Chapter 1

INTRODUCTION

BACKGROUND AND PURPOSE

A major goal of the Surface Mining Control and Reclamation Act of 1977 (SMCRA) is to ensure the adequate reclamation of all areas disturbed by surface coal mining operations. The primary mechanism for accomplishing this is a permitting and enforcement process that allows mining to proceed only after filing a performance bond sufficient to ensure completion of an approved reclamation plan. The performance bond serves as a guarantee that reclamation will be completed and, in the event of bond forfeiture, performance bond monies will be used by the regulatory authority to contract for the necessary reclamation work.

OSMRE regulations of 30 CFR 800.14(a)(1) specify that the bond amount is to be determine by the regulatory authority. The purpose of this document is to describe the approach to be used by OSMRE personnel in estimating performance bond amounts where OSMRE is the regulatory authority. As part of their approved programs, State regulatory authorities (SRA) have adopted procedures consistent with 30 CFR 800.14(a). SRA's and other individuals familiar with surface coal mining operations and activities may find the handbook useful in understanding how OSMRE determines performance bond levels. However, OSMRE in no way mandates State use of this handbook.

The method presented uses standard engineering cost-estimating procedures to develop site-specific costs for each reclamation activity. Bonds calculated in this fashion account for differences in mining site conditions and in postmining land uses. This method provides a rational and defensible approach to calculating performance bonds.

REGULATORY REQUIREMENTS

Section 507 of SMCRA requires each applicant to submit, as part of the permit application, a reclamation plan of sufficient detail to demonstrate compliance with State or Federal standards for reclamation. Section 509 requires that a bond be filed in sufficient amount to cover the cost of reclamation in accordance with the approved plan if such reclamation had to be performed by the regulatory authority (RA) in the event of forfeiture. Furthermore, bonds must be filed with the RA after a coal mining permit application has been approved but before the permit is issued.

The amount of the bond is set by the RA based on an analysis of the applicant's estimated cost of reclamation and the requirements of the approved reclamation plan. Regulatory requirements covering performance bonds can be found in 30 CFR, Part 800. Major provisions of these regulations found at 30 CFR 800.14 and 800.15 include the following:

- The amount of bond for each permit area is determined by the RA. The amount of bond should reflect the probable difficulty of reclamation giving consideration to such factors as topography, geology, hydrology, and revegetation.

- The amount of bond is based on but not limited to the applicant's estimated reclamation cost.

- The amount of bond shall be sufficient to ensure the completion of the reclamation plan if the work has to be performed by the RA in the event of forfeiture.

- The minimum bond amount for any permitted area is $10,000.

- Bond amounts may be periodically adjusted to account for changes in the mining plan, postmining land use, or any other circumstance that may increase or decrease the cost of reclamation.

ASSUMPTIONS

Although SMCRA and the permanent program regulations provide specific bonding requirements, it is important to recognize the fundamental assumptions inherent in this cost-estimating methodology. The fundamental assumptions are:

- Performance bonds are based upon the costs of performing reclamation by a third-party contractor engaged by OSMRE.

- Performance bonds are based on those conditions that define the point in the planned mining operation that presents the greatest estimated reclamation costs for that permit term. Calculating the bond in this manner will ensure the availability of adequate reclamation funds regardless of when a forfeiture may occur during the permit term.

- The permit applicant is responsible for providing all reclamation information necessary to validate the reclamation plan and bond estimates. However, other sources of information will be used in addition to those provided by the applicant to validate costs.

- Performance bonds are based on the applicant's adherence to the approved mining and reclamation plans, permit conditions and performance standards.

METHODOLOGY

The methodology presented is based on standard cost-estimating procedures for determining earthmoving and revegetation costs for the site-specific operation proposed in the permit application. There are different methodologies for determining bond levels, but many are variations of the methodology presented in this handbook. The costs of structure removal, earthmoving, and revegetation of the disturbed area are the most significant elements of the reclamation estimate. For most surface mining situations, earthmoving costs represent the major portion of the direct cost of reclamation.

DATA SOURCES

There are four major sources of information that will be used by OSMRE to estimate performance bonds. These sources are:

- The mining and reclamation plans provided by the permit applicant;
- Equipment productivity and performance guidebooks;
- Construction cost guidebooks; and
- The Abandoned Mine Lands Reclamation Program, the Tennessee Valley Authority, and the Soil Conservation Service, and other contract data.

The mining and reclamation plan is the chief source of information for calculating reclamation costs. It contains essential information on spoil and topsoil volumes, haul distances, extent of areas disturbed, and structures used during the mining operations.

Another major source of information is the equipment productivity and performance handbooks. These handbooks are essential when estimating backfilling and grading costs. Most manufacturers of heavy equipment publish handbooks containing performance data for their equipment lines. The Caterpillar Performance Handbook is one of the most complete. It includes data on tractors, loaders, scrapers, haulage vehicles, and small hydraulic shovels and excavators, in addition to a variety of other information such as estimating methodologies and heavy equipment cost accounting. Other sources of productivity and performance data are acceptable for cost estimation depending on the documentation provided and the overall reasonableness of the data.

One comprehensive equipment cost reference is the Dataquest Cost Reference Guide for Construction Equipment, which is updated periodically. This reference covers hourly ownership and operating costs for a wide range of heavy equipment. Ownership rates used in this reference are based on factors such as purchase prices, depreciation, equipment ownership-related overhead costs, and average annual use. Hourly operating expenses are based on average fuel, lubrication and wear item costs, and maintenance labor costs; but do not include equipment operator costs. The rates in the Dataquest manual represent the actual cost of buying equipment. This reference is widely used by Government and industry to prepare engineering cost estimates. Equipment operator costs based on regional labor rates will be used. These rates, however, will at least equal the Davis-Bacon wage rates since OSMRE reclamation projects will be performed by Federal contractors.

