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

by
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Abstract. Selective handling of overburden materials involves implementing mining techniques that will reduce the probability of creating acid mine drainage (AMD). These include separately handling toxic materials and placing them in locations in the backfill to limit their exposure to air and water, or blending alkaline- and acid-producing materials to create a neutral rock mass. This paper uses three selective handling situations and estimates the additional costs of selective handling above those which would normally be incurred during mining. Scenario 1 depicts a 2-m (6-ft) toxic shale layer (acid-producing) on top of the coal that must be specially handled and placed within non-toxic layers in the backfill. Scenario 2 has a 2-m toxic shale layer over the coal and also a 2-m layer of alkaline material, and these two layers are blended during backfilling. Scenario 3 details specially handling a 0.4-m (1.4-ft) toxic layer located 5 m (15 ft) up from the coal bed which requires blasting in two stages. Based on these scenarios and the overburden layers separately handled, additional costs for loading and hauling the material ranged from $663 per 46 by 43 m (150 x 142 ft) cut (or about $3,348 per ha or $1,353 per acre) for scenario 1 to $1,119 per 46 by 43 m cut (or about $5,652 per ha or $2,284 per acre) for scenario 2. These cost estimates do not include additional management costs, additional blasting costs, or training costs for equipment operators.

Additional Key Words: acid mine drainage, acid-producing materials, backfilling, land reclamation, mine hydrology, reclamation economics.

Introduction

Selective handling of overburden materials refers to several techniques that are designed to reduce the probability of encountering an acid mine drainage (AMD) problem during and after mining. These techniques are currently being used by surface mine operators to meet their Surface Mining Control and Reclamation Act (SMCRA) permit obligations and to minimize the costs of post-mining reclamation, especially with regard to AMD treatment. In 1979, the West Virginia Surface Mine Drainage Task Force (SMDTF, 1979) published "Suggested Guidelines for Method of Operation in Surface Mining of Areas with Potentially Acid-Producing Materials." This publication outlined techniques for handling surface water, ground water, and overburden during the mining process to help control the production of AMD. The task force recommended: 1) identification of acid- or alkaline-producing materials before mining, 2) mixing or blending acid and alkaline materials during backfilling when alkaline materials were in greater amounts than acid-producing materials, and 3) isolation of acid-producing material within the backfill to minimize contact with air and water when insufficient alkaline materials were available to neutralize potential acidity.

The selective handling process has two stages: analysis and implementation. The analysis stage involves identifying the quantity, type, and location of acid- and alkaline-producing materials in the overburden. The implementation stage involves developing and carrying out the selective handling plan. The plan may incorporate a number of techniques including special blasting or fragmentation techniques; blending, mixing, and isolation of overburden layers during backfilling; the use of liners or seals; alkaline addition; and total removal and disposal of acid-producing materials off site or in a refuse area.

[1]Paper presented at the 1996 National Meeting of the American Society for Surface Mining and Reclamation, Knoxville, Tennessee, May 18-23, 1996. Support for this research was provided by the U.S. Bureau of Mines and the National Mine Land Reclamation Center under Project WV-10, and the West Virginia Agricultural and Forestry Experiment Station.

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Proceedings America Society of Mining and Reclamation, 1996 pp 407-423
DOI: 10.21000/JASMR96010407

https://doi.org/10.21000/JASMR96010407

Analysis

It is necessary first to determine the composition of the overburden in order to select the best mining methods, the proper equipment, and the most efficient selective handling techniques. There are three primary techniques currently used to determine overburden characteristics: 1) acid-base accounting, 2) leaching and weathering procedures, and 3) modeling of hydrogeochemical systems based on data from Acid-Base Accounting (Perry 1985, Skousen et al. 1987). Each technique has advantages and disadvantages and the techniques may also be used alone or in combination. All techniques require sampling distinct rock units in the overburden and subjecting the rocks to whole rock analysis or leaching procedures. The results of the analysis should give the operator an estimate of the quantity, type, and distribution of acid-producing and acid-neutralizing materials in the overburden. Continued sampling and analysis of overburden should occur during the mining process.

Implementation

Once the composition and distribution of the overburden materials have been established, a plan for overburden removal and replacement can be developed. The hydrological characteristics of the site are important in determining this plan and may designate the areas on the site where placement of acid-producing materials should or should not occur. In general, it is best to keep toxic materials isolated from water to minimize leaching of acid into water courses. **Fragmentation** refers to the practice of blasting or ripping overburden into predetermined sizes. The operator's goal is to minimize the total surface area of acid-producing materials by leaving those strata largely intact, thereby reducing their acid-producing potential. In contrast, operators attempt to maximize the total surface area of alkaline strata by blasting or ripping them into the smallest possible fragments to enhance their neutralizing capability (Skousen and Larew 1994).

If analysis of the overburden indicates that there will be enough alkaline-producing material at the site to neutralize the acid-producing material, the mine operator may choose to **blend** these two materials. There are two ways to blend. The first is by pushing and mixing the alkaline and acid-producing materials together with equipment during overburden removal and placement. The other method, called **layering**, involves placing a layer of alkaline material on top of a layer of acid-producing material.

Isolation involves placing acid-producing material away from the highwall and above the pit floor in the backfill. Isolation is designed to minimize the contact of acid-producing material with oxygen and water. Isolation is accomplished by placing alkaline material above, below, and around the acid-producing material. In its most elaborate installation, a low permeability barrier or seal of compacted material is placed above or around the acidic material. Clay, shale, or synthetic **seals** or liners reduce air contact with acid-producing material and decrease water infiltration into the acid material.

