow on the spoil pile, but to minimize erosion and surface water infiltration, it should be planted with a suitable grass cover. Hydroseeding may be possible if access to the lower portion of the slope was provided. The yard area should also be regraded and planted.

It is estimated that between 10 and 15% of the 75+ acres south of the Rattler Mine Road that were disturbed by surface mining require additional planting. These areas could be hydroseeded with a grass cover that eventually will promote other growth.

Estimated cost of surface reclamation 21.2 acres @ $500.00/acre:	$ 10,600.00

ABATEMENT:

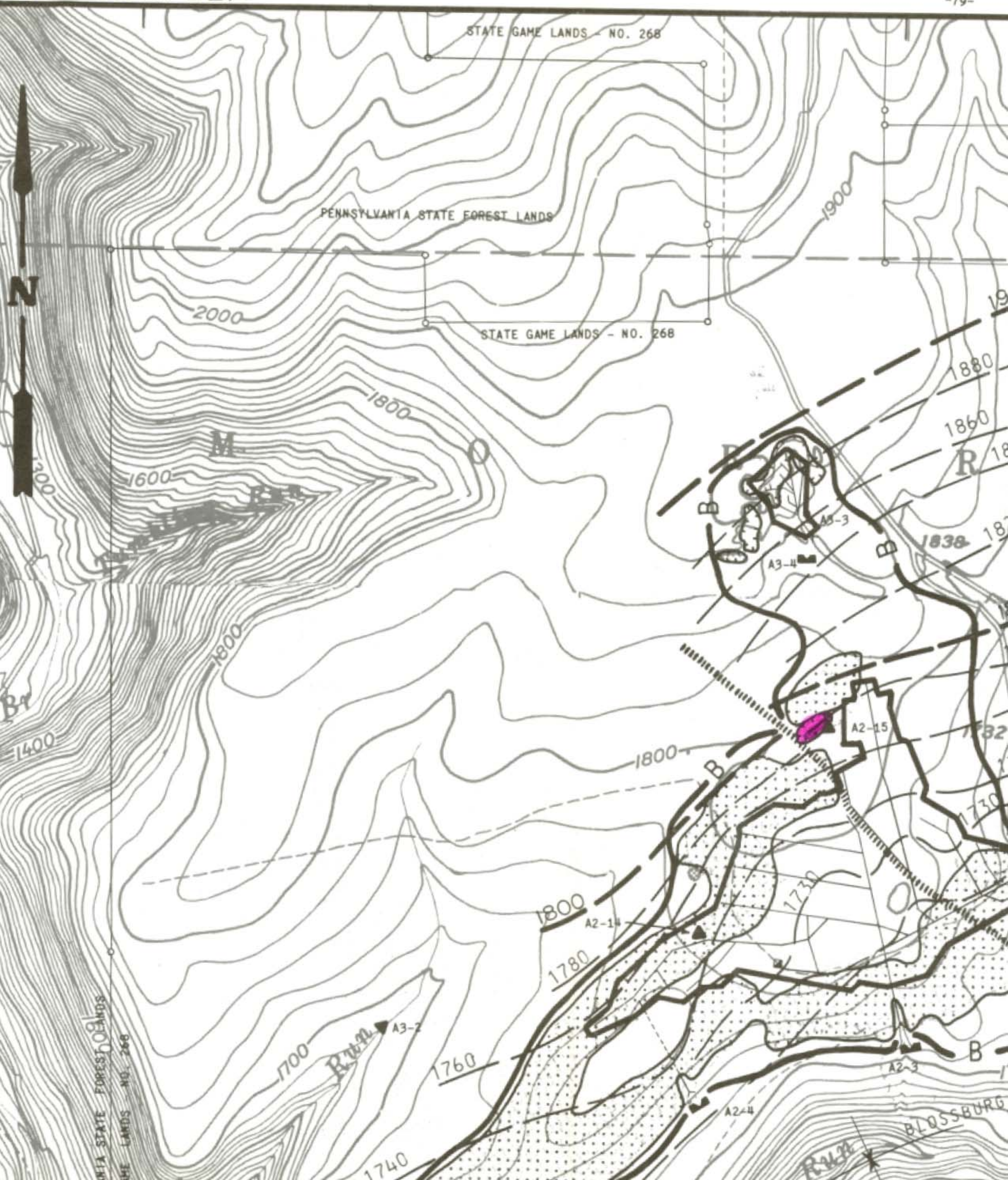
The Antrim Mine: Pollution source B1-14.

