FINAL REPORT
FEASIBILITY INVESTIGATION
ABATEMENT OF MINE ACID DRAINAGE
CUCUMBER RUN WATERSHED
OHIOPYLE STATE PARK
FAYETTE COUNTY, PENNSYLVANIA

1.0 Introduction

Ohiopyle State Park is presently the second largest state park in the Commonwealth of Pennsylvania. Due to its proximity to Pittsburgh and other urban areas and the uniqueness of its attractions, including white water canoeing and rafting on the Youghiogheny River, it is one of the most heavily visited parks in the state system. One of the principal scenic attractions of the park is Cucumber Falls located on Cucumber Run which enters the Youghiogheny River a few hundred yards downstream from the Ohiopyle Falls. Staining of the falls by acid mine drainage from coal mining in the Cucumber Run watershed has seriously detracted from the appearance of the Falls. In addition, the Cucumber Run Valley, particularly in the vicinity of the former village of Stonerville, would be a more attractive and usable part of the park if Cucumber Run were unpolluted.

For these reasons, the firm of E. D'Appolonia Consulting Engineers, Inc., was retained to investigate the abandoned mining operations in the Cucumber Run watershed (Fig. 1) and to determine the feasibility of sealing the deep mine entries to prevent or reduce the acid mine drainage into Cucumber Run and its tributary, the North Branch. A complete field study, including a surficial investigation, subsurface exploration by borings, excavation of the old mine entries, and sampling of water flowing from the various mine entries and in the stream, was conducted beginning in August 1969 and continuing through the fall of 1971.

2.0 Mining History

The history of mining operations along Cucumber Run is incomplete. No final mine maps are on file with the Department of Environmental Resources, and the current mine inspector was not serving this area when any of the operations were active. Most of the information detailed in this report was obtained from Mr. Shelby Mitchell, who owned and operated two of the mines and who purchased or shipped coal from most of the other operators, and from the mine drainage permit files of the former Pennsylvania Department of Health.

The first mining, in the Cucumber Run watershed was a small country bank mine opened in the 1880's on the North Branch. The first commercial mining operation was opened in the 1920's by the East Fayette Coal Company on the upper Cucumber Run watershed (Fig. 2). This mine apparently operated only a short time before being closed by labor trouble. A map of this mine exists, but it is not known if it shows the mine at the time of abandonment.

Whipkey Coal Company began mining on the north side of the North Branch of Cucumber Run in the 1930's and continued operations until the coal rights were purchased by the Western Pennsylvania Conservancy in 1964. In 1956, Mitchell reopened the old country bank mine adjacent to and upstream of the Whipkey Mine, and this mine (Taylor Mine) was operated until about 1961. In 1960, the Joseph A. Miller Coal Company began mining adjacent to and downstream of the Whipkey Mine. Only a small amount of coal was taken from the mine before it was flooded by water from the abandoned portions of the Whipkey Mine. Of these three adjacent mines, only Mitchell's Taylor Mine was mapped. However, it is known that the three mines are interconnected.

In 1949, James A. King opened a mine on the south side of the North Branch across from the Whipkey Mine. The final extent of mining is not known, but it was proposed at the time of opening to remove 70 to 75 acres of coal. In 1958, Miller opened a small mine (less than 10 acres) adjacent to and downstream of the King Mine, and in 1960, Mitchell opened another small mine (less than five acres) upstream of the King Mine. Entry into Mitchell's Mine (Taylor No. 2 Mine) was through abandoned workings of the King Mine, and drainage. from the Taylor No. 2 Mine was diverted into the King Mine. The King and Miller mines may be interconnected but details of neither of these mines are known.

In 1955, King opened a mine (King No. 2 Mine) on the south side of Cucumber Run. The available map indicates that this mine extends approximately 2000 feet along the hillside and 500 feet back under the hill. It is isolated from all other mines and was abandoned in 1963 following purchase by the Western Pennsylvania Conservancy.

Strip mining of the outcrop by Smithfield Mining Company began in the 1950's. Coal was removed by stripping on both sides of the North Branch. The stripping operation intercepted the deep mine workings in several locations. Interception of abandoned workings of the Whipkey Mine in 1961 permitted a large quantity of acid water to enter Cucumber Run, causing serious staining of Cucumber Falls. In addition, the acid water was drawn into the Connellsville Water Treatment Plant on the Youghiogheny River, where it created serious problems. This pollution resulted in the Smithfield Mining Company operations being stopped permanently. When the Western Pennsylvania Conservancy later purchased the property, most of the strip mine was backfilled and planted.