Alkaline material in the form of limestone or other lime products can be imported when insufficient quantities of alkaline materials are found on-site to neutralize the acid-producing materials or to create a neutral rock mass. These products can be used in conjunction with the other selective handling techniques. They can be blended with or placed strategically around the acid-producing materials (Meek 1991, Skousen and Larew 1994). **Total removal** involves taking the acid-producing materials from the mining site to an area that is better suited for their disposal. Refuse sites are a common location for disposing of acid-producing materials. The area that receives the toxic materials will also need to be analyzed, sufficient alkaline material emplaced, and the entire area compacted and reclaimed.

Selective handling techniques are not mutually exclusive. These methods can be used to complement 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

Estimating the costs of selective handling is a more complex task compared to evaluating the costs of AMD treatment systems as demonstrated in Phipps et al. (1991). With AMD treatment systems, costs can be broken down into investment costs, chemical reagent costs, annual labor and maintenance costs, and management costs (Skousen 1991, Skousen et al. 1993). These costs can be estimated separately and added together to get the total cost of the AMD treatment system. Management costs--the most difficult costs to quantify--are a small proportion of total costs with AMD treatment. With selective handling of overburden, management costs can be substantial, both in terms of developing the original toxic materials special handling plan to obtain the SMCRA permit and in day to day operations to identify, move, blend, or isolate acid-forming materials. Selective handling 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 stratum blasted separately.

Several studies have been concerned with the costs of selective handling. Kelley et al. (1982) developed a mining engineering plan to integrate selective placement of overburden into the mining cycle. They used a two bench, dragline operation as a case study and compared it to a typical shovel-truck contour mining method. Their goal was to find the most cost-effective method of selective placement for their particular mining situation. They found that truck haulback of toxic overburden was more cost effective in the mountainous Appalachian Coal Region of the eastern U.S than the use of draglines. They did not attempt to break out the incremental costs due to selective handling.

Meek (1991) evaluated the costs and effectiveness of a number of selective handling procedures employed at the Upshur Complex of Island Creek Coal Corporation in West Virginia. The techniques employed on the site include isolation and placing the toxic material above the pit floor; layering non-toxic overburden above the toxic material; covering acid-producing material with a plastic liner; and mixing phosphate and alkaline materials with toxic materials. The study found that all the selective handling techniques added significant costs to the mining operation, but that each technique reduced the total amount of acid produced on the site. Of the techniques used at the site, Meek found the two most cost-effective practices were the addition of phosphate to toxic material and the placement of a liner above toxic material. The study also compared these costs of selective handling with the costs of water treatment over specified time periods. At this site, mining costs (including special handling costs and alkaline amendments) were estimated to be $47,000 per ha ($19,000 per acre) compared with annual treatment costs of $8,400 per ha ($3,400 per acre). Therefore, if water treatment continued for more than six years, selective handling techniques resulted in lower overall reclamation costs.

Skousen and Larew (1994) studied the costs and effectiveness of transporting alkaline materials about 1.6 km (1 mile) and blending these materials with acid-producing overburden at a coal mine near Masontown, WV. The authors estimated the costs of transporting the alkaline material to be about $9,900 per ha ($4,000 per acre) and the costs of water treatment per year to be about $800 per acre. Like Meek's study, selective handling and importing alkaline materials was expensive during the mining phase of the operation, but this process eliminated the long-term treatment of AMD. If water treatment was necessary on the site for more than five years, selective handling was a more cost-effective reclamation approach.

The primary limitation of the latter two studies is their site specific focus, and the results cannot be effectively applied to other sites. The goal of this paper is to present a method for estimating the incremental costs of special handling toxic materials during the mining process for a contour surface mining operation in Appalachia. The method attempts to separate the costs of special handling into their individual components and then determine how each of the component costs vary with different mining situations and geologic characteristics.

The analysis is simplified in this paper by assuming that all SMCRA conditions have been met (i.e., any special core drilling to determine geologic layers, analysis by acid-base accounting, and other costs to obtain the necessary SMCRA and National Pollution Discharge Elimination System (NPDES) permits). The cost of gaining information needed to obtain the SMCRA permit includes any expenses necessary to develop a toxic materials special handling plan including identification and classification of overburden layers. While the three example scenarios are simplified from real world conditions, the method should be readily adaptable to other conditions.

Methods

Three scenarios are used to capture the different cost components that may be encountered when using selective handling on a contour surface mine using the haulback method. Each scenario is based on actual mine conditions found in West Virginia. All three scenarios are assumed to have a single, 1.5-m (5-ft) thick coal bed and an average ground surface slope of 25 percent. Based on this slope, the mine in each case is developed into the hillside to a distance of 39 m (129 ft) correlating to a highwall height of 20 m (64 ft), using the rule of thumb of 0.3 m (1 ft) of highwall for every 2.5 cm (1 inch) of coal (Sengupta 1993). Each stage or cut is 46 m wide (150 ft) along the contour and 39 m (129 ft) into the hillside. However, land area is calculated from 46 m in width and 43 m in length (142 ft) up the slope equaling 1,978 m^2 or 0.198 ha (21,300 sq ft or about 0.49 acres). Topsoil is stockpiled and spread later on the reclaimed area during typical contour mining, so no additional costs are assumed for topsoil handling and placement with these scenarios except for increased hauling distance. For scenario 1, there is a 1.8-m (6-ft) acid-producing layer that lies directly on top of the 1.5-m coal bed. Scenario 2 adds a 1.5-m alkaline layer located in the middle of the overburden. Scenario 3 has only a 0.4-m (1.4-ft) acid-producing layer in the middle of the overburden.