Inundation: Although the area of the Antrim Mine is extensive, coal contours suggest that it could be inundated with a relatively small hydraulic head--40 to 60 feet. The only known discharge from the mine is the watercourse adjacent to the main entry (Antrim No. 1 Drift, station B1-14). With some excavation access to these entries could be gained and hydraulic double bulkhead seals installed. Grout should be injected around the seals and into weakened strata where danger of an outbreak exists.

The pre-act stripping along the Bloss crop line between the Antrim No. 1 Drift and the Cemetery may be an area where an outbreak may occur. In order for inundation to be successful, it will be necessary to excavate along the highwall of this stripping and place an impermeable barrier against any exposed mine workings before backfilling and grading. (See Figure VII, page 40.)

. Consideration should be given to the effect of inundation on the Antrim community. Creating a mine pool in excess of 60 feet may affect old dug wells and a significant pool head might result in possible crop line outbreaks. These contingencies should be controlled with the placement of a "mine pool level control valve" at the southern end of the pre-act stripping which must become part of the subsurface barrier for the impoundment. Here, topography will permit an automatic overflow or a "mine pool tap-off" at elevation 1690, thus limiting hydraulic head pressure to 40 feet. It is estimated that a top water elevation of 1690 should inundate approximately 75% of the workings and eliminate 75% or more of the pollution referable to the Antrim Mine, (See Plate VII.)

ING COMPLEX


STATE GAME LANDS - NO. 268
PENNSYLVANIA STATE FOREST LANDS
STATE GAME LANDS - NO. 268
N
2000
1900
1800
1880
1860
1838
1800
1800
1730
1730
1800
1780
1760
1700
1740
1600
1400
A3-3
A3-4
A2-15
A2-14
A3-2
A2-3
A2-4
B
BLOSSBURG
Run
PENNSYLVANIA STATE FOREST LANDS
STATE GAME LANDS NO. 268

SL-145-1

THE RATTLER MINING COMPLEX - PLATE IX

The Bloss vein in this area has been extensively mined both from the surface and underground. The Tioga Coal Co. operated the Rattler Mine until about 1930. The last deep mine permit application was made by E. Manford Hart and Son in 1949 and mining continued until 1958.

The Rattler Complex includes the most westerly outlier of minable coal in the Blossburg Basin. The coal bearing strata are preserved in a dip slope remnant which forms the divide between Black Run and Paint Run. The Bloss coal, having a reported mined thickness of 42 inches, and minor amounts of badly weathered Cushing coal are present in this remnant which extends northward from the axis of the syncline. Although the main mined coal (Bloss) rises almost 200 feet to the northern outcrop, overburden depths rarely exceed 60 feet.

A northwest-southwest trending fault traverses both this complex and a portion of the Anna S Complex to the southeast. The effects of the fault apparently are negligible, although the Bloss coal is offset vertically about 15 feet along the fault line at the northwestern crop line.

The Rattler Mine encompassed an area of approximately 100 acres. Records show that roughly 300,000 tons of coal were mined between 1931 and 1958. Approximately 147 acres were disturbed by surface mining in the area, including much of the perimeter of the underground mine. With the exception of one small area (1.5 acres) north of the mine, all stripping was restored, although vegetation is still sparse in some sections. The entire mining complex is situated on State Game Lands, Tract No. 268.

between limestone and acidic water is provided. Such renovation is dependent upon keeping the interfaces of the limestone free from clogging by silt or metal hydroxides such as iron and aluminum.[1]

It appears that maximum benefit can be achieved when crushed limestone is placed in streams with an initial pH of between 3.0 and 5.0. At a lower pH, such as in streams grossly polluted by A.M.D., the exsolution of CO_2 restricts the reactivity of the limestone. In water with an initial pH greater than 5.0 the free available hydrogen ion concentration is not sufficient to disassociate calcium carbonate, thereby restricting the neutralization process.

