EVALUATION OF ACID PREVENTION TECHNIQUES USED IN SURFACE MINING[1]

Meek, F. Allen Jr., P.E.[2]

Abstract: Surface coal mining was conducted in a potentially acid producing region of central West Virginia between 1979 and 1986. Seven different surface mining operations were conducted at the complex with different acid preventative techniques employed at six of the operations. No acid preventative techniques were utilized on the first operation that serves as the control for this evaluation. Water quality, treatment reagents and acid preventative costs were closely monitored from the time the operations were started to several years after reclamation. The evaluation indicates that 50% to 70% of the control acidity was prevented by the techniques employed at the facility. The evaluation also indicates that the acid generation at these facilities has a defined life of 16 to 20 years. The economics of the evaluation indicates that the preventative techniques employed at the facility were more expensive than treating the drainage from the sites with no preventative techniques employed.

Additional Key Words: acid mine drainage, overburden, acid preventative technique.

Introduction

The Upshur Complex of Island Creek Mining Inc. consists of approximately 27,000 acres of both surface and deep mine reserves located in Upshur County West Virginia. The principle seams on the reserve are the Middle and Lower Kittanning. Other mining in the area during the late 1960's and early 1970's produced surface mines that exhibited severely acidic drainage characteristics both during the mining phase, and after reclamation was completed. The Buckhannon River, the principle drainage for the area, is a high quality, lightly buffered stream, that is periodically stocked with trout. Because past mining had caused post mining acidic discharges and the Buckhannon River was a valuable recreational resource, mining permits for the area were put on hold by regulatory authorities until solutions to the acid mine drainage questions could be addressed.

In 1978, the director of the West Virginia Department of Natural Resources appointed a Task Force consisting of Industry, Regulatory and Academic participants. This Task Force was charged with gathering information and evaluating field procedures used during mining to prevent acidic mine drainage. In 1979, the group published a document titled "Suggested Guidelines for Mining in Potentially Acid Producing Overburdens" which summarized material handling and mining procedures that could be employed to help prevent the occurrence of post mining acid mine drainage. In 1982,

---

[1]Paper presented at the AIME Conference in Denver, CO, February, 1991.

[2]F. Allen Meek, Jr., Director of Environmental Affairs, Glenn Springs Holdings, Inc., Lexington, KY, USA.

Proceedings America Society of Mining and Reclamation, 1994 pp 41-48
DOI: 10.21000/JASMR94020041

https://doi.org/10.21000/JASMR94020041

a Technical Advisory Committee was appointed consisting of well known researchers in the field of acid mine drainage prediction and prevention. The group was charged with the task of conducting research in the field of acid mine drainage prevention.

Mining conducted at the Upshur Complex between 1979 and 1986 employed various acid mine drainage preventative techniques recommended in the suggested guidelines manual and techniques concurrently being researched by the Technical Advisory Committee. Costs for the various techniques were documented and the resulting post-mining water monitored.

Description of Site

The Upshur Complex is located on the western slope of the Allegheny Mountain Range. Average elevation at the site is 2200 feet. Topography consists of plateaus intersected with frequent valleys having moderate to steep slopes, with relief ranging from 300 to 500 feet.

The Kittanning Coal seams are located at the base of the Allegheny group of the Pennsylvanian formation. The Lower Kittanning occur in two splits, with 15 to 24 inches of shale parting material separating the seam. The Middle and Lower Kittanning seams have 4 to 15 feet of shale/bone coal interburden separating the seam, with only minimal portions in the Middle Kittanning seam itself. Total seam height mined at the property is typically 10 feet. Overburden encountered at the site has ranged from 60-80 feet, with those areas having less than 80 feet of cover mined by mountain top removal method, and those with higher cover are contour mined with an 80 foot highwall. The overburden consists of primarily sandstone with minor amounts of carbonaceous shale streaks and lenses.

Overburden removal at the site was conducted after blasting, by utilizing three 20 cubic yard electric shovels. Coal was mined using D-9 ripper tractors in combination with front end loaders and trucks. The interburden separating the seams was removed with 10 cubic yard backhoes and trucks. Annual production at the operation between 1979 and 1986 averaged slightly under one million TPY.