All scenarios are compared to a typical contour mining operation using the haulback method that does not utilize special handling (Figure 1). As shown, pit (cut) 1 has been backfilled and reclaimed with the overburden from pit 3 and the topsoil from pit 4. The coal has been removed in cut 2 and backfilling may begin with overburden from cut 4 and topsoil from cut 5. It was assumed that machinery operators possess sufficient skills to identify, move, and place toxic materials adequately.

The additional equipment and labor costs of selective handling for one 46-m cut were calculated by determining the increased number of front-end loader cycles required to load overburden, toxic material, and topsoil. Each front-end loader cycle takes approximately one minute (based on field observation) and loads 10 cubic meters (13 cubic yards) of material. The total time per front-end loader cycle was 20 percent longer when handling toxic or alkaline material than when loading overburden because of the greater effort required to keep these materials separated from the rest of the overburden.

The number of truck cycles needed to haul the material was calculated based on truck and front-end loader capacities. Cycles were then converted to time, using data from Caterpillar, Inc. (1991). Truck turning and maneuvering was estimated to take 0.7 minutes at the loading site and 1.1 minutes at the dump site. Trucks hauled 30 cubic meters (39 cubic yards) of material, and loading time was assumed to be 3 minutes (three loader cycles). Travel time from the loading to the unloading site was based on an average speed of 13 km per hour (8 miles per hour). Finally, half a minute of slack time for each truck cycle was added to ensure the loader remained busy. The cycle time was estimated to be 7 minutes for the 183-m (600-ft) haul (2 pit widths back and forth or a total of 4 pit widths), 7.5 minutes for the 275-m (900-ft) haul (3 pits widths back and forth), 8 minutes for the 367-m (1200-foot) haul (4 pit widths), and 8.5 minutes for the 459-m (1500-ft) haul (5 pit widths). The costs developed in this paper should be added to the costs incurred for a typical mine operation per 46 by 43 m (150 by 142 ft) pit or per ha.

Results and Discussion

Scenario 1

While scenario 1 is the most simplistic of the three, it illustrates many of the management issues encountered with selective handling. Scenario 1 has a 1.8-m toxic (acid-producing) shale layer over the coal bed and a 4.4-m (14.5-ft) layer of oxidized material to encapsulate toxic material above the pavement and away from the highwall (Figure 2).

Figure 3 shows the mining process in six stages. The first cut has been fully reclaimed. The reclamation process proceeded as follows. After the coal was removed from cut 1, part of the oxidized material from cut 4 (no acid-producing potential) was placed on the pit floor or pavement of cut 1; then the toxic material from cut 3 was placed over the oxidized material, and then the remaining oxidized material from cut 4 was used to cover the toxic material. The 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 while overburden from cut 4 and topsoil from cut 5 are being placed in cut 1. The backfilling process in cut 2 then continues with part of the oxidized material from cut 5 being placed on the pavement of cut 2, followed by the toxic layer from cut 4, the remainder of oxidized material from cut 5, then backfilling with overburden from cut 5, and finishing with topsoil from cut 6 until cut 2 is fully reclaimed. Figure 4 shows a cross section of a fully backfilled cut with the dark area representing the toxic material placed within encapsulating layers of oxidized material.

With the mining system described above, the primary additional costs of selective handling are: 1) a longer haul of one additional cut length (46 m one-way or 92 m for round trip) for the overburden and topsoil; 2) additional costs incurred from having to shift the front-end loader from loading oxidized material in cut 4 to loading toxic material in cut 3 and then back to loading the remaining oxidized material in cut 4; and 3) 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. Total haul length for hauling the toxic material is 183 m (600 ft) or 2 pit widths back and forth, the length of the haul for overburden is 275 m (900 ft, or 3 pit widths) because it has to be moved the length of one additional cut, and the haul for topsoil is 366 m (1200 ft, or 4 pit widths). If selective handling were not being used, there would be one less cut, reducing the haul length for the overburden and topsoil by 92 m (300 ft).