By placing crushed limestone in sections of streams where much of the iron hydroxide from A.M.D. has already precipitated out it may be possible to limit the metalic coating of the limestone. Furthermore, in heavily forested areas such as the Babb Creek Watershed where the erosion of silt and clay particles is negligible, sedimentation of the limestone should not be a restrictive factor.

Water quality data in Upper Babb Creek and in some of its tributaries as well as the general stream characteristics, indicate that several sections of these streams may be well suited for the installation of crushed limestone barriers such as channel linings and/or gabions. The following locations were selected to provide the maximum amount of contact time between limestone and water in relatively turbulent portions of these streams. Access to these locations already exists or can be provided with minor improvement to abandoned roads.

C8-1 - Lick Creek downstream from the influx of South Creek C7-1 - Mouth of Lick Creek
CI-7a - Babb Creek upstream from the influx of Rock Run C13-1 - Mouth

of Rock Run

(1) ibid.

The neutralization process resulting from crushed limestone barriers at the above locations may be supplemented by also placing limestone barriers in three small tributaries that are accessible from the Landrus Road.

CI-10 - Mouth of unnamed tributary 1/2+ mile southwest of Bear Run C6-1 - Mouth of Bear Run
C7-3 - Mouth of Silver Run

Figure XI, page 87 is a map showing four (4) primary and three (3) supplementary locations.

Pearson and McDonnell have developed a simple design procedure to determine the quantity of limestone required to neutralize a given stream flow to any required degree. The design parameter is the Load Factor, defined as the number of effective tons of crushed limestone per inch of stone diameter, per cubic foot per second of stream flow.[1] At the proposed locations for crushed limestone barriers listed on pages 85-86 the design parameter is the actual stream bed area in which limestone can be placed rather than the Load Factor. Therefore, after establishing the amount of effective crushed limestone that can be accommodated at these sites, the Load Factor was computed for both low flow and average flow conditions at the four (4) primary locations. With a given Load Factor, the amount of neutralization (rise in pH) that can be expected was taken from the design graph prepared by Pearson and McDonnell. [2] This information, with supporting data, is listed in Tables I and J.

(1) Pearson, F. H. and McDonnell, A. J., "Evaluation of Prototype Limestone Barriers for the Neutralization of Acidic Streams," Research Publication No. 80, p. ix, The Pennsylvania State University, June 1974.

(2) ibid., Figure 16, p. 44.

Acid mine drainage is occurring at three major sources from the underground mine; sources now designated as A2-2, A2-3 and A2-4. The combined flow from the three averages 0.215 MG/day and contributes 1313 lbs. of acidity per day to Paint Run. This accounts for 92% of the net acidity from mine sources which drain into Paint Run and approximately 13% of the net acidity from mine sources in the Babb Creek Watershed. A small acid water seep occurs periodically at station A2-5, but not with sufficient flow to sample or monitor.

North of the Rattler Mine is a small, deep mine and several small pre-act strippings that have revegetated themselves. (See Rattler Annex, Plate IX.) A flow averaging 0.032 MG/day with an acid load of 13.5 lbs./day originates from the mine and drains into the Black Run tributary of Stony Fork Creek.

Table H is a loading summary for the mine discharges in the Rattler Complex. Complete monthly water analysis and loading data for each station are given in Appendix C, page 109 and page 111.