The Smithfield Mining Company also made exploratory excavations along the outcrop south of Cucumber Run adjacent to the King No. 2 Mine, but apparently no coal was removed in this area.

3.0 Geology

The coal seam mined in the Cucumber Run watershed is the Lower Kittanning coal, which is the middle member of the Pennsylvanian Series, Allegheny Group (Fig. 3). Overlying the coal are varying thicknesses of shale and sandstone. The mines are located on the western limb of the Ligonier syncline. The rock dips to the southeast at approximately three degrees and strikes in a northeast-southwest direction. No evidence of faulting was observed, and no reference to faulting in the area is found in the literature. Jointing was observed in all exposures and the predominant attitude was nearly vertical and striking N65°W. A minor joint pattern was observed striking N35°E with a vertical dip.

4.0 Field Investigation

4.1 Surficial Reconnaissance: A field reconnaissance of the watershed was the initial step in the feasibility investigation. At the time of the first site visits, the exposed entries were the three entries to the Taylor Mine (Nos. 22, 23, and 24 on Fig. 4), one entry to the Taylor No. 2 Mine (No. 13), and three entries to the King No. 2 Mine (Nos. 3, 4 and 5). All other entries were either caved or buried by strip mine backfill. Since the lower end (east end) of the strip mine north of the North Branch was not on Western Pennsylvania Conservancy property, it had not been backfilled and contained a large pond of acid water.

A surficial investigation of the East Fayette Coal Company Mine on the upper reaches of the Main Branch of Cucumber Run found that the three entries to the mine are caved, and no significant drainage from this mine was observed during several inspections. It was, therefore, concluded that no remedial work was necessary at this mine, and no further investigation was carried out in this area.

Concurrent with the field investigation, a search was made of the files of the Department of Mines and Mineral Industries and the Department of Health. The search of files of the Department of Mines and Mineral Industries revealed that apparently no final mine maps were ever filed for any of the mines in the area. If such maps were filed, they have been subsequently lost. Mine drainage permit applications were filed with the Pennsylvania Department of Health for most of the mining operations, and this was a major source of information.

Discussions were also held with Mr. Earl Whipkey, Mr. James A. King, and Mr. Shelby Mitchell, all former mine operators along Cucumber Run. Only Mitchell was able to give us significant information, including several mine maps. The current mine inspector, Mr. J. M. Muchnok, came to the area after operations in the Cucumber Run watershed had ceased and had no personal knowledge of the area. The former mine inspector had no maps and could provide only general information about the operations.

As information was obtained from these various sources, it was cross checked in the field to locate mine entries and to verify that observed drainage points were old entries. As this investigation continued, the need for a substantial amount of exploratory excavation to establish both the number and condition of entries into the abandoned workings became apparent.

4.2 Exploratory Excavation: Exploratory excavation was recommended in the spring of 1970. The work was advertised by the Commonwealth for public bidding and a contract (SL 138-1) was awarded to Shelby Mitchell, a local general contractor, with the work beginning in January 1971. All known or suspected entries were completely excavated. Trenches were excavated along portions of the strip mine highwall on both sides of the North Branch to inspect the areas where it was suspected that stripping operations broke into the deep mine workings. This exploratory excavation disclosed a total of 34 openings into the abandoned workings. Some were caved, but many were open and would permit entry into the old workings.

Figure 4 shows the openings originally suspected and the area of excavation originally recommended. Figures 5 and 6 show the areas of the trench excavations and the details which were uncovered by these excavations. It will be noted that in addition to actual openings into the mine, there are several areas noted on the plans where the deep mine workings are very close to the stripping face, generally less than two feet. These areas, of course, will also require some treatment in an effective sealing program.

4.3 Subsurface Investigation: In conjunction with the exploratory excavation, a drilling contract (SL 138-2) was awarded to Pennsylvania Drilling Company on the basis of competitive bids obtained by the Commonwealth. Eight borings were drilled at the locations shown on Fig 7. The boring logs are presented in Figs. 8 and 9. Ten borings were originally planned, but Borings 3 and 9 were later omitted. The boring logs were used in developing the profiles shown on Figs. 5 and 6.