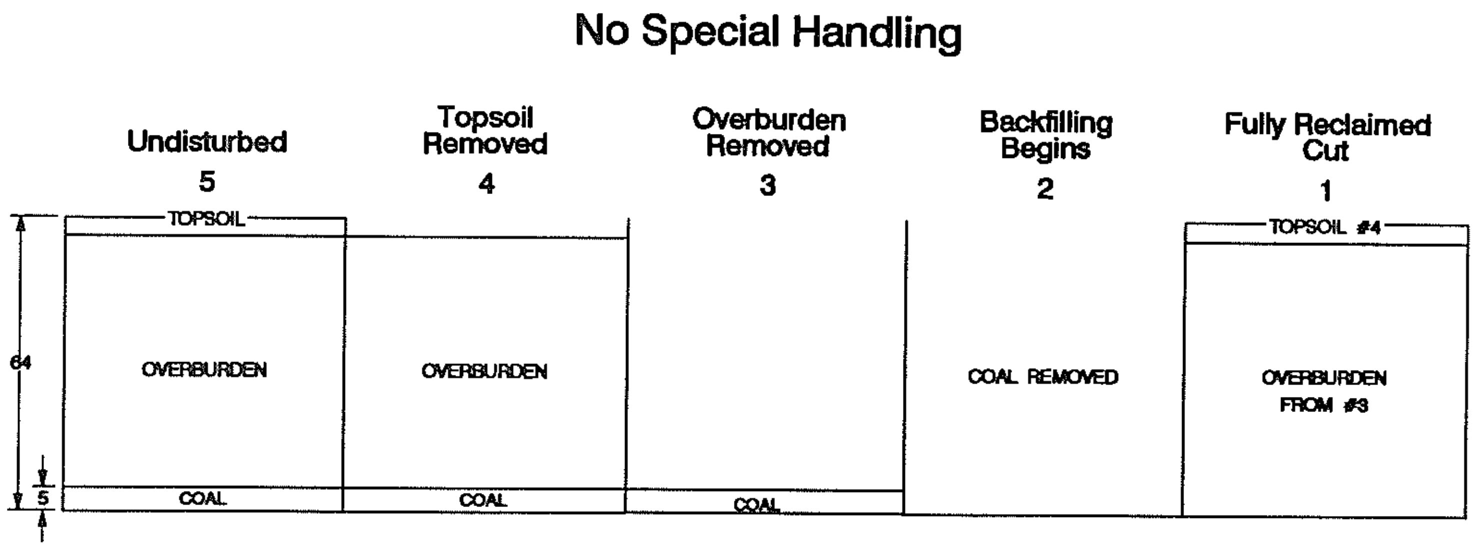

Figure 1. A simplified view of the mining process for a typical contour surface mining operation in West Virginia. Normally three pits are open at any one time to remove topsoil, overburden and coal. Cut 1 is fully reclaimed and shows the material and pit number used for backfilling.

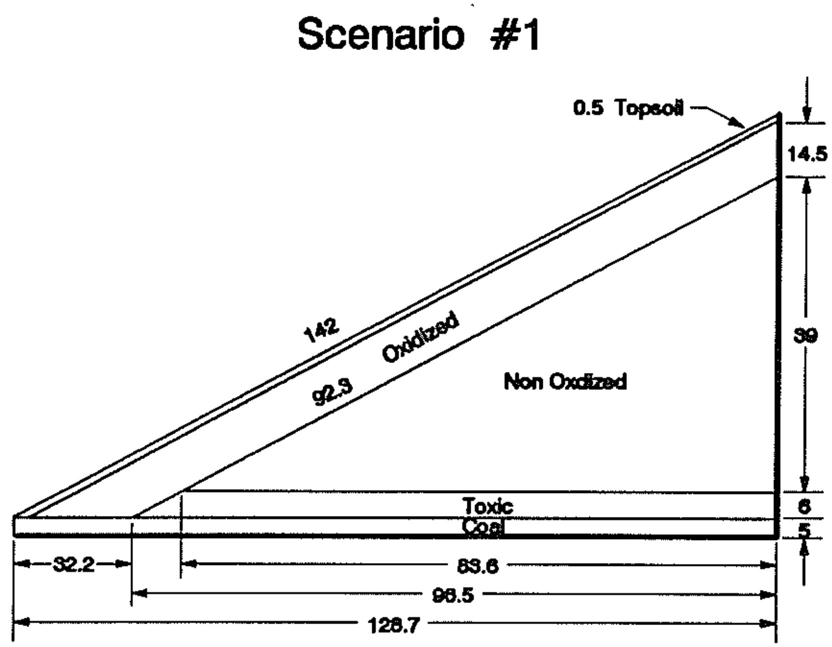

Figure 2. Undisturbed geologic cross-section for scenario 1 (all numbers in feet) with a 6-ft toxic layer overlying the coal bed.