Although water quality at the mouth of Paint Run (station A2-1) indicates it has the second largest net acid load of any stream in the watershed, this acid load appears to be neutralized by the alkaline waters of Stony Fork Creek. Downstream, Stony Fork Creek shows little evidence of acid mine drainage contamination and, at its confluence with Babb Creek, it has an

TABLE H

	STATION	FLOW MGD	pH	ACIDITY LBS./DAY	ALKY. LBS./DAY	TOTAL FE LBS./DAY	FERROUS LBS./DAY	SULFATE LBS./DAY
Rattler Mine	A2-2	0.103	2.8	446.8	0	101.47	29.24	573.1
	A2-3	0.073	2.6	473.9	0	83.95	4.45	509.7
	A2-4	0.039	2.6	392.0	0	71.44	12.94	377.6
TOTAL		0.215		1312.7	0	256.86	46.63	1460.4
Rattler Annex	A3-4	0.032	3.4	13.5	0	0.23	0.05	23.5

average pH of 6.6 and an average net alkalinity of 8861 lbs./day.

ABATEMENT:

The Rattler Mine: Pollution sources A2-2, A2-3 and A2-4.

Inundation of the Rattler Mine would require extensive stabilization around the mine's northern and southern perimeter in order to obtain even a minimal mine pool build-up. Here strip mining the Bloss coal has disturbed the overlying strata so that inundation may not be feasible. It is not known what procedures were used in backfilling the final cuts along the mine's perimeter, but most of the restored areas were not graded to the original contour.

In light of this fact, consideration should be given to "daylighting" the old mine workings and restoring the area in a manner that will eliminate the present sources of acid mine drainage. If 1/3 of the Bloss coal vein remains, it can be estimated that approximately 120 acre feet of recoverable coal lie within the 69.1+ acres of the Rattler Mine not disturbed by surface mining. In addition, 28+ acres between the Bloss outcrop and the mine's eastern perimeter may also contain recoverable coal. If this is the case, daylighting the mine appears entirely practical.

If abatement of existing acid mine drainage should become a condition of future strip mining in the Rattler Mine area, it may be necessary that some sort of incentive be granted that would limit the contractor's liability but also insure adequate improvement.

The Rattler Annex: Drainage at station A3-4.

Estimated cost of daylighting and restoring 97.1 acres:	$ 4,380,000.00
Estimated recoverable coal:	380,000 tons

The discharge flowing from the Rattler Annex (station A3-4--0.032 MG/day, 13.5 lbs. acid/day) does not appear to be of a sufficient magnitude to justify attempting to inundate the mine. Abatement could be related to future surface mining permits such as was described for daylighting at the Rattler Mine. However, the flow from the Annex only accounts for roughly 7% of the net acid load in Black Run.

The origin of the acid present at the mouth of Black Run (station A3-1) has not been determined, although certain amounts of natural organic acid in the headwaters has been suspected. This, combined with periodic run-off from restored surface mined areas, may explain the condition.

STREAM NEUTRALIZATION IN UPPER BABB CREEK AND LICK CREEK

CRUSHED LIMESTONE CHANNEL LININGS AND GABIONS

It is evident that the high levels of net acidity in streams contaminated by A.M.D. inhibits the growth of microflora on which other aquatic life is dependent. The net acidity in Upper Babb Creek and Lick Creek, whether from abandoned underground mines or from other natural origins, varies according to the following set conditions: (a) the total volume and the acid concentration from the sources of A.M.D., (b) dilution from non-acidic waters flowing into these polluted waters and (c) natural neutralization derived from stream

bottom sediments. [(1)]

The traditional procedure for the treatment of acidic streams in Pennsylvania has been the infusion of hydrated lime directly into the A.M.D. flow or directly into the receiving stream using some sort of automatic feeding device. Recently, research has indicated that "crushed limestone barriers are capable of renovating acidic streams to the point that normal aquatic life can be restored". [(2)] In the "Evaluation of Prototype Crushed Limestone Barriers for the Neutralization of Acidic Streams" the authors have shown that a useful degree of renovation can be achieved in streams where sufficient contact time

(1) Analysis of stream sediments in Babb Creek and Lick Creek indicate the presence of clay fractions composed predominately of kaolinite, illite and vermiculite which contribute to the neutralization or partial neutralization of these streams. A more detailed discussion of this process is presented in Crouse, H. L. and Rose, A. W. "Natural Benefication of Acid Mine Drainage by Interaction of Stream Water with Stream Sediment," Sixth Symposium of Coal Mine Drainage Research, October 1976, pp. 237-269.