For estimating construction-related costs, a number of data sources are available including Means' Building Construction Cost Data, Dodge's Guide to Public Works and Heavy Construction Costs, and Engleman's Heavy Construction

Cost File. The Means' guide contains an extensive array of line-item costs for building construction. This reference, which is updated annually, is especially useful for estimating material acquisition costs and costs of specific reclamation tasks such as structure removal. Costs obtained from the Means' manual must be taken from the category labeled "Total Bare Costs," which excludes profit and overhead.

Table 1 presents the major information needs and sources for calculating reclamation costs using the estimating method presented in this handbook.

Table 1.--Data Needs and Sources for Estimating Reclamation Costs

Need	Source
Volumes of material to be moved (cross-sections, material handling plans, special handling requirements, and swell factor)	Reclamation Plan
Conditions and characteristics of the minesite (haul distances, grades, etc.)	Reclamation Plan
Disturbed acreage	Reclamation Plan
Description and characteristics of facilities to be removed	Reclamation Plan
Revegetation requirements	Reclamation Plan
Equipment types and productivity for activities such as backfilling and grading	Equipment productivity handbooks and information presented in this document
Equipment ownership and operating costs	Dataquest Cost Reference Guide for Construction Equipment
Labor rates, material, and certain reclamation activity costs such as structure removal	Davis-Bacon wage rates, supplier estimates, standard materials guidebooks, and construction cost guides

Chapter 2

BOND ESTIMATING PROCEDURES

The major steps that the estimator must follow to calculate a performance bond amount are presented in Table 2. Each step is discussed in the following pages. Calculation worksheets that provide a mechanism for the orderly documentation of information necessary to complete each step are included in Appendix A.

Table 2.--Major Steps for Estimating Bond Amount

Step	Task
1	Determine Maximum Reclamation Requirements
2	Estimate Direct Reclamation Costs
	- Structure Removal and Demolition
	- Earthmoving
	- Revegetation
	- Other Reclamation Costs
3	Estimate Indirect Reclamation Costs
	- Mobilization and Demobilization
	- Contingencies
	- Redesign Costs
	- Profit and Overhead
	- Contract Management Fee
4	Calculate Total Bond Amount

STEP 1 DETERMINE MAXIMUM RECLAMATION REQUIREMENTS

This is the most important step in the estimating procedure. Generally, the greatest estimated reclamation costs will occur at that point in the mining plan where one or more of the following conditions exist:

- The greatest area of disturbance or the greatest area requiring final grading, topsoil placement, and revegetation;
- The largest volume of material to be backfilled and graded to establish suitable postmining contours;
- The longest haul distance between spoil and/or topsoil storage areas and the location of final placement;
- The greatest number of structures on site;
- The greatest amount of material that must be handled to cover refuse disposal sites; and/or
- The need for special reclamation activities, such as handling of acidic or toxic materials, developing final cut lakes, handling of topsoil in prime farmlands, sealing underground mine entries, and addressing difficult topographic situations.

The estimator should recognize that any of the factors listed above may influence the reclamation cost estimate and it is essential that mining and reclamation plans be studied carefully to determine which conditions represent the maximum reclamation costs. In order to better understand this concept, the reader should review the example narratives and mine maps in Appendix B and identify the point in each proposed operation where the maximum reclamation requirements would exist.

STEP 2 ESTIMATE DIRECT RECLAMATION COSTS

This section will explain the estimating principles used to determine costs for the unit operations that make up the reclamation sequence in most surface coal mining operations. Throughout this section there are references to the worksheets in Appendix A that are designed to assist the estimator in making the calculations for each step. The reader should become familiar with these worksheets before proceeding.

Most surface coal mining is conducted in a sequence of steps that include:

- Preparing the surface.
- Drilling and blasting.
- Overburden removal.
- Loading and hauling coal.
- Reclamation.

This handbook will address only the reclamation sequence that is comprised of the following unit operations or activities:

- Spoil ridge reduction.
- Highwall reduction.
- Final pit elimination.
- Final grading.
- Topsoil handling.
- Special tasks (for example, demolition of structures and facilities and reclamation of ponds, stockpiles, roads, etc.).
- Revegetation.

Not all of these reclamation steps occur at every surface coal mining operation. Spoil ridge reduction, higwall reduction, final pit elimination, final grading, and topsoil handling will be discussed in the section on earthmoving, while structure removal and revegetation will be discussed in separate sections.

STRUCTURE REMOVAL AND DEMOLITION

This reclamation activity includes the removal and disposal of structures such as buildings, crushers, coal storage bunkers or silos, conveyor systems, foundations, and other facilities at the mine site. In estimating the demolition costs, all structures, unless they are allowed under the approved postmining land use, will be demolished and the rubble disposed of properly. The most commonly used guidebooks to estimate these costs are the Means and Dodge guides and Engleman's Heavy Construction Cost File. When using these guidebooks, carefully study the introductory and instructional material to understand how they should be used. Do not use cost estimates that contain overhead and profit, since these will be added later under the methodology used in this handbook. For surface mines, demolition of structures and facilities will generally be a small percentage of the total cost of reclamation. However, for some underground mines and virtually all processing plants, the cost of this activity can be as much as half, or more, of the total cost of reclamation, because such facilities occupy a larger portion of the disturbed surface area for underground mining and processing operations.

Buildings and Facilities

In order to estimate reclamation cost for this activity, data describing the physical characteristics of all structures present at the site must be collected. The demolition costs are based primarily upon the type of building material, the size of the structure, the type of foundation, access, and the location of the disposal site. Worksheet No. 2 can be used to summarize all activities involved in demolition and removal of structures.

All buildings, if not a part of the approved postmining land use, must be removed.

Debris disposal created by building demolition must be calculated as part of the cost estimate. Costs for handling debris are given in the Means guide and include the costs for hauling to a disposal site. It may be possible to dispose of the material onsite. When using the Means reference, the estimator must be careful not to use the cost column that includes overhead and profit.

If the site contains stored materials such as drill steels and bits, bucket teeth, roof bolts, and cable wire, etc., or equipment such as pumps and motors or tools, the cost of disassembling, removing, and disposing of these items will not generally be included in the bond estimate.