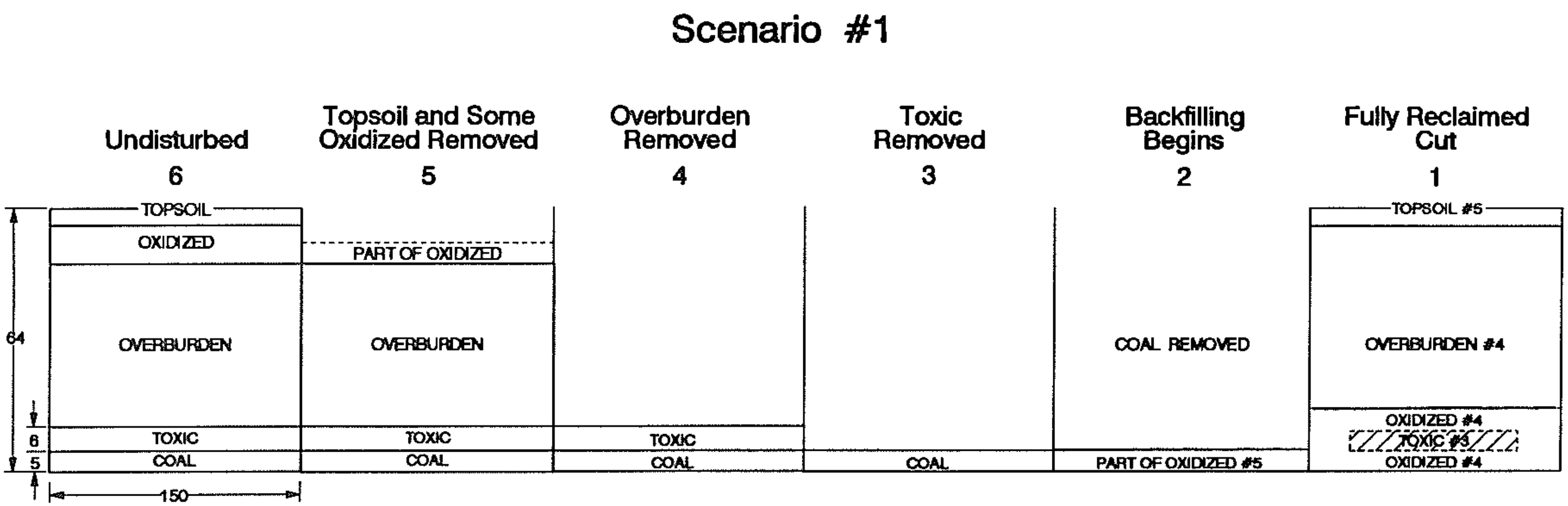

Figure 3. Simplified view of the mining process of a contour operation (scenario 1) where a 6-ft toxic layer above the coal bed is being selectively handled. Cut 1 is fully reclaimed and shows the material and pit number used for backfilling. In this case, four pits are open.

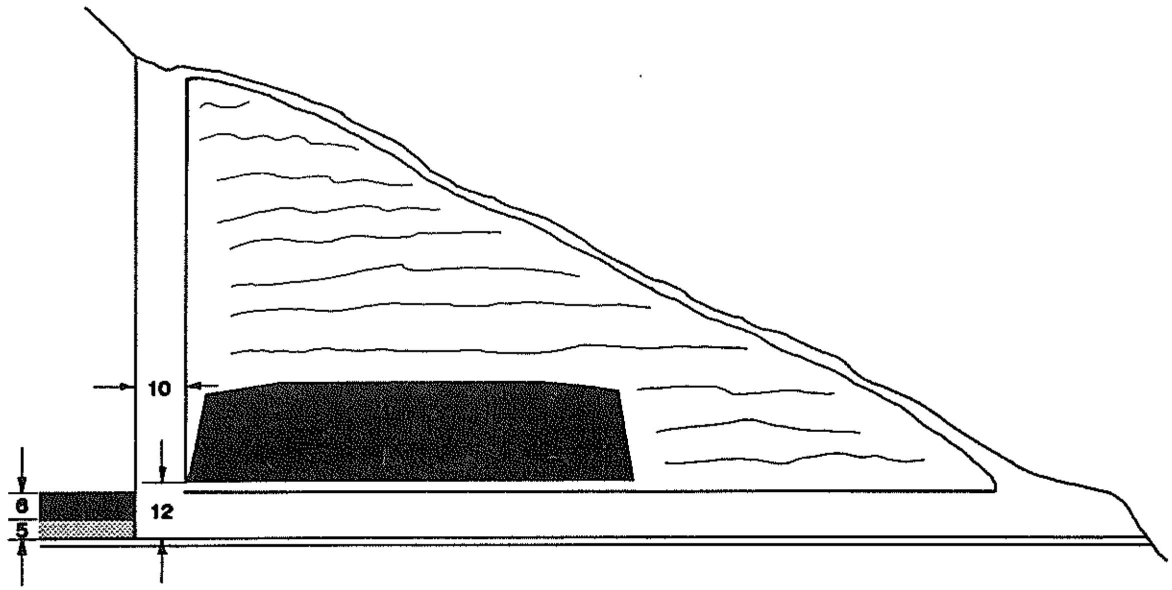

Figure 4. Cross sectional view of a fully backfilled cut for scenario 1 (numbers are in feet). The black material is the 6-ft toxic material special handled and placed on a layer of oxidized, non-toxic material.

Table 1. Types and purpose of equipment used in contour surface mining.

Type	Number	Capacity	Purpose
Cat D8[1]	1		backfilling
Cat D9	1		ripping and pushing
Cat 992	1	13 cu yds	front-end loader
Cat 773	3	50 tons	rock trucks

[1]Use of a specific brand name does not constitute endorsement of a product or its performance by the U.S. Bureau of Mines, the National Mine Land Reclamation Center, West Virginia University, or any of its affiliates.

Selective handling increased front-end loader time by an estimated 56 minutes and truck time by an estimated 278 minutes for each 46-m (150-ft) reclaimed cut. Using Caterpillar, Inc. (1991) costs (plus $39 per hour for the equipment operators), operation costs for the equipment were estimated to be $184 per hour for the loader and $104 per hour for the rock truck (under extreme terrain conditions). The total estimated increase in costs due to selective handling for both a front-end loader and rock trucks was $663 per 46 by 43 m (150-ft) cut ($3,348 per ha or $1,353 per acre). The results are shown in Tables 2 and 3.

Table 2. Estimated additional costs for a front-end loader in scenario 1 having a 1.8-m (6-ft) toxic layer above the coal bed.

	Cubic Yards	Loading Cycles	Total Time (min)	Increase For Selective Handling (min)	Cost of Increase ($184/hr)
Overburden (1 min)	21,655	1,667	1,667	0	0
Toxic (1.2 min)	3,607	278	334	56	$172
Topsoil (1 min)	394	30	30	0	0
Total	**25,656**	**1,975**	**1,975**	**56**	**$172**

Table 3. Estimated additional costs for rock trucks in scenario 1 having a 1.8-m (6-ft) toxic layer above the coal bed.