(2) Pearson, F. H. and McDonnell, A. J., "Evaluation of Prototype Limestone Barriers for the Neutralization of Acidic Streams," Research Publication No. 80, p. viii, The Pennsylvania State University, June 1974.

FIGURE XI

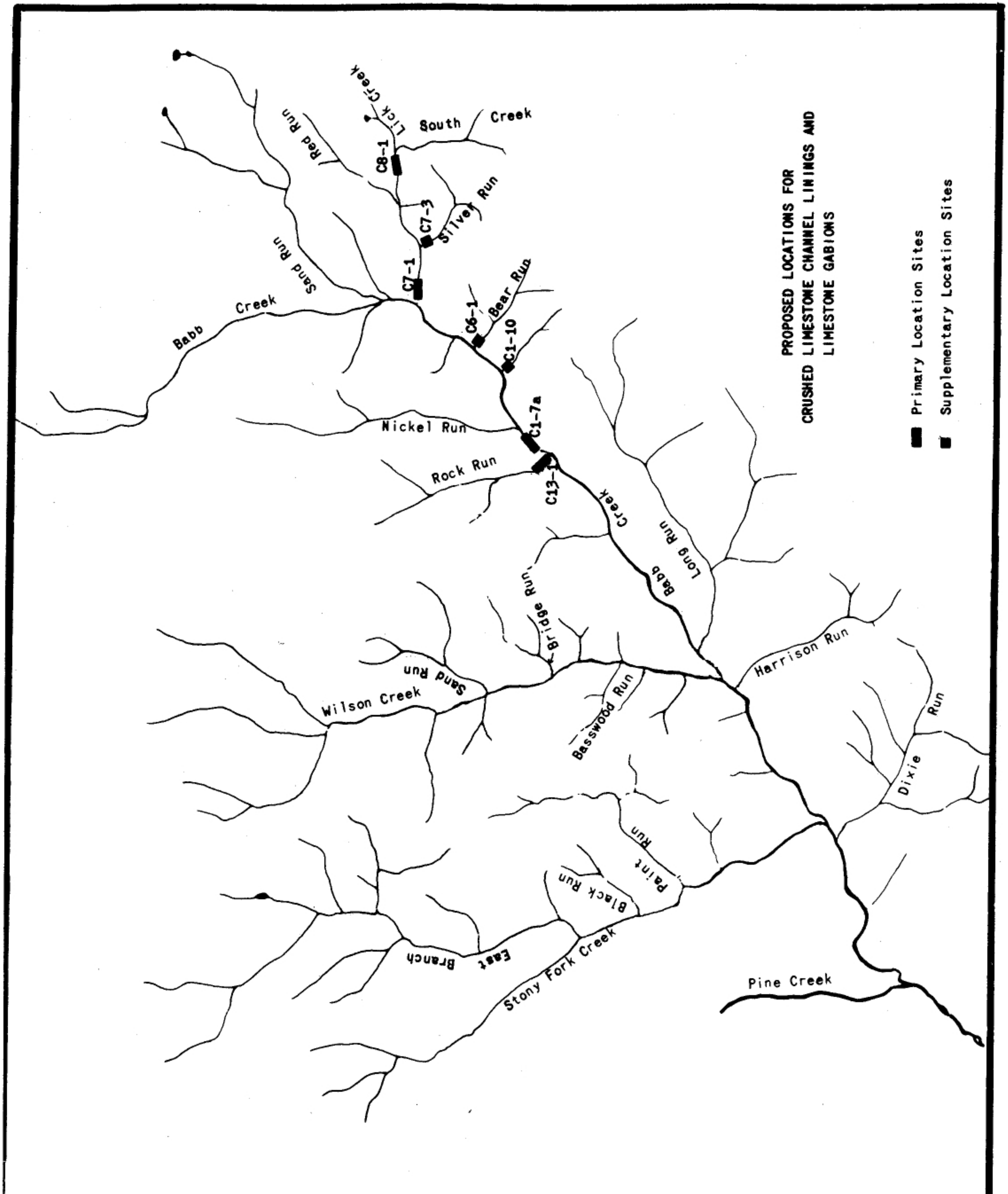

PROPOSED LOCATIONS FOR
CRUSHED LIMESTONE CHANNEL LININGS AND
LIMESTONE GABIONS
Primary Location Sites
Supplementary Location Sites
Lick Creek
South Creek
Red Run
C8-1
Silver Run
C7-3
C7-1
Sand Run
Babb Creek
Bear Run
C6-1
C1-10
Nickel Run
C1-7a
Rock Run
C13-1
Babb Creek
Long Run
Bridge Run
Sand Run
Wilson Creek
Harrison Run
Basswood Run
Dixie Run
Paint Run
Black Run
East Branch
Stony Fork Creek
Pine Creek

TABLE I

LOCATION	FLOW	INITIAL pH	LIMESTONE CAPACITY	EFFECTIVENESS*	CONSUMPTION RATE	FINAL pH	COST
C8-1	Low Flow 1.545 MGD	4.2	480 tons			5.1	$ 5,300.00
	Av. Flow 6.101 MGD	4.4	480 tons	48%	3%	4.6	
C7-1	Low Flow 2.689 MGD	3.7	1590 tons			5.4	$ 18,600.00
	Av. Flow 9.703 MGD	4.0	1590 tons	64%	6%	4.7	
C1-7a	Low Flow 11.075 MGD	4.4	3850 tons			4.9	$ 42,500.00
	Av. Flow 39.111 MGD	5.1	3850 tons	48%	0.30%	5.2	
C13-1	Low Flow 0.453 MGD	3.7	460 tons			5.1	$ 5,600.00
	Av. Flow 3.888 MGD	4.1	460 tons	24%	7%	4.2	

*Computed assuming 80% purity for limestone delivered from local sources x estimated percentage reduction in the dissolution of the limestone due to siltation and/or metal hydroxide coating.