Road Removal

Paved road surfaces (for example, asphalt) may have to be separated from the road and removed. This can be accomplished using a variety of equipment. Large road graders or bulldozers can be used to rip and/or scrape up the pavement into piles. Front-end loaders are then used to pick up the piles and load them into trucks for hauling to disposal sites. If scrapers are used to remove surfacing material, then the removal, loading, and hauling are combined into a single operation. Loose road surfacing (for example, limestone aggregate) can be mixed with fill materials and no special measures are needed for disposal. The estimated cost of removing road surfacing materials can be found in the referenced cost-estimating guidebooks.

Miscellaneous Structures

Certain other removal costs for such things as waste and junk piles, conveyors, railroad spurs, culverts, bridges, powerlines, or fences must be estimated on a case-specific basis. In some situations, foundations and underground pipelines and conduits may be located sufficiently below grade to be left in place.

No single cost manual contains all of the above items; however, the standard cost manuals listed in Chapter 1 may be consulted to obtain the necessary information.

EARTHMOVING

The backfilling and grading operation serves two primary requirements: (1) to establish an acceptable postmining topography in the mined area and (2) to ensure a stable surface for topsoil placement and revegetation. The first requirement usually involves the handling of large amounts of material to backfill final cuts or pits, reduce highwalls, regrade spoil ridges, or regrade large cut-and-fill sections. The second requirement involves final grading of the site to reestablish grades along stream channels; minor road regrading; facilities site regrading; or minor recontouring in the mine area. Depending upon the operation, several different types of equipment can be used to backfill and grade the disturbed area.

Costs associated with backfilling, grading, and topsoil redistribution are estimated using the following steps: (1) develop a Materials Handling Plan and (2) calculate equipment productivity and costs.

Standard equipment performance guidebooks and cost-estimating guidebooks will be used to estimate backfilling and grading costs. The costs of miscellaneous earthmoving activities such as removal of diversion and siltation structures; removal of stockpiles, mining debris, and roads; and reconstruction of stream channels are also included under earthmoving operations.

Materials Handling Plan

The estimator must develop a Materials Handling Plan for the mine layout at the point of the maximum reclamation requirements. In developing this plan, the estimator determines the volume of material to be handled, the haul distances and grades, and the types of equipment to be used.

Worksheet No. 3, the Materials Handling Plan Summary Sheet, should be used to identify and describe each specific earthmoving activity. It is suggested that the reader review the Worksheet 3 examples in Appendix B. The determination of equipment needs, productivity, and costs will depend on the information provided on this worksheet. Worksheet No. 4 is used to compute material volumes.

Material Volume Estimates

Several methods are available for determining the amount of material to be handled. In general, these methods require comparing pre-reclamation topography with post-reclamation topography. The determination of volumes can be done either by estimating the volume of geometric shapes or by developing cross-sections through the areas where backfilling and grading will occur. Both approaches are demonstrated in the Appendix B examples.

The total volume of material to be handled must be carefully considered. This requires use of swell factors for the material to be handled. The swell factor is defined as the percentage increase in volume of material from bank state to loose state. Initially, when material is cut from a bank or its natural state it will swell. This is called the initial swell factor. The amount of swell is dependent upon the physical characteristics of the material involved. After the material is placed, it will tend to settle or shrink over time. The resulting final swell volume is generally one-half the initial swell.

The estimator should use swell factors (sometimes called bulking factor) provided in the reclamation plan. However, care should be taken to verify the figures provided. Table 3 provides swell factors for some typical materials encountered in surface mining. However, the estimator should use the swell factors that are listed in, or that can be derived from, tables in many standard equipment productivity manuals.

Another factor that may be found in equipment manuals is the load factor (LF). The LF is defined as the relationship between the bank volume and loose volume. The LF is equal to the loose density divided by the bank density. The table on page 650 of the Caterpillar Performance Handbook (edition 16) lists load factors for most of the materials encountered in surface mine reclamation. The relationship between load factor and swell factor is:

$$LF = \left(\frac{100}{100 + SF}\right)$$

Table 3.--Swell Factors For Various Materials

Material	Initial Swell (%)	Final Swell (%)[a]
Earth-rock mixtures	25 - 45[b]	10 - 25
Shale	35 - 45	10 - 25
Sandstone	60 - 70	25 - 45

[a] The greater the compaction by equipment, the lower the final swell. It is generally assumed in this document that no special compaction equipment is used.

[b] The higher swell factor is associated with greater quantities of rock.

The Earthwork Quantity Worksheet, Worksheet No. 4, should be used when the cross-section method is used to calculate volumes. When volume calculations of geometric shapes are used to determine the backfilling requirements, these calculations should be documented. This documentation, as shown in a number of examples in Appendix B, would be used in lieu of Worksheet No. 4.

Haul Distance Estimates

The haul distance is one of the primary factors affecting the efficiency and cost of the backfilling and grading operation and, therefore, must be determined for each area where backfilling and grading will occur.

The haul distances can be determined from the mine plan. The approximate centroid (for example, surface expression of the center of mass) of each source and destination must be identified so that the centroid-to-centroid distance can be determined. In some instances, additional haul roads may have to be constructed to increase efficiency.

Grade Estimates

The haulroad grade and surface conditions must be specifically considered since they are necessary for determining the equipment to be used and the equipment's productivity. Most of the equipment manuals will require a determination of the total resistance (TR) of the haul. Total resistance is the combination of rolling resistance (RR) and resistance due to grade (GR) and may be expressed as:

$$TR = RR + GR$$

Frequently, the RR component is expressed as an equivalent percent grade. Tables showing the RR as an equivalent percent grade can be found in most equipment manuals for various types of road and work-area surface conditions.

Equipment Selection

The largest portion of the cost of reclamation is usually the equipment and labor costs associated with earthmoving. This section of the handbook provides: (1) a description of the procedures to estimate equipment performance and the subsequent costs for each reclamation activity and (2) a summary of the typical operations associated with backfilling and grading.