Methodology

All mining conducted at the Upshur Complex between 1979 and 1986 was within a two square mile area located in the central portion of the reserve. Prior to mining, each individual permit area (ranging in size from 150 acres to 400 acres) was core drilled and samples of individual strata were retained for laboratory analysis. The number of holes completed on each permit varied according to the size of the area to be mined. Holes were placed at a maximum of 1000 foot spacings.

Each stratum was analyzed for "Acid/Base Accounting" which consists of: paste pH, a total sulfur/pyritic sulfur ratio and neutralization potential.

Paste pH is an indication of the amount of sulphide oxidation present which in turn is an indication of the amount of weathering the stratum has been subjected to. Upon exposure, overburden having a low pH will produce acidic leachate until the soluble salts are leached from the material. The total pyritic sulfur analysis indicates the amount of acid producing material present in the rock being

analyzed. The higher the sulfur content, the more likely the material will produce acidic leachate upon exposure. The neutralization potential analysis is a measure of the amount of alkalinity or neutralizing material present in the stratum.

Both the total sulfur, (acidic potential) and the neutralization potential test results are expressed in Calcium Carbonate equivalents. The amount of alkalinity and acidic potential contained in each stratum is an indication of the quality of leachate the material will produce upon weathering. In addition to acid base accounting, simulated weathering tests were performed on selected cores on each permit. Simulated weathering tests were conducted by subjecting the material to alternating cycles of moist and dry air, followed by leaching the samples with water. The leachate water was collected and analyzed for acid and/or alkaline constituents.

Analytical results at Upshur indicate that the acid producing material is confined to the interburden, and about 15 feet of overburden directly above the middle Kittanning Coal seam. The more acidic components are associated with carbonaceous materials in the coal partings and interburdens. Although there are differences in overburden quality between boreholes and permit areas, for the purpose of this report, the acid producing potential of the areas under discussion was assumed to be equal. This is justified by the fact that statistically, with the standard deviation of laboratory procedures, there are no significant difference in the overall quality of the overburden mined within the study area. All sites have potentially acid producing material associated with the interburden and the overburden directly above the middle Kittanning, with the remainder of the overburden being neutral.

Acid Preventative Measures

Various acid preventative techniques were utilized at the Upshur Complex. A brief description of these are listed below.

Selective Handling and Placement

Selective handling and placement is a very basis approach to the prevention of acid mine drainage from surface mining operations. The technique involves the identification of acid producing material prior to mining, and placement of this material, during reclamation in a location which minimizes exposure to oxygen and water (fig. 1). The potentially acid producing material is placed off the pit floor, on a porous pad and a porous non-acid producing drain is placed against the highwall of contour operations. Groundwater entering through the highwall will move through the drain and porous material, without coming in contact with the acid producing material. In addition, acid material is covered with a minimum of 4 feet of non-acid producing overburden. The acidic material is also compacted prior to capping to further minimize ground water infiltration.

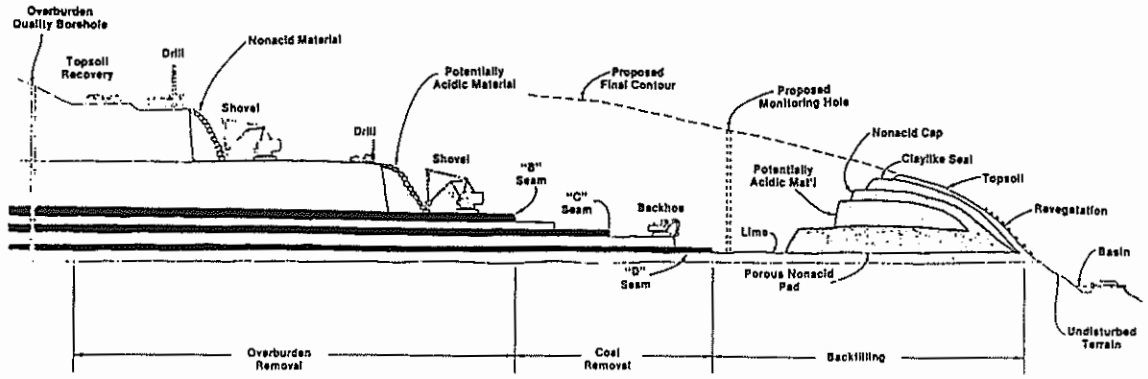

Figure 1. Backfill of Regrading Plan (section)