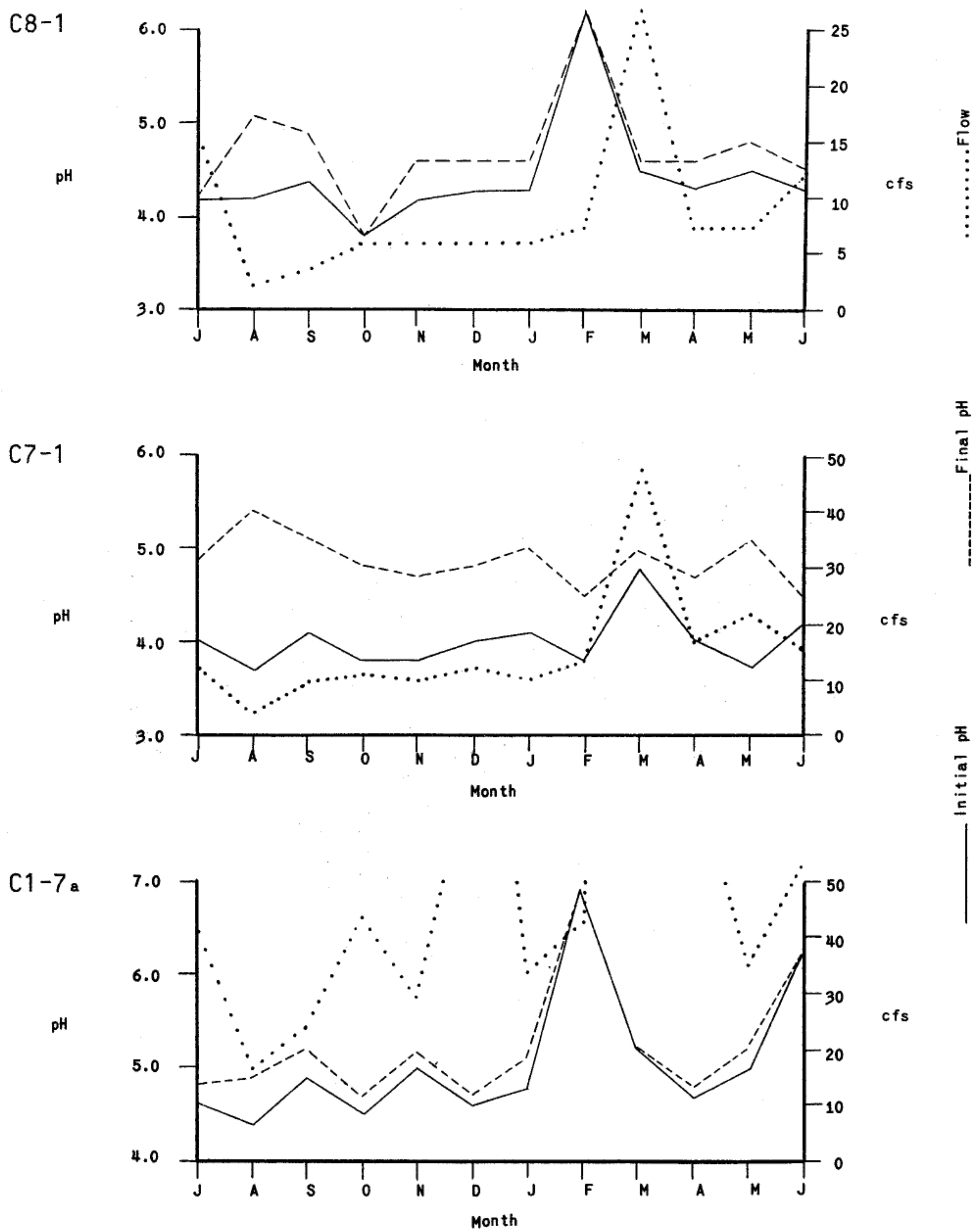
TABLE J

LOCATION	ESTIMATED FLOW*	INITIAL pH	LIMESTONE CAPACITY	EFFECTIVENESS	CONSUMPTION RATE	FINAL pH	COST
C7-3	0.969 MGD	4.5	220 tons	68%	1%	5.3	$ 2,400.00
C1-10	0.674 MGD	4.5	40 tons	68%	3%	4.7	$ 400.00
C6-1	2.539 MGD	4.3	120 tons	68%	5%	4.5	$ 1,300.00