	Cubic Yards	Truck Cycles	Total Time (min)	Increase For Selective Handling (min)	Cost of Increase ($104/hr)
Overbrdn (7.5 min)	21,655	555	4,163	278	$482
Toxic (7.0 min)	3,607	92	644	0	$0
Topsoil (8.0 min)	394	10	80	5	$9
Total	**25,134**	**657**	**4,887**	**283**	**$491**

Scenario 2

Scenario 2 adds a 1.5-m (5-ft) layer of alkaline material in the middle of the overburden (Figure 5). In this scenario, selective handling involves blending the alkaline material with the toxic material as it is placed on oxidized material above the pavement. This procedure requires opening one more cut than scenario 1. The mining process is shown in seven stages in Figure 6. The first cut has been fully reclaimed. The reclamation process proceeded as follows. After the coal was removed in cut 1, part of the oxidized material from cut 5 is placed on the pavement. Then the toxic material from cut 3 and the alkaline material from cut 4 are placed on top of the oxidized layer, followed by the remaining oxidized material from cut 5. Backfilling continues with the lower overburden layer from cut 4 (OB2) and the upper overburden layer from cut 5 (OB1). Backfilling of cut 1 is finished with the topsoil from cut 6.

Additional costs for selective handling in scenario 2 (Figure 6) based on no selective handling (shown in Figure 1) occur because oxidized material, OB1, and topsoil must be hauled two additional cuts and alkaline material and OB2 must be hauled an additional cut. As in scenario 1, front-end loader time is increased by 20 percent when handling the toxic or alkaline materials. Total and incremental costs for the front-end loader and rock trucks are given in Tables 4 and 5.

Front-end loader time was estimated to increase by 101 minutes. Rock truck time would increase by 467 minutes per 46-m cut. Valuing the time as before for both a front-end loader and rock trucks, this would add $1,119 to the cost of mining for each 46 by 43 m cut, or $5,652 per ha ($2,284 per acre). The additional costs of scenario 2 are due to the two additional open cuts and the increased front-end loader time from having to selectively handle both toxic and alkaline materials.

Table 4. Estimated additional costs for a front-end loader in scenario 2 having toxic and alkaline layers that are selectively handled.

	Cubic Yards	Loading Cycles	Total Time (min)	Increase For Selective Handling (min)	Cost of Increase ($184/hr)
Oxidized (1 min)	9,750	750	750	0	0
Toxic (1.2 min)	3,607	278	333	56	$172
Alkaline (1.2 min)	2,930	225	270	45	138
OB1 (1 min)	4,118	317	317	0	0
OB2 (1 min)	4,857	374	374	0	0
Topsoil (1 min)	394	30	30	0	0
Total	**25,656**	**1,974**	**2,074**	**101**	**$310**

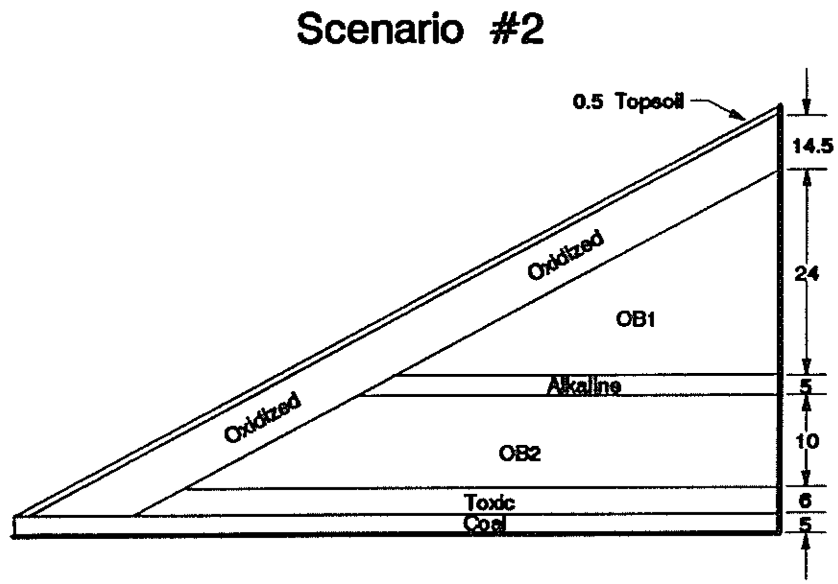

Figure 5. Undisturbed geologic cross-section for scenario 2 (all numbers in feet). This example has a 6-ft layer of toxic material overlying the coal bed and a 5-ft layer of alkaline material higher in the overburden. OB1 and OB2 are abbreviations for overburden sections 1 and 2.

