A METHODOLOGY FOR EVALUATING THE COSTS OF SELECTIVE HANDLING[1]

by

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The object of this paper is to outline a method of determining the costs of special handling of acid-producing materials during the mining process. Our method attempts to break down the costs of special handling into their individual components and then determine how each of those component costs vary with different mining situations and geologic characteristics. We use a highly simplified situation in order to focus attention on our method. We plan to deal with more complex mining situations in future work.

Special Handling

Special handling of potentially acid producing material refers to several techniques that are currently being utilized by mining operators to meet their Surface Mining Control Reclamation Act (SMCRA) permit obligations and to minimize the costs of post-mining reclamation problems. In 1979 the Surface Mining Task Force published the bulletin "Suggested Guidelines for Method of operation in surface Mining of Areas with Potentially Acid-Producing Materials." This publication outlines techniques for handling surface water, ground water, and overburden during the mining process that would help control AMD.' The task force emphasizes: 1) identification of potentially acid- or alkaline-producing materials, 2) the mixing of acid and alkaline materials to neutralize the acid producing material, and 3) isolation of acid-producing material within the backfill to minimize contact with air and water. Today special handling can refer to any or all of the following: analysis and identification of potentially acid- and alkaline-producing material, blasting techniques (fragmentation), blending, mixing, isolation, the use of liners/seals, chemicals, and total removal of potentially acid-producing materials.

Identification

It is necessary to determine the composition of the overburden in order to select the best mining methods, the proper equipment, and the most efficient special handling techniques. There are three primary techniques currently used to determine the characteristics of the site's overburden: 1) acid-base accounting, 2) leaching and weathering procedures, and 3) modeling of hydrogeochemical systems. All techniques require the sampling of overburden materials.

The hydrological characteristics of the site are important in determining appropriate special handling practices. Hydrological characteristics determine the areas on the site where placement of acid-producing materials should and should not occur. In general, it is best to try and keep toxic materials isolated from water to minimize leeching processes.

Fragmentation

Fragmentation refers to the practice of blasting or ripping overburden into pre-specified sizes. It is the operator's goal to minimize the total surface area of the acid- producing material by leaving those strata largely intact, thereby lowering its relative acid-producing potential. In contrast, the operators attempt to maximize the total surface area of the alkaline strata by blasting or ripping it into the smallest possible fragments. This enhances the alkaline layer's inherent ability to neutralize the acid-producing material.

Blending

If the mine operator has determined that there will be enough alkaline-producing material at the site to neutralize the acid producing material, he may choose to blend these two materials. There are two ways to blend. First, you may blend by mixing (or co-mingling) the alkaline and acid-producing material. The other method, called layering, blends by placing a layer of alkaline producing material on top of a layer of acid-producing material.

Isolation

Isolation refers to the placement of acid-producing material in the backfill, away from the high wall and up from the pit floor. Separating this material from other overburden and placing it in the backfill is designed to minimize contact of this material with oxidizing agents. Isolation is accomplished by placing alkaline or oxidized layers from the overburden above, below, and around the acid-producing material.

Seals and liners

Clay or synthetic seals or liners may also be placed over the acid-producing material to further reduce the rate of oxidization. These seals reduce air contact with acid producing material and decrease water infiltration into the acid material.

Chemical Treatment

Chemicals and additives foreign to the mining site can be used when there are insufficient alkaline materials present to neutralize the acid-producing materials. These chemicals can be used in conjunction with the other special handling techniques. They can be blended with or placed strategically around the acid-producing materials.

Total Removal

Total Removal is a procedure in which the acid-producing materials are removed from the mining site and taken to an area that is better suited for their disposal. Refuse sites are the most common areas for disposing acid-producing materials. The area that receives the toxic materials will also need to be analyzed and reclaimed.

Special handling techniques are not mutually exclusive. They can be used to compliment each other in some situations, while in others it may be more efficient to concentrate on a single technique with which the operator has the most confidence and familiarity.

Costs of Selective Handling

Determining the costs of selective handling is a more complex task than evaluating the costs of AMD treatment systems. With AMD treatment systems, costs can be broken down into investment cost, chemical cost, annual labor and maintenance, and management costs (Phipps, et al. 1991). These costs can be estimated separately and added together to get the total cost of the AMD treatment system. In general, management costs--the most difficult costs to quantify--are a small proportion of total costs. With selective handling of overburden, management costs can be substantial, both in terms of developing the original toxic materials management plan to obtain the SMCRA permit and in day to day operations to identify, move, and isolate acid forming materials.

Selective handling of overburden is a more complex issue than treatment of AMD. Necessary practices are highly site specific. Costs will vary greatly depending on whether the acid forming strata lie directly on top of the coal, or occur in multiple strata throughout the overburden. In the latter case, blasting may have to be conducted in multiple stages, with the overburden above each acid forming strata blasted separately.

We simplify the analysis in this paper by assuming that all SMCRA conditions have been met (i.e., any special core drilling to determine material layers, analysis acid-based accounting, and other costs to obtain SMCRA permit). The cost of gaining information needed to obtain the SMCRA permit includes any expenses necessary to develop a management plan for special handling.