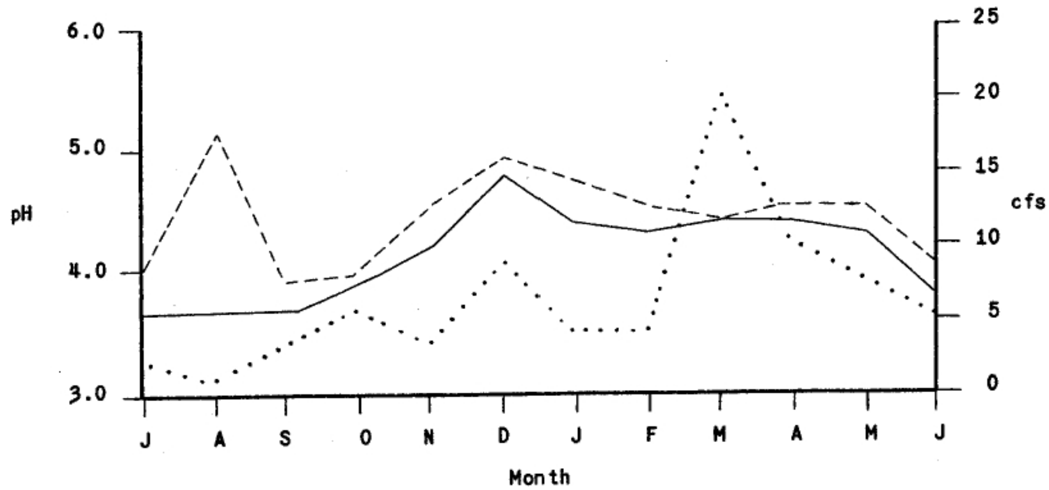
*Because complete and accurate flow data is not available at these supplementary sites, the estimate of the effect from crushed limestone barriers has been prepared using data obtained from grab sample analysis in February and March 1975.