The estimator must recognize that equipment selection has a crucial impact on the reclamation cost estimate and that selection procedures are difficult to generalize.

When there is a bond forfeiture, the operator and his equipment will not be available to complete the reclamation work. For example, large draglines or stripping shovels used for removing overburden and loading coal are assumed not to be available for use by the reclamation contractor. When the bond amount for such operations is calculated, the estimator should check with several regional earthmoving contractors to determine what, if any, large specialized pieces of equipment may be typically available for the reclamation job. Care must be taken, however, to avoid calculating the bond amount based on a specialized piece of equipment that is available to, or used by, only one contractor.

Equipment selection is a two-step process:

- First, initial selection of equipment type (for example, dozer versus scraper) based on the information presented in this handbook, the reclamation plan, equipment manuals, and experience.

- Second, select the model and size of equipment based on information contained in the Materials Handling Plan developed in Step 2 (Worksheet No. 3), the operator's reclamation plan, and equipment manuals.

It may be necessary to make several iterations of equipment model selections to develop the most cost-effective estimate for each specific earthmoving activity. Appendix C provides additional information on equipment selection. Typical earthmoving operations and the equipment associated with these activities are described below.

Spoil Ridge Reduction. This operation includes the rough grading of spoil ridges. Normally, one to four spoil ridges will be left ungraded behind the active pit. For some mining methods such as modified area and block-area mining, regrading and reclaiming occur concurrently with the mining operation. For these mining methods, spoil material--other than from the initial cut--is not stored separately but is stripped and placed directly in the last mined-out pit requiring only one handling. Generally, the tops of the spoil ridges need to be moved into the valleys between the ridges; typically, bulldozers will be used.

Highwall Elimination. Eliminating highwalls is a task associated with most coal mines. Usually a ripper-equipped bulldozer will be used to reduce the slopes or to grade the backfill material. In some cases, use of explosives is appropriate for highwall reduction.

Final Pit Elimination. The last pit will normally be backfilled using stockpiled overburden material, adjacent spoil ridges, and material obtained from the reduction of the highwall. Alternatively, the postmining land use may allow development of water resources in a final-cut lake. This can be done by partially backfilling the final pit and reducing the highwall and spoil slopes to acceptable grades. In this case, any box-cut spoil stored in a stock pile would be blended into the surrounding terrain or used for other backfilling tasks on the site. The final pit impoundment may require special engineering designs. Depending on haul distances, a scraper or combination truck and loader may be used to move the material.

Final Grading. The final grading task prepares the disturbed areas for receiving topsoil. This task includes:

- Ensuring large rocks and boulders are buried.
- Final shaping of the ground surface is conducted to allow proper drainage.
- Ensuring the reclaimed topography fits into the surrounding undisturbed contour by smoothing out the hills and gullies left by the backfilling operations.

The final graded surface should be left slightly rough to assist in the bonding between the backfill and the topsoil. In some cases, ripping may be required to eliminate compaction. Equipment used may be any of those previously mentioned, although scrapers, dozers, and motor graders are most common.

Topsoil Handling. The cost of topsoil handling procedures proposed in the reclamation plan must be included in the cost estimate. In selecting equipment for this task, the estimator must consider haul distance between stockpiles and placement areas and the volume of material to be moved. Topsoil placement generally involves the use of scrapers, front-end loaders, trucks, dozers, and graders. Prime farmland areas usually require more attention to equipment selection and material handling in order to ensure proper soil horizon segregation, placement, and soil depth. Spreading generally requires more operator skill than backfilling operations.

Special Reclamation Tasks

Other mine site areas may require additional grading and possibly backfilling to complete the reclamation. Each site should be evaluated to determine whether backfilling and grading are necessary to reclaim roads and railroad beds, water-control structures, coal stockpile and refuse areas, and valley and hollow fills. The estimator must determine the volume of material to be handled, haul distances and grades to be encountered, and equipment required to complete special reclamation tasks.

Reclamation of roads and railroad beds may include the following steps:

- Regrading of cut/fill sections.
- Stabilization of slopes.
- Removal of culverts.
- Ripping roadbeds to allow for better adhesion of topsoil and enhance vegetation success.

In determining the cost for grading of diversions and siltation structures, several factors must be considered. For an excavated pond, it can be assumed that the embankment material will only require grading into the depression. However, if the embankment is entirely constructed with material brought to the site from a borrow area, then disposal of embankment material will require replacement of the fill to the borrow area or to other backfilling areas as appropriate.

Coal slurry impoundments may require substantial grading to achieve an acceptable postmining topography. The slurry will probably require time for dewatering, and the embankment structures will require partial removal if the slurry impoundment has not been completely filled.

Coal refuse and spoil disposal sites may require only minor grading to achieve an acceptable postmining topography for runoff control; however, in some instances, substantial grading may be required to achieve acceptable postmining topography. Coal slurry impoundments and coal refuse disposal sites require a cover of 4 feet of nontoxic material. Compaction may be required to prevent spontaneous combustion.

Reclamation of coal stockpiles and noncoal waste disposal sites may include covering the site with 4 feet of nontoxic material and grading to an acceptable postmining topography, or removing coal and coal refuse material and properly placing this material in a backfilled pit. Reclamation of such sites should include segregation and burial of any toxic material, construction of rock drains, and terracing or slope reduction grading and possibly compaction.

Valley and hollow fills are associated with mining coal on a mountaintop where the entire mountaintop is removed. This operation requires the disposal of large volumes of initial cut material and excess spoil in adjacent valley or head-of-hollow fills. Material from subsequent cuts is placed in preceding pits, and the operation advances in a manner similar to an area surface mining operation. Reestablishing an acceptable postmining topography requires grading large volumes of material.