While the situation we describe is simplistic it is illustrative of the problems faced when special handling is implemented. We assume there is a single coal layer covered by a 6 ft toxic (acid-forming) shale layer. The overburden has a 25% slope and the mine will be developed to a highwall of 60 feet (figure 1). We assume there is a sufficient layer of oxidized, weathered or other suitable material in the overburden to encapsulate and isolate toxic material above the pavement and away from highwall and surface area.

Figure 2 shows the mining process in six stages. Each stage or cut is assumed to be 150 feet wide. The first cut has been fully reclaimed, as follows: after the coal seam was removed, a layer of oxidized or weathered material from cut 4 was placed on the pavement; then the toxic material from cut 3 was placed over the oxidized material, followed by another encapsulating layer of oxidized material from cut 4; the remaining overburden from cut 4 was then backfilled in cut 1, followed by a layer of topsoil from the newly opened cut 5. The coal from cut 2 is removed during this process. The process then continues with the oxidized material from cut 5 being placed on the pavement of cut 3, followed by the toxic layer from cut 4, with the process continuing until cut 2 is fully reclaimed and the coal is removed from cut 4. Figure 3 shows a cross section of a fully backfilled cut.

Figure 1. Cross section view of the coal seam, acidic shale layer, and overburden.

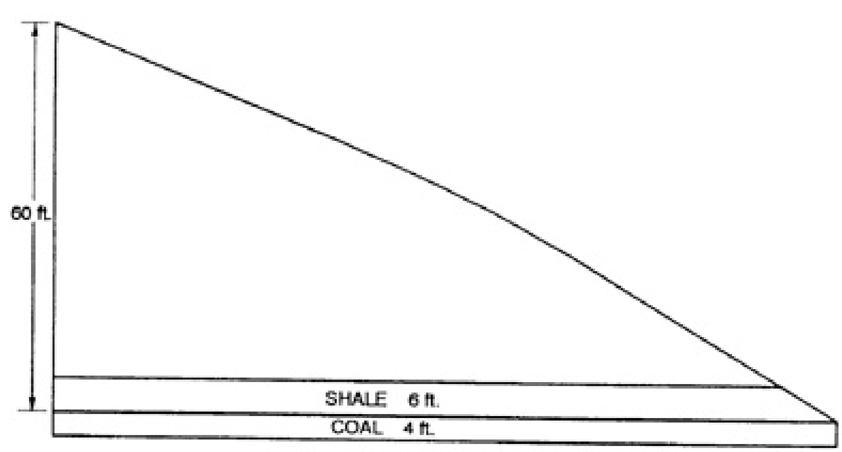


Figure 2. Simplified view of the mining process in six stages.

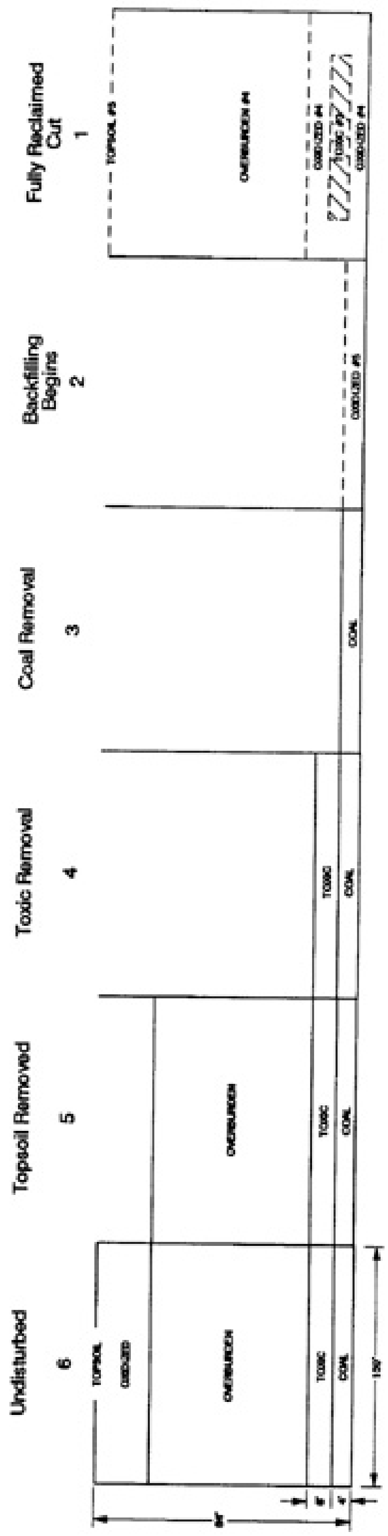
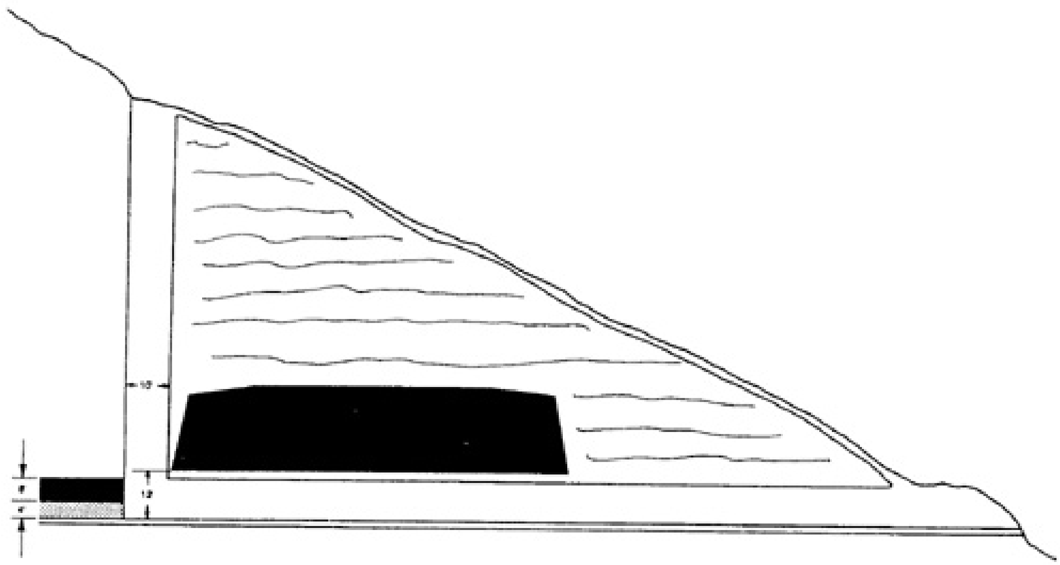