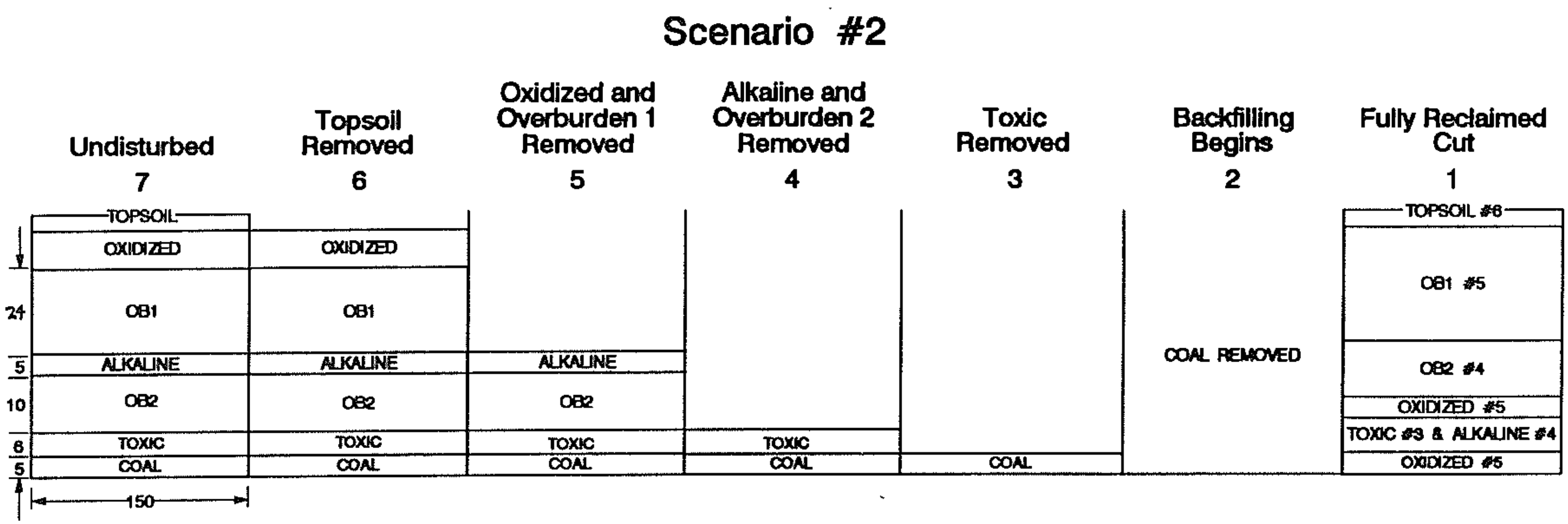

Figure 6. Simplified view of the mining process of a contour operation (scenario 2) where toxic and alkaline layers are being selectively handled and blended during backfilling. Cut 1 is fully reclaimed shows the material and pit number used for backfilling. Under scenario 2, five pits are open.

Table 5. **Estimated additional costs for rock trucks in scenario 2 having toxic and alkaline layers that are selectively handled.**

	Cubic Yards	Truck Cycles	Total Time (min)	Increase For Selective Handling (min)	Cost of Increase ($104/hr)
Oxidized (8.0 min)	9,750	250	2000	250	$433
Toxic (7.0 min)	3,607	92	644	0	$0
Alkaline (7.5 min)	2,930	75	563	38	66
OB1 (8.0 min)	4,118	106	848	106	184
OB2 (7.5 min)	4,857	125	937	63	109
Topsoil (8.5 min)	394	10	85	10	$17
Total	**25,656**	**658**	**4721**	**467**	**$809**

Scenario 3

The final scenario has only one stratum that requires special handling: a 0.4-m (1.4-ft) toxic layer located 4.6 m (15 ft) up from the coal bed (Figure 7). The complication in this scenario arises from the need to blast in two stages to allow special handling of the toxic layer and to avoid fracturing it into small pieces. Like scenario 1, this case also increases rock truck haul times because of the need for one additional cut, and also involves 20 percent more front-end loader time when handling toxic material.

Figure 8 shows the mining process in six stages. Cut 1 was reclaimed in the following manner. First, part of the oxidized material from cut 4 was placed on the pavement, followed by placing the toxic material from cut 3 and the remaining oxidized material from cut 4 on top. Backfilling of cut 1 continues with the lower overburden layer (OB2) from cut 3, and then the upper overburden layer (OB1) from cut 4. Finally, backfilling is concluded with the topsoil layer from cut 5.

The total and incremental costs of the front-end loader and rock trucks are given in Tables 6 and 7. The methodology is identical to that used in the earlier scenarios. Total front-end loader time per 46-m cut increased by only 6 minutes (due to the small volume of toxic material) and rock truck time increased by 221 minutes. Total cost increased by $401 per 46 by 43 m cut, or $2,025 per ha ($818 per acre).

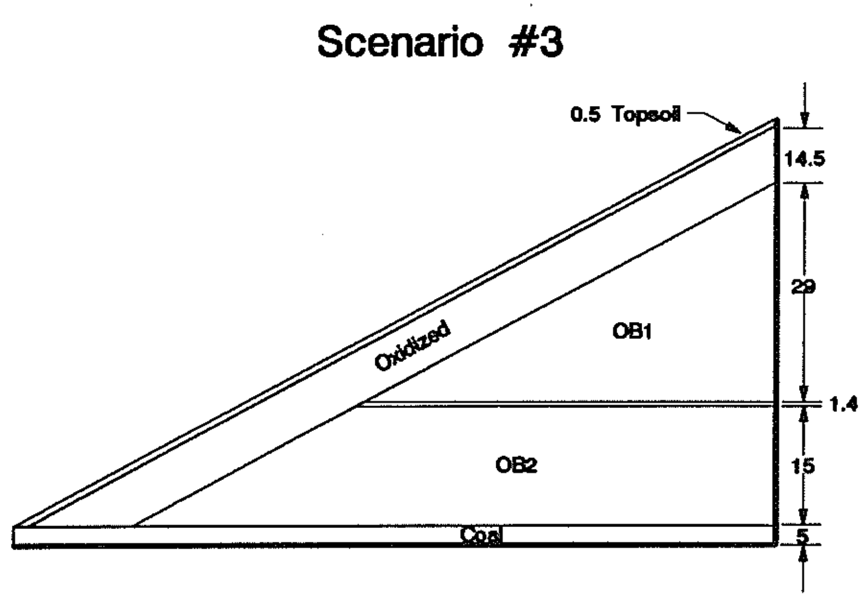

Figure 7. Undisturbed geologic cross-section for scenario 3 (all numbers in feet). This overburden is separated by a small toxic layer in the middle of the overburden. OB1 and OB2 are abbreviations for overburden sections 1 and 2.