Equipment Productivity and Costs

The next step after developing the Materials Handling Plan is to determine equipment productivity and earthmoving costs. The production of individual pieces of equipment and the hours required for the job are calculated using Worksheets No. 5 through 12 (see Appendix A); earthmoving costs are calculated using Worksheet No. 13.

Generally, the productivity of a piece of equipment is expressed in cubic yards per hour. Common factors governing equipment productivity are capacity, cycle time, site conditions, and material characteristics. For each piece of equipment identified in the Materials Handling Plan, the method used to determine productivity is demonstrated in the examples in Appendix B. The resulting productivity rates are applied to the amount of material identified to yield the number of hours that the equipment is needed. The cost of equipment for the required period is then determined from Dataquest's Cost Reference Guide for Construction Equipment. Hourly labor costs, based on regional labor rates, are added to equipment costs. At a minimum, Davis-Bacon wage rates will be used.

REVEGETATION

Revegetation tasks generally consist of seedbed preparation, seeding, planting, and mulching. Costs for each of these tasks are determined on a dollar-per-acre basis. Information on revegetation tasks can be found in the reclamation plan where details on topsoil replacement, plant species to be used, and the approved postmining land uses are provided. In addition, the Soil Conservation Service, other agencies, universities, and revegetation contractors can be consulted for local conditions, best plant species, planting times, fertilizers, and revegetation costs. Representative Abandoned Mine Lands Reclamation Program contracts can be another source of cost information. Costs are calculated on Worksheet No. 14.

OTHER DIRECT RECLAMATION COSTS

Examples of other reclamation activities include pumping and chemical treatment of siltation structures and other mine water, sealing of entries and openings that may involve blasting and installation of concrete barriers, and haulroad maintenance. Costs for these activities must be determined on a case-by-case basis and be included in the performance bond. Cost estimates for those items should be included on Worksheet No. 15. The cost-estimating guidebooks are used to provide cost data for these activities.

STEP 3 ESTIMATE INDIRECT RECLAMATION COSTS

Indirect costs are those fees and charges over and above the direct reclamation costs. They must be included in the bond calculation. Indirect costs will be determined using the procedures in this section of the handbook, and each category of indirect costs will be entered on Worksheet No. 16.

Because the handbook is specifically intended to be used by OSMRE personnel, it does not include procedures for calculating contract preparation or administration costs. These functions will be performed by existing OSMRE staff and their costs should not be included in the bond calculation.

Indirect costs were derived from standard references where possible. Should the estimator determine that, in some cases, different percentages should be used, an explicit explanation statement must be attached to Worksheet 16.

MOBILIZATION AND DEMOBILIZATION

This category of indirect costs is an allowance for the cost of moving equipment to and from the reclamation site. Costs will vary based on the type and number of equipment to be hauled and the distance to the site.

This allowance will normally range between 1 and 5 percent of the total direct costs shown on Worksheet No. 16.

CONTINGENCIES

A contingency cost will be included in the bond amount to provide for project uncertainties and unexpected natural events. The contingency percentage will be based upon the level of direct costs as shown in Table 4.

Table 4.--Contingency Allowances

Total Direct Costs ($)	Contingency (%)
0 - 500,000	10
500,000 - 5 million	7
5 million - 50 million	4
Greater than 50 million	2

The rates in Table 4 are based on various guidebook sources as well as experience with large and small earthmoving and construction projects.

ENGINEERING REDESIGN COSTS

The reclamation plan, as submitted by the operator, functions on the assumption that the operation will continue for the full permit term. However, the reclamation plan may not adequately reflect site conditions at time of forfeiture. Therefore, a new reclamation design may need to be developed or the existing one may need to be modified. In the event of bond forfeiture, OSMRE may have to:

- Prepare maps and plans to show the extent of required reclamation.
- Survey topsoil and overburden stockpiles to determine amount of material available.
- Analyze topsoil and overburden piles to determine whether special handling or treatment is necessary.
- Evaluate structure to determine requirements for demolition and removal.
- Evaluate impoundments to determine if treatment, clean out, or other improvements are necessary.
- Assess reclaimed areas to determine whether completed reclamation was satisfactory.

Engineering redesign cost will be based on a percentage of the total direct costs. The percentage will be determined from Graph 1 and entered on the Summary Sheet. In some cases, the estimator may be justified in applying a different percentage to obtain the engineering redesign cost. An explanation should be included with the Summary Sheet.

PROFIT AND OVERHEAD

In all cases, OSMRE will have to retain a third party to do the actual reclamation work. It is necessary, therefore, to add an amount for contractor's profit and overhead, because profit and overhead are not included in any of the individual cost categories discussed above. Profit and overhead allowances will be calculated based on a percentage of the total direct costs as determined from Graph 2.