Sealing of Acid Producing Material

While selective handling and placement has been used as the only preventative technique in some cases, at Upshur a combination of a plastic liner placed over the acid producing material was studied at one 45 acre area. In utilizing this technique, the acid material was placed on a ten foot porous pad, brought up to final grade, and the surface prepared for liner placement. Thirty mil PVC was used for the liner. After installation, approximately 10 feet of non-acid producing overburden was placed on the liner. The area was then topsoiled and seeded. In this application, the mining method was mountain top removal, and no highwall drains were utilized.

Lime Addmixing

A method of acid prevention described in the Suggested Guidelines manual and utilized at the Upshur Complex is lime addmixing. In this technique, the acid spoil is selectively handled, as described above, but ground limestone is added to the backfill at specific rates and in specific locations. At Upshur, the limestone consisted of quarry by product called #10 block sand. This material ranged in size from 3/8" down to less than 200 mesh and is approximately 85% Calcium Carbonate. The limestone was placed at a rate of 5-10 tons/acre on the pit floor, prior to backfilling, blended into the acid spoil at a rate of 20 to 30 tons/acre, and placed on the surface at a rate of 5 tons/acre.

A slight variation to the technique was also used on a permit area at the site. In this variation, more soluble Quick lime was blended into the acidic spoil. Ground limestone was still placed on the pit floor and the surface, but 250 tons/acre of quick lime was blended into the acid spoil.

The alkaline material placed at specific locations of the backfill are intended to prevent acid formation by keeping the acid producing material in an alkaline environment. This alkaline condition helps to prevent bacterial oxidation of pyrite while neutralizing the pyritic material that is oxidized. In the process it is theorized that precipitated metal hydroxides coat the reactive surfaces of the pyrite thus slowing further oxidation.

Phosphate Addmixing

A relatively new acid preventative technique used at Upshur is the application of Apatite rock (Calcium FloroPhosphate) as an addmixed material to surface mined overburden. Phosphate ions in solution react to form highly insoluble Iron Phosphate compounds when in contact with pyrite oxidation products. Apatite rock is relatively insoluble at a neutral pH with increased solubility as the pH decreases. The technique requires that the Apatite rock be thoroughly blended with the acid producing material within the backfill. When pyrite begins to oxidize, and pore water within the fill becomes acidic, the Apatite rock will release phosphate ions into solution. The phosphate ions will then complex the oxidized iron ions on the pyrite surfaces to coat the reactive surfaces with iron phosphate compounds. Once the reactive pyrite surfaces are coated, further oxidation will be reduced. When oxidation and acid production is stopped, further solubilization of the Apatite rock will also cease.

At Upshur, when this technique was used, overburden was selectively handled as with the other techniques described above. Apatite rock was placed on the pit floor prior to backfilling and blended into the acidic overburden at the rate of 3 tons Apatite/1000 tons of acidic spoil. The gradation of the Apatite used was 28 mesh x 0, with most of the material being between 10 and 28 mesh in size.

Alkaline Addition

The acid producing spoil is selectively handled and segregated in the backfill area. The surface of the acidic spoil is then graded and a 2 foot thick compacted earthen seal is applied as a clay liner. The acid spoil is then covered with 4 feet of non-acid producing overburden, topsoiled and vegetated. In addition, at the toe of the clay liner, an alkaline trench is installed. This trench is 3 feet wide and 6 feet deep and is filled with different gradations of limestone and Soda Ash briquettes at the rate of 0.65 lb/sq. ft. The technique is designed to modify the hydrology of the backfill by limiting infiltration into the acidic region while directing surface runoff through the alkaline trench. In theory, the acidity that is produced within the acidic region of the backfill will be neutralized within the fill.