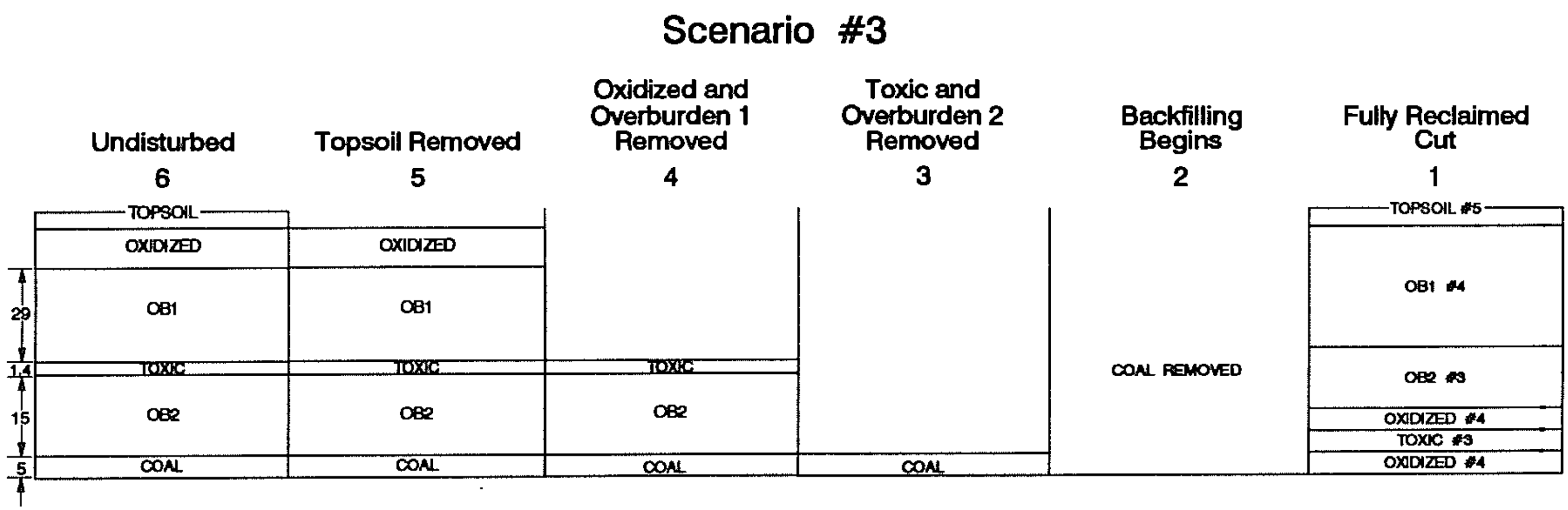

Figure 8. Simplified view of the mining process for scenario 3. This example shows a toxic layer being selectively handled and the remainder of the overburden being removed in two phases. Cut 1 is fully reclaimed and shows the material and pit number used for backfilling.

Table 6. Estimated additional costs for front-end loader in scenario 3 having a 0.4-m (1.4-ft) toxic layer.

	Cubic Yards	Loading Cycles	Total Time (min)	Increase For Selective Handling (min)	Cost of Increase ($184/hr)
Oxidized (1 min)	10,787	830	830	0	0
Toxic (1.2 min)	415	32	38	6	$18
OB1 (1 min)	6,013	463	463	0	0
OB2 (1 min)	8,047	619	619	0	0
Topsoil (1 min)	394	30	30	0	0
Total	**25,656**	**1,974**	**1,980**	**6**	**$18**

Table 7. Estimated additional costs for rock trucks in scenario 3 having a 0.4-m (1.4-ft) toxic layer.

	Cubic Yards	Truck Cycles	Total Time (min)	Increase For Selective Handling (min)	Cost of Increase ($104/hr)
Oxidized (7.5 min)	10,787	277	2,078	139	$241
Toxic (7.0 min)	415	11	77	0	$0
OB1 (7.5 min)	6,013	154	1,155	77	133
OB2 (7.0 min)	8,047	206	1,442	0	0
Topsoil (8 min)	394	10	80	5	$9
Total	**25,656**	**658**	**4,832**	**221**	**$383**

Conclusion

This paper presented three selective handling situations and estimated the additional costs associated with extra front-end loader time and rock truck time in these situations. Based on a toxic layer just above the coal and the necessity for placing that material on a layer of oxidized material, selective handling required the opening of an additional 46-m (150-ft) wide pit (compared to a non-selective handling plan) and cost an additional $663 per pit or about $3,348 per ha ($1,353 per acre) to reclaim. Other scenarios with more complex overburden handling schemes increased the costs of selective handling to $1,119 per pit or $5,652 per ha ($2,284 per acre) to reclaim. In actual mining situations, the costs of selective handling would increase if the toxic material were distributed more widely or unevenly throughout the overburden and may thereby make the cost of mining coal on the site too costly. The cost estimates do not include additional management costs, additional blasting costs, or training costs for equipment operators. In a given situation, each of these factors could add to the costs of selective handling.

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