RECLAMATION MANAGEMENT FEE

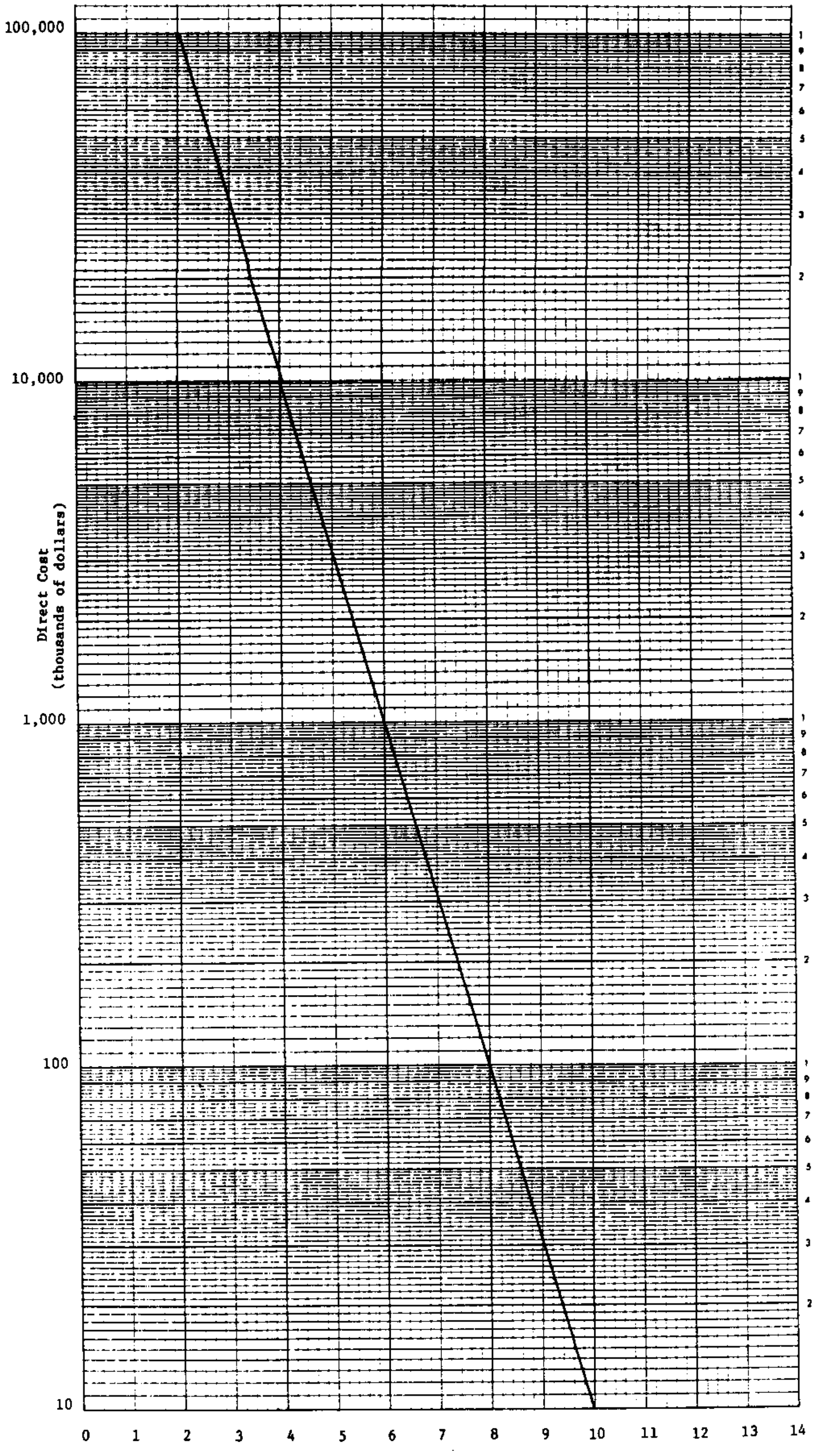
This fee is for reclamation management, which includes project inspection and supervision. These activities are usually performed by businesses specializing in project management. Reclamation management may include recommending change orders, verifying completed work, verifying compliance with project specifications, and other reclamation management oversight activities. This fee is determined from Graph 3 and entered on Worksheet No. 16.

STEP 4 TOTAL PERFORMANCE BOND COST

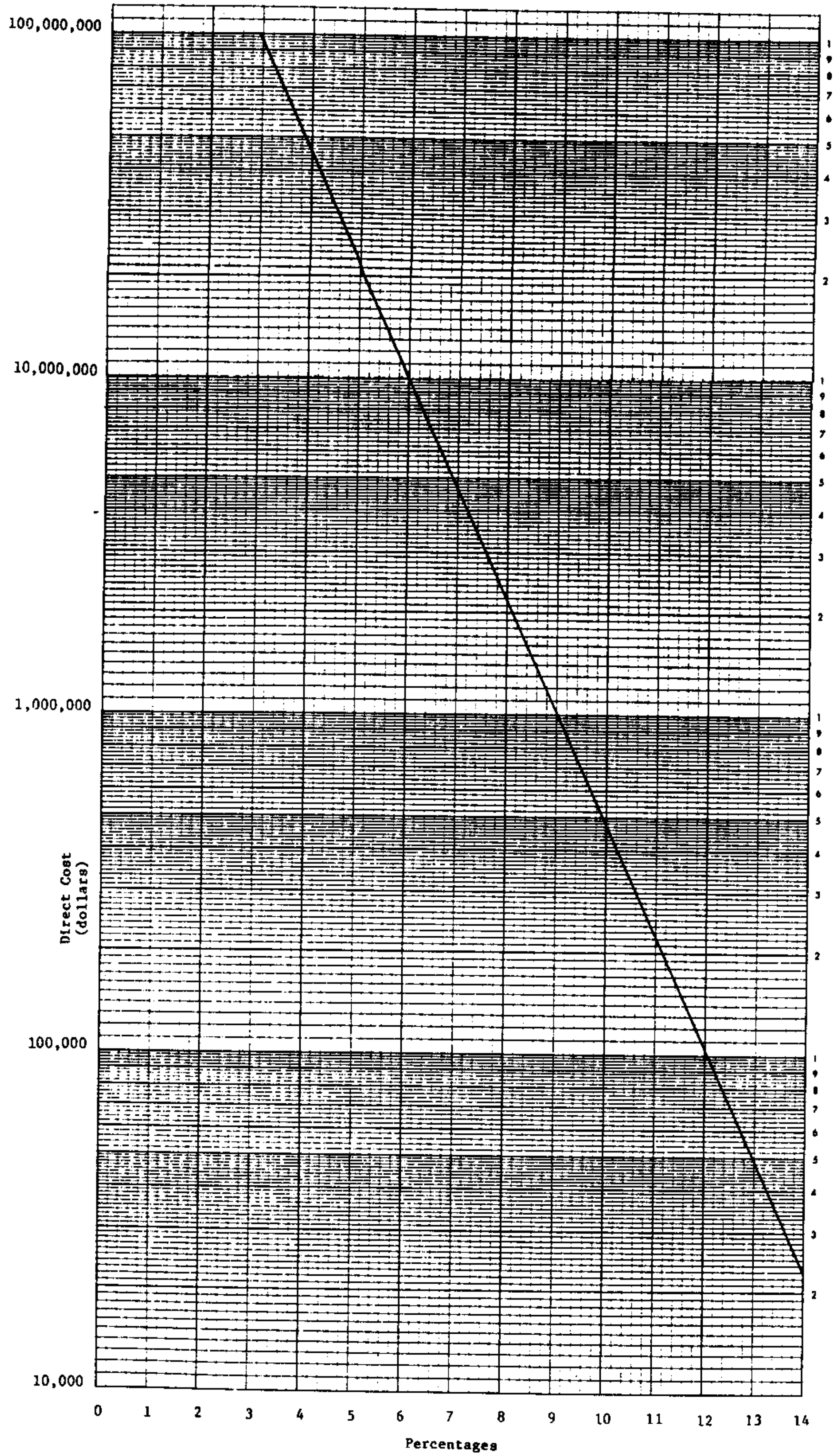
The sum of the indirect costs produces the total bond amount. The Reclamation Cost Summary Sheet provides a space to record a current cost index at the time the bond estimate is made. This index allows the bond estimate to be updated periodically such as at midterm review without the need to recalculate the entire bond, assuming that no major changes to the mining or reclamation plan have been made. The cost index to be used for all bond estimates is the McGraw-Hill Construction Cost Index, published monthly in Engineering News Record. This index provides a good measure of price-level changes in the heavy construction-earthmoving industry. The index will be used only to adjust direct costs.