Evaluation

The techniques employed to reduce the amount of acidic mine drainage at the Upshur Complex are new to the surface coal mining industry. Many of the methods described above were tried for the first time at this site. All the techniques add significant costs to the mining operation while each benefited in reduced water treatment costs during and after the mining operation is completed to some degree. With the added cost, it became quickly apparent that a method of determining the effectiveness of each technique needed to be developed. One would expect that by comparing the water quality draining from the individual permit areas, a good determination can be made. However, because these measures were applied in sequence rather than concurrent, it became difficult to make direct comparisons because of the age differences of each reclaimed area. A study conducted by the Office of Surface Mining and subsequent report titled "Methodology For Water Quality Predictions" reported that the mineralization of surface mine leachate varied with time. Figure 2 graphically shows the mineralization of mine runoff with respect to the age of the operation.

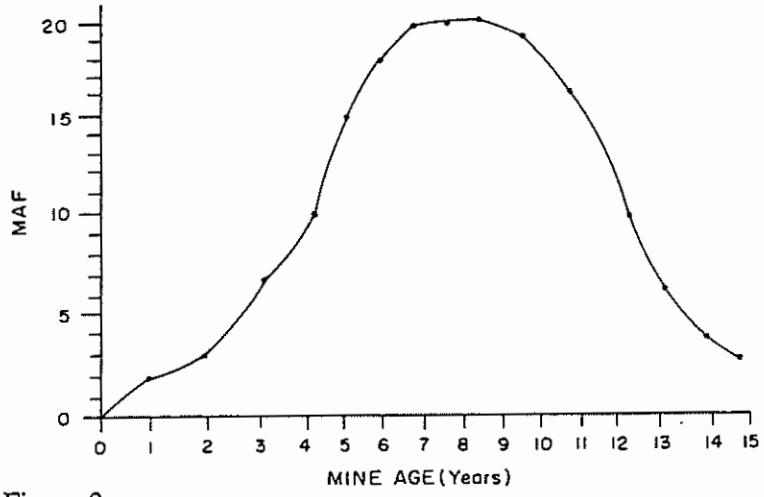

Figure 2.

The effectiveness of preventative techniques used at the Upshur Complex is measured by the resulting water quality of mine runoff at each of the mine areas. Flow measurements and acidity concentrations are taken on the untreated runoff at specific locations and at various times during the year. Measurements are used to double check acid production numbers generated from the amount of neutralizing agent used at our water treatment facilities throughout the complex. The amount of chemical used to neutralize the runoff is a direct correlation to the acid mine drainage being produced at each site and is measured on a continuous basis. The amount of neutralizing agent being used at each site is converted mathematically to acid production, and divided by the acres of coal extracted from each permit area. The resulting number is the acid production rate in pounds of acidity ($CaCO_3$ equivalents) per acre of area mined. The acid production rates of the mine areas having different preventative techniques employed are graphically shown in Figures 3-8. The numerical results are tabulated in Table 1.

Table 1.

PERMIT NO.	PREVENTATIVE TECHNIQUE	TOTAL ACID PROD/ACRE
163-76	None	100,000 lb/ac
112-78	Selective Plac. Lime Add. 35TPA	60,000 lb/ac
57-80	Selective Plac. Quick Lime 250TPA	50,000 lb/ac
S-12-82	Selective Plac. Alkaline Addition	50,300 lb/ac
S-108-82	Selective Plac. PVC Liner	27,500 lb/ac
S-91-83	Selective Plac. Phosphate Added	31,250 lb/ac

The results indicate varying degrees of success with the different techniques employed. None of the techniques were successful in eliminating the production of acid mine drainage completely. However, a reduction of greater than 70% over that of the control was demonstrated with the PVC liner technique. All preventative techniques reduced acid production to some degree.