FIGURE XII

EFFECT OF FLOW ON CHANGE IN pH



C13-1



The amount of limestone that can be placed in the stream bed is dependent upon the local stream depth, gradient, and expected degree of siltation. Channel lining entails the lining of the stream bed and banks with crushed limestone ranging from 3" to 6" in size laid to a depth not to exceed one (1) foot. Little or no stream bed modification is needed in preparation for the channel lining.

In those areas where waterfalls exist, because of the turbulent flow, wire mesh gabions are necessary to keep the limestone in place and to permit use of the more efficient smaller sized crushed limestone. The limestone gabions should be placed directly under the falls to facilitate dissolution of the limestone. The perimeter and bottom of the pool at the base of the falls should also be lined with gabions.

TABLE K

ESTIMATED FIRST YEAR COST AND PROJECTED FIFTY YEAR COST

SITE	1ST YEAR COST	CONSUMPTION RATE	LIFE SPAN	NUMBER OF REPLACEMENT PER 50 YEARS	50 YEAR COST
C8-1	$ 5,300.00	3%	33 years	2	$ 10,600.00
C7-1	$ 18,600.00	6%	17 years	3	$ 55,800.00
C1-7a	$ 42,500.00	0.30%	333 years	0	$ 42,500.00
C13-1	$ 5,600.00	7%	14 years	4	$ 22,400.00
C7-3	$ 2,400.00	1%	100 years	0	$ 2,400.00
C1-10	$ 400.00	3%	33 years	2	$ 800.00
C6-1	$ 1,300.00	5%	20 years	3	$ 3,900.00
TOTAL	$ 76,100.00				$ 138,400.00

SL-145-1

ESTIMATED COST OF ACID MINE DRAINAGE NEUTRALIZATION

The following is a list of the estimated cost for the collection and treatment of acid mine drainage from the combined mine discharges in each mining complex. Cost is referable to the amount of treatment required to neutralize the maximum flow volume and the maximum acid concentration from those discharges.

Total 1st year cost includes the estimated construction cost"of an on-site mine drainage treatment plant (Capital Cost) combined with an estimated yearly operation and maintenance cost (Yearly 0 & M). The yearly operation and maintenance cost includes the cost of chemicals, power, maintenance and labor for treatment and sludge disposal, but it does not reflect an inflationary cost increase for those items in years subsequent to 1976.

MINING COMPLEX	CAPITAL COST	YEARLY O & M	TOTAL FIRST YEAR COST
Arnot C8-5, C8-8	$ 50,400.00	$ 9,700.00	$ 60,100.00
Klondike C7-2, C9-2	$ 50,450.00	$ 12,350.00	$ 62,800.00
Bear Run C1-14, C1-15, C1-16	$ 68,300.00	$ 21,700.00	$ 90,000.00
Rock Run C13-2, C13-3	$ 24,500.00	$ 8,000.00	$ 32,500.00
Antrim B1-14, B1-16	$ 84,800.00	$ 70,800.00	$ 155,600.00
Anna S B1-5, B1-20, B1-22, B1-23, B1-31	$ 71,200.00	$ 50,900.00	$ 122,100.00
Rattler A2-2, A2-3, A2-4	$ 40,400.00	$ 30,500.00	$ 70,900.00