The general formula for updating past dollar amounts to current levels is:

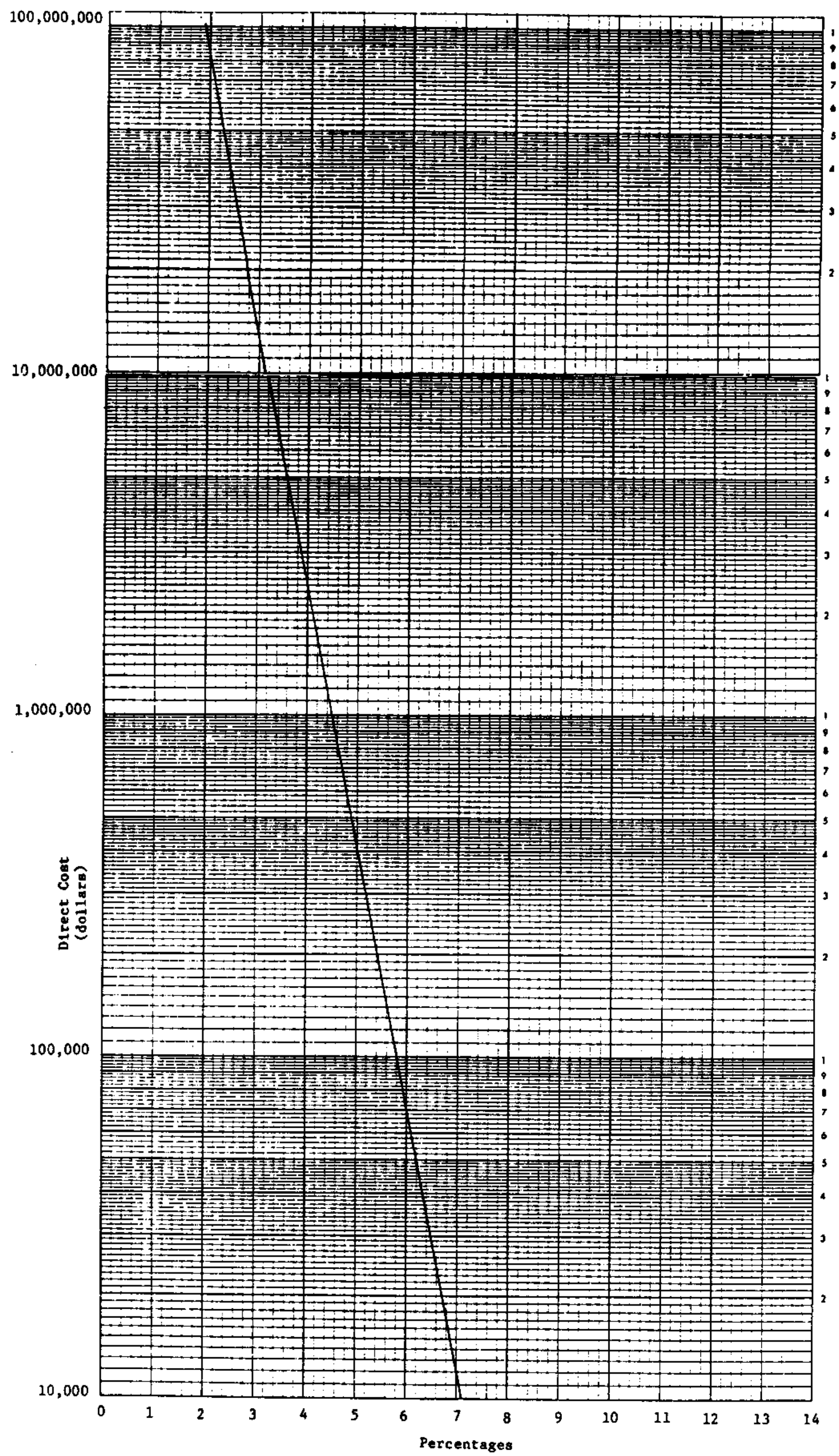
Current Costs = (Current Index/Past Index) x Past Cost



Graph 1.--Engineering Redesign Fee
(Source: Modified from Engleman's Heavy Construction Cost File)



Graph 2.--Profit and Overhead
(Source: R.S. Means Co., Inc., 44th ed.)