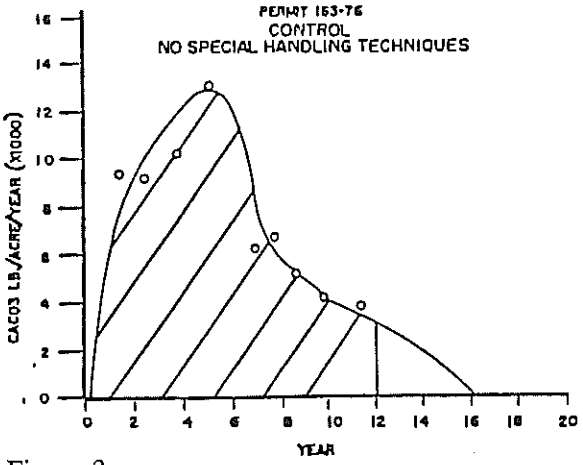

Figure 3.

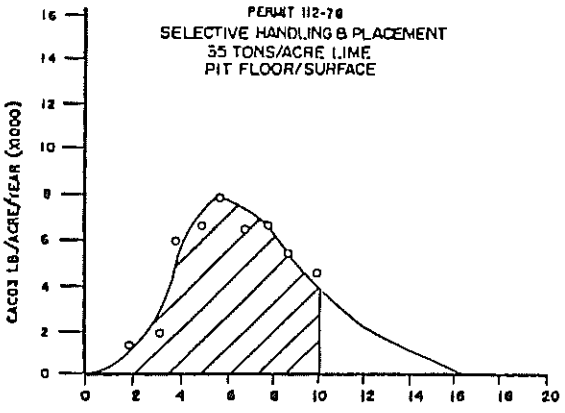

Figure 4.

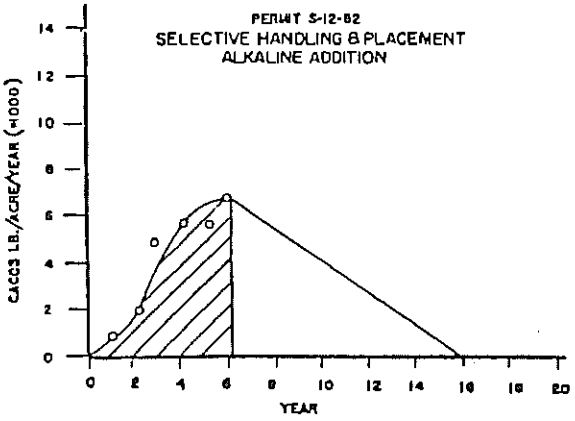

Figure 5.

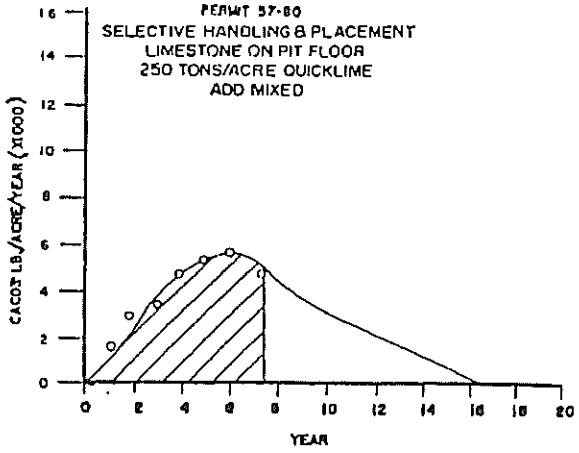

Figure 6.

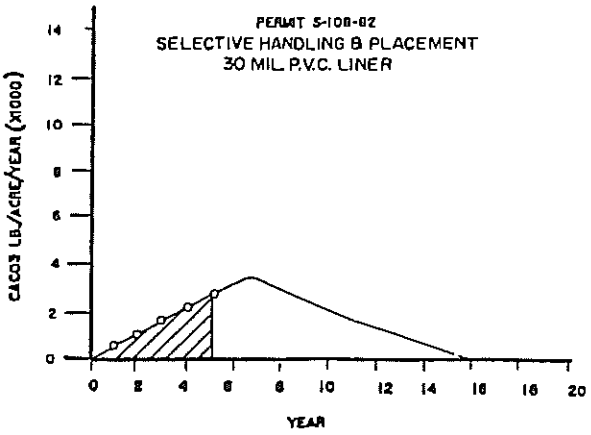

Figure 7.