All borings were pressure tested to estimate the rock permeability. The results (Table I) provide an estimate of the potential effectiveness of mine seals in these areas and the necessity of grouting the natural rock around the seals to minimize leakage through joints or bedding planes in the rock. The majority of the permeabilities are in the range of 10^{-5} to 10^{-6} cm/sec, with many of the test intervals taking no flow during the test period. Test intervals in Borings 2 and 4 which showed permeabilities in the range of 10^{-3} cm/sec were all near the top of rock in the more weathered material.

Piezometers were installed at the Taylor Mine and the King No. 2 Mine to permit monitoring of the water levels after seals have been installed. Additional piezometers will be recommended for installation during construction of seals.

4.4 Water Quality Analysis: Since a detailed water quality survey was not included in the scope of work of this project, only a limited number of water samples were taken and flow rates estimated to determine the quality and quantity of water flowing from the mines and in the streams. Chemical testing was done by Seewald Laboratories, Williamsport, Pennsylvania, under a contract directly with the Department of Mines and Mineral Industries (now part of the Department of Environmental Resources).

Water quality data for the streams are presented in Fig. 10. The quality of water in the North Branch is satisfactory upstream from the point where water from the abandoned mines enters the stream near the upper limits of the Whipkey Mine. Substantial aquatic. life has been observed in this upper reach of the stream and in the Main Branch of Cucumber Run, almost to its confluence with the North Branch. Just upstream of the confluence, flow from the King No. 2 Mine enters the Main Branch and seriously degrades its quality. The quality of the stream from this point to its entry into the Youghiogheny River is poor.

At the time of stream sampling, the flow at Cucumber Falls was estimated to be about 8 cfs, flow in the North Branch just above the confluence with the Main Branch was estimated to be 2.5 cfs, and flow in the Main Branch was estimated to be 5.0 cfs. The water quality data and computed pollution loads are presented in Table II. There appears to be an inconsistency between water quality measured for two samples obtained 200 feet apart on the Main Branch just upstream of the confluence with the North Branch. The data indicate improvement of the quality, although no significant dilution was noted and no precipitation on the stream bottom was observed. Thus, the pollution load contributed by the Main Branch depends on which set of data is used. An additional inconsistency exists in that the pollution loads contributed by the two branches do not add up to the load computed at the Falls. During wet periods, there is a small amount of acid mine drainage entering the stream near the Falls from a mine located primarily in the adjacent Meadow Run watershed; but, at the time of sampling, this flow was not noted. Also given in Table II are the pollution contributions of the two streams on September 5, 1970. when flow was very low--less than 0.5 cfs in the Main Branch and less than 1 cfs in the North Branch. As would be expected from the extent of the mine workings, the water quality data indicate that the greatest contribution of acid drainage comes from the North Branch.

Major discharges entering the streams from the abandoned mines were sampled and tested, and the results are shown on Fig. 11. Generally, the pH was about 2.8 and acidity ranged from 200 mg/l to 1200 mg/l. Although only limited data are available, the quality of water discharging from the mines appears to vary little from season to season. Seasonal variations of pollution load were not established, but observations made during the field work indicate that these variations probably amount to less than a factor of three. It is further estimated that the pollution loads given in Table II are near or slightly below average.

5.0 Abatement Methods

Abatement of acid drainage from the mines in the Cucumber Run watershed will require sealing the mines in such a way that complete flooding occurs. This will exclude from the mine the oxygen necessary for the acid-forming reaction. Since the quantity of oxygen which can be dissolved in water is small compared to the quantity needed to produce acid in undesirable concentrations, the seals need not even be completely impermeable. Flooding will be maintained as long as the leakage is less than the potential inflow. At this site, several different types of seals will be necessary, including concrete or grouted gravel bulkheads, grouting of in situ rock, construction of compacted, impervious embankments, and strip pit regrading.

Where entries have not caved, concrete or grouted gravel bulkhead seals can be placed, either remotely through boreholes or from within the mine. Working within the mine is preferable where possible, because it permits better preparation of the site for the seal and better control of the construction to assure the effectiveness of the seal. Isolated caved entries will probably require carefully controlled grouting from above. Where the overburden rock and remaining coal are highly fractured and where the deep mine workings are close to the final strip mine cut, it will be necessary to construct an impervious earth embankment against the highwall to act, in effect, as an earth dam. The remaining strip mine spoil can then be graded over this impervious core to provide additional strength and the final contours desired.