Graph 3.--Reclamation Management

APPENDIX A
BOND CALCULATION WORKSHEETS

OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT
BOND AMOUNT COMPUTATION

Applicant ______________________________

Permit Number ______________________________

Date ______________________________

Number of Acres ______________________________

Type of Operation ______________________________

Location ______________________________

Prepared by ______________________________

Project ____________________

Date ______________________

WORKSHEET NO. 1

DESCRIPTION OF THE WORST-CASE RECLAMATION SCENARIO

Data Sources:

Project ____________

Date ____________

WORKSHEET NO. 2

STRUCTURE DEMOLITION AND DISPOSAL COST SUMMARY

Listing of Buildings to be Demolished:

Item	Type of Construction Material	Volume (cubic feet)	Unit Cost Basis	Demolition Cost
1)				
2)				
3)				
4)				
5)				

Total Cost = $ ____________

Other Items to be Demolished:

Debris Handling and Disposal Costs:

TOTAL DEMOLITION AND DISPOSAL COST = $ ____________

Data Sources:

Project ________________

Date ________________

WORKSHEET NO. 3

MATERIAL HANDLING PLAN SUMMARY SHEET

Listing of All Earthmoving Activities:

Description	Volume	Origin	Destination	Haul Distance	Grade	Equipment to be Used
1)						
2)						
3)						
4)						
5)						
6)						
7)						
8)						
9)						
10)						

Project ____________________

Date ____________________

WORKSHEET NO. 4

EARTHWORK QUANTITY WORKSHEET

CROSS-SECTION/ STATION	DIST.	END AREAS (ft^2)		VOLUMES (yds^3)		ADJUST. VOLUMES (yd^3)*		MASS
	ft	CUT	FILL	CUT	FILL	CUT	FILL	
TOTALS								

*Indicate swell factors used

Data Sources:

Project ____________________

Date ______________________

WORKSHEET NO. 4

EARTHWORK QUANTITY WORKSHEET

Project ____________________

Date ____________________

WORKSHEET NO. 5

PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE

Earthmoving Activity:

Characterization of Dozer Used (type, size, etc.):

Description of Dozer Use (origin, destination, grade, haul distance, material, etc.):

Productivity Calculations:

Operating Adjustment Factor = ________ (operator factor) x ________ (material factor) x ________ (work hour factor) x ________ (grade factor) x ________ (weight correction factor) x ________ (production method/blade factor) x ________ (visibility) x ________ (elevation) x ________ (direct drive transmission) = ________

Net Hourly Production = ________ (normal hourly production) yd^3/hr x ________ (operating adjustment factor) = ________ yd^3/hr

Hours Required = ________ (volume to be moved) yd^3 ÷ ________ (net hourly production) yd^3/hr = ________ hrs

Data Sources:

Project ____________

Date ____________

WORKSHEET NO. 6

PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE--GRADING

Earthmoving Activity:

Characterization of Dozer Used (type, size, etc.):

Description of Dozer Use (push distance, % grade, blade effective length, operating speed, etc.):

Productivity Calculations:

Operating Adjustment Factor = ______ (operator factor) x ______ (material factor) x ______ (work hour factor) x ______ (grade factor) x ______ (weight correction factor) x ______ (production method/blade factor) x ______ (visibility) x ______ (elevation) x ______ (direct drive transmission) = ______

Hourly Production = ______ (speed) mi/hr x ______ (eff. blade width) ft x 5280 ft/mi x 1 ac/43,560 ft^2 = ______ ac/hr

Net Hourly Production = ______ (hourly prod.) ac/hr x ______ (op. adj. factor) = ______ ac/hr

Hours Required = ______ ac ÷ ______ ac/hr = ______ hrs

Data Sources:

Project ____________

Date ____________

WORKSHEET NO. 7

PRODUCTIVITY AND HOURS REQUIRED FOR RIPPER-EQUIPPED DOZER USE

Ripping Activity:

Characterization of Dozer and Ripper Used:

Description of Ripping (ripping depth, cut spacing, cut length, and material to be ripped):

Productivity Calculations:

Cycle time = (________ ft / 88 fpm) + ________ = ________ min/pass
(cut length) (speed) (turn time)

Passes/hour = ________ min/hr ÷ ________ min/pass = ________ passes/hr
(work hour factor) (cycle time)

Volume cut per pass = (________ ft x ________ ft x ________ ft) / 27 $\frac{ft^3}{yd^3}$ = ________ bank yd^3/pass
(tool penetration) (cut spacing) (cut length)

Ripping Production = ________ bank yd^3/pass x ________ passes/hr = ________ bank yd^3/hr

Hours Required = ________ bank yd^3 ÷ ________ bank yd^3/hr = ________ hrs
(volume to be ripped) (hourly production)

Calculate separate dozer hauling of ripped material in each lift on Worksheet No. 5, using material factor to account for swell.

Data Sources:

Project ______________

Date ______________

WORKSHEET NO. 8

PRODUCTIVITY AND HOURS REQUIRED FOR LOADER USE

Earthmoving Activity:

Characterization of Loader Used (type, size, etc.):

Description of Loader Use (origin, destination, grade, haul distance, etc.):

Productivity Calculations:

Cycle time = ________ (haul time (loaded)) + ________ (return time (empty)) + ________ (basic cycle time) = ________ min

Net Bucket Capacity = ________ (heaped bucket capacity) yd^3 x ________ (bucket fill factor) = ________ yd^3

Net Hourly Production = ________ (net bucket capacity) yd^3 ÷ ________ (cycle time) min x 50 min/hr (work hour factor) = ________ yd^3/hr

Hours Required = ________ (volume to be moved) yd^3 ÷ ________ (net hourly production) yd^3/hr = ________ hrs

Data Sources:

Project ____________________

Date ______________________

WORKSHEET NO. 9

PRODUCTIVITY AND HOURS REQUIRED FOR TRUCK USE

Earthmoving Activity:

Characterization of Truck Used (type, size, etc.):

Description of Truck Use (origin, destination, grade, haul distance, truck capacity, etc.):

Productivity Calculations:

Cycle time = ________ (haul time) + ________ (return time) + ________ (total loading time) + ________ (dump and maneuver time) = ________ min