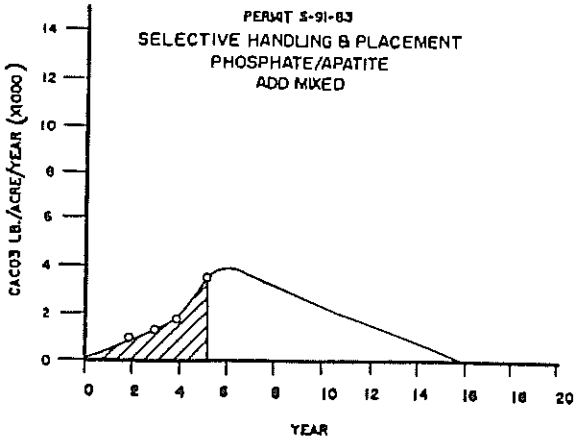

Figure 8.

Economic Considerations

From the time that mining began at the Upshur Complex, the environmental sensitivity of the area made it necessary to give serious consideration to the prevention of acid mine drainage. The area was known to produce acidic drainage upon mining, and it was thought the resulting water treatment requirement would go on indefinitely. Therefore, the costs incurred to prevent perpetual water treatment were considered a necessity. However, after years of monitoring, a trend of reducing acidity with time has become apparent. The evaluation indicates that over a period of 20 years or so, the raw water quality will reach levels similar to background and minimal, if any treatment will be required as shown in figures 2 and 3. Table no. 2 shows the costs of the acid preventative techniques, the difference in acidity produced from the control, and the treatment cost savings.

Table 2.

PERMIT IDENT.	PREVENT. TECH. COST	ACID PREVENTED	TREATMENT COST SAVING
163-76	Control	Control	Control
112-78	$15,300/ac	40,000 lb/ac	$2,000/ac
57-80	$25,500/ac	50,000 lb/ac	$2,500/ac
S12-82	$22,800/ac	40,700 lb/ac	$2,500/ac
S108-82	$16,300/ac	72,500 lb/ac	$3,600/ac
S91-83	$19,000/ac	68,750 lb/ac	$3,400/ac

The evaluation indicates the most cost effective acid preventative technique employed at the Upshur Complex has been the Selective Handling and Placement with Phosphate/Apatite Addmixed technique used on permit S-91-83. In conclusion, it can be said that none of the techniques attempted were entirely successful in the complete elimination of acid mine drainage. It is also apparent, considering the economics, that acid prevention can be more expensive than simply treating the drainage from a site. The most cost effective preventative technique cost $16,300/acre to prevent a potential of $10,880/acre of treatment costs. This evaluation indicates that this facility would have been better served by utilizing the capitol spent on preventative techniques to construct dependable, efficient treatment systems for treating the acid mine drainage produced.

REFERENCES:

Anon., 1979 "Suggested Guidelines for Surface Mining of Areas with Potentially Acid-Producing Materials" West Virginia Surface Mine Drainage Task Force.

Flynn, J.P. 1969. Treatment of earth surface and subsurface for prevention of acidic drainage from the soil. US Patent 3,443,882, May 13.

Meek, F.A. 1984. Optimization of apatite rock addition rates to acid producing mine spoils for the prevention of acidic drainage. West Virginia Surface Mine Drainage Task Force Symposium, Morgantown. Mar.

Sobek, A.A. 1978. Field and laboratory methods applicable to overburdens and mine soils. EPA-6001/2-78-054, U.S. EPA. Cincinnati, OH.

Stiller, A.H. 1982. A method for prevention of acid mine drainage. 3rd West Virginia Surface Mine Drainage Symposium. Clarksburg, WV. May 17.