Detailed plans and specifications for sealing the mine complexes presently being completed under a separate contract.

5.1 King No. 2 Mine : Figure 12 shows the plans for sealing the King No. 2 Mine. Three individual clay seals (Kl, K2 and K3) at the surf proposed at the upper entries of the mine, and three deep mine seals (K4 and K6) are proposed at the lower entries to the mine. The in-mine sea' to be placed in competent, unweathered rock.

Individual clay seals at the surface are proposed for the upper entries to the King No. 2 Mine because the seals will not be subjected to significant head. Maximum inundation level will be approximately El. 1430, the elevation as the seals. The lower mine entries are too badly caved to permit entry of men and materials, and the seals must be placed remotely through boreholes. Remotely placed, tamped gravel bulkheads have been specified, with pumped concrete placed between two gravel bulkheads. Sufficient irregularities in the roof, floor and sides of the entries should exist to prevent sliding of a concrete plug ten feet long. With proper placement of the concrete under pressure, cutoffs should not be necessary to prevent leakage along the interface between the seal and the in-place rock. Two piezometers have been specified to permit the water level within the mine and the pressure on the seals to be monitored.

To improve the effectiveness of the in-mine seals, a grout curtain through the seals has been specified. Grouting along the coal outcrop between the two work areas may also be necessary. The mine map indicates that the mine workings may extend close to the outcrop in this area, and increasing the head of the mine may cause leakage. However, no grouting is recommended in this area until the extent and location of leakage has been established. It may not be necessary to grout the entire length of the outcrop.

5.2 North Side of North Branch: On the north side of the North Branch, 19 openings into the deep mines were uncovered. Four of these openings were heavily subsided; the others were open enough to permit entry into and inspection of the workings. In three areas, as noted on Fig. 5, the deep mine workings are very close to the stripping face. Complete flooding of the mine workings on the north side will require a water level of approximately El. 1460.

The two entries into the Miller Mine (15 and 16) at the lower end of the strip pit are to be sealed using individual seals constructed from within the mine (N4 and N5, Fig. 13). Construction within the mine permits closer inspection of the seal location and more complete preparation of the site thus assuring a better seal. It is also estimated that such seals will cost less

than remotely placed seals. The three entries to the Taylor Mine (22, 23 and 24) above the upper end of the strip cut can also be individually sealed from within the mine (NI, N2 and N3). Between Stations 4+00 and 19+00, however, the extent of the deep mine workings and their closeness to the stripping face would make installation of individual seals difficult and probably ineffective. In this area, therefore, a compacted impervious embankment against the strip mine highwall is recommended. A typical section of the proposed embankment seal and the details of its design are shown on Figs. 13 and 14. The embankment will be constructed of the weathered shale in the adjacent spoil banks. Since the head to be resisted varies over the length of the seal, its height must also vary (Fig. 13). Proper preparation of the strip highwall will permit the compacted embankment to be tied into the silty shale such that potential leakage along the interface is minimized. The width of the embankment perpendicular to the highwall will be enough to permit operation of earth-moving equipment, particu-larly compactors. Prior to placement of the compacted embankment, the open entries into the deep mine will be filled to the extent possible with available soil and weathered rock to provide lateral support for the embankment at these points.

After the effectiveness of the sealing has been evaluated, the remaining spoil material can be graded against and over the impervious embankment to the final desired contours. These final contours should be established in cooperation with the Ohiopyle State Park superintendent or other officials. To minimize infiltration, the grading should prevent ponding of water at any location and assure that runoff occurs as quickly as possible without causing erosion.

5.3 South Side of North Branch: On the south side of the North Branch, ten entries into the deep mine workings were uncovered. Five of these entries are heavily subsided. Two of the entries can be sealed with individual seals constructed within the mine, and one can be sealed with a clay seal at the ground surface. In the remaining areas, compacted impervious embankments such as the one proposed on the north side are proposed. The maximum water level expected is approximately El. 1445.

The airway entry into the Taylor No. 2 Mine (14, Fig. 4) is completely subsided over the entire distance where it passes through the very weathered rock near the ground surface (100 to 150 feet). Sealing of this entry can best be accomplished by an individual compacted clay seal at the ground surface (S1). This entry is at the highest elevation of any entries on the south side, and significant pressure on the seal is not anticipated. The main entry to the Taylor No. 2 Mine is to be sealed by an in-mine seal (S2) constructed from within the mine.

At the upper end of the strip cut, the trench excavation exposed four entries, two open and two subsided. In addition, there is significant subsidence and severe fracturing of the overburden rock. In this area, the principal joint system is vertical and strikes parallel to the highwall. Consequently, large blocks of overburden rock are tending to slump into the strip mine cut. Sealing of this area will be difficult, and prevention of leakage from the mine, particularly in the area of the slumping joint blocks, will be limited. However, construction of a compacted impervious embankment seal along the 325 feet of the exploratory trench should provide sufficient sealing to totally flood the mine workings, even if leakage occurs through the fractured rock at higher elevations.

At the lower end of the strip pit, the trench excavation along the highwall exposed one open entry and two subsided entries and significant fracturing of the overburden above the coal seam. Over approximately 200 feet of this distance, the deep mine workings are very close to the stripping face, and a compacted impervious embankment is proposed. The open entry into the Miller Mine (9, Fig. 4), the lowest entry on the south side, can be sealed by an individual seal (S3) from within the mine entry.

5.4 <u>Estimated Construction Cost and Effectiveness:</u> The estimated cost of construction for the sealing work proposed in this report is summarized in Table III. Total estimated construction cost is $668,000. This does not include regrading the strip mine spoil banks or extensive grouting along the highwalls or along the outcrop adjacent to the King No. 2 Mine. The cost of regrading the spoil banks is estimated to be about $150,000. At the present time, extensive grouting is not expected to be required, but an additional

$300,000 to $500,000 for grouting could be required. The possible total construction cost is thus about $820,000 to $1,300,000. The effectiveness of this sealing program in abating acid mine drainage from these mines is estimated to be 90 to 95 percent for the King No. 2 Mine and the north side of the North Branch. On the south side, severe fracturing and block movement at the upper end of the strip cut may reduce the effectiveness of the sealing in that area to 70 to 75 percent. For the total watershed, the reduction in acid mine drainage is expected to be 85 to 90 percent.

6.0 Recommendations

To substantially reduce the acid mine drainage from abandoned mines in the Cucumber Run Watershed, the following construction work is recommended:

1. The installation of six individual seals in the King No. 2 Mine, as shown on Fig. 12. A grout curtain should be placed through the seals at the lower end of the mine to improve their effectiveness. Grouting along the outcrop may be required, but this should be postponed until the seals can be evaluated and the extent of grouting necessary can be determined.
2. Individual seals should be installed in the three entries of the Taylor Mine, the main entry to the Taylor No. 2 Mine, and the three entries to the two Miller Mines. The airway entry to the Taylor No. 2 Mine is caved and should be sealed by compacted clay at the ground surface.

3. In three areas, where the deep mine workings are very close to the stripping face, compacted impervious earth embankments should be constructed against the highwall. Open mine entries in these areas should be filled with available soil and rock prior to construction of the embankments to assure lateral support for the embankment. Following evaluation of the sealing operations, the remaining strip mine spoil should be graded against and over the impervious zone to the desired final contours.

4. During construction, piezometers should be installed at the locations shown to permit continuous monitoring of the mine water level. Following completion of construction, the area should be frequently inspected to observe seepage which may develop, to read piezo-meters, and to monitor water quality of the streams.

5. No provision for controlled drainage is recommended in any area. There are no water supplies in the area to be effected by the mine flooding and mined areas are of limited extent.'

7.0 Conclusion

A complete field study of abandoned mining operations in the Cucumber Run watershed, including a surficial investigation, subsurface exploration by borings, excavation of old mine entries, and sampling of water flowing from the mine entries and in the streams, was conducted to determine the feasibility of sealing the abandoned workings to eliminate or reduce acid mine drainage into Cucumber Run which has caused staining of Cucumber Falls, one of the principal attractions of Ohiopyle State Park. This study has shown that the workings can be sealed by a combination of individual seals, impervious embankments, grouting of in situ rock, and regrading of strip mine backfill.

These seals should result in flooding of nearly all of the abandoned mine workings, thereby substantially reducing the flow of acid mine drainage into the streams of the watershed. Limited water quality sampling and testing indicate the present average pollution load in Cucumber Run is about 4300 lb/day of acidity, 73 lb/day of iron, and 12,500 lb/day of sulfates. It is expected that the proposed sealing program would reduce this pollution load by 80 to 85 percent. Estimated construction cost of this work is $820,000 to $1,300,000.

Respectfully submitted,

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