Figure 3. Cross section view of a fully backfilled cut.



Note: black area represents toxic material.

With the mining system described above, the primary additional costs of selective handling involve a longer haul of one additional cut length for the overburden and topsoil; any additional costs incurred from having to shift the front loader from loading oxidized material in cut 5 -- to loading toxic material in cut 4 -- back to loading overburden in cut 5, and any delays involved when handling toxic material or when switching from one material to another.

The equipment used in the operation is shown in table 1.

Table 1.

Table 1. Equipment Complement

Type	Number	Capacity	Purpose
Cat D8	1		backfilling
Cat D9	1		ripping and pushing
Cat 992	1	13 cu. yds	front end loader
Cat 773	3	50 tons	rock trucks
Drilltech D40K	1		Drill
Cat 988B	1		backhoe

Our method estimates the additional costs due to selective handling for each 1501 cut in a contour surface mine. We assume that the total haul length for hauling the toxic material is 400 yards, and the length of the haul for topsoil and overburden is 500 yards because it has to be moved the length of one additional cut. If selective handling were not being used, this additional cut would not be necessary. We calculated the additional equipment and labor costs of selective handling for one 150 foot cut by calculating the number of front loader cycles required to load overburden, toxic material and topsoil. Each front loader cycle takes one minute (based on field observation) and loads 13 cubic yards of material. We assumed that the total time per loader cycle was 20 percent longer when handling toxic material than when loading overburden because of the greater care that must be taken to keep the toxic material separated from the rest of the overburden.

Next, we calculated the number of truck cycles needed to haul the material. Cycles were then converted to time, using data from the Caterpillar handbook. We estimated that *turning and* maneuvering would take .7 minutes at the loading site and 1.1 minutes at the dump site. Loading time was assumed to be 3 minutes (three loader cycles). Travel time from the loading to the *unloading site* was estimated based on an average speed of 8 miles per hour. Finally, half a minute of slack time for each truck cycle was added to insure the loader remains busy. The cycle time for the 400 yard haul was calculated to be approximately 7 minutes; the calculated time for the 500 yard haul was 7.5 minutes.

It was estimated that selective handling would lengthen front loader time by 79 minutes and truck time by 269 minutes for each 1501 cut. Using Caterpillar (1991) estimated costs of $184 per hour for the loader and $104 per hour for the rock truck (under extreme terrain *conditions)* and $39 per hour for the operators, the total increase in costs due to selective handling was $709 per 1501 cut. The results of this analysis are shown in tables 2 and 3.

Table 2. Front Loader Time for one 150′ Cut

	Cubic Yards	Loading Cycles	Total Time (min)	Increase From Selective Handling	Cost of Increase ($184/hr)
Overburden	20,592	1,584	1,584		
Toxic	5,148	396	475	79	$243
Topsoil	394	30	30		
Total	26,134	2,010	2,090	79	$243

Table 3. Rock Truck Time for one 150′ Cut

	Cubic Yards	Truck Cycles	Total Time (min)	Increase From Selective Handling	Cost of Increase ($104/hr)
Overburden	20,592	528	3,960	264	$458
Toxic	5,148	132	924	0	$0
Topsoil	394	10	76	5	$9
Total	26,134	670	4,960	269	$466

Clearly, we have described a very simplified operation in this paper. In a real mining situation, the costs of selective handling would increase if the toxic material were distributed more widely throughout the overburden. We have also not included any additional management costs in our calculations and have assumed that the machinery operators possess sufficient skills to identify, move, and place toxic materials adequately. In a given situation, each of these factors could add to the costs of selective handling. We plan to address these additional cost factors in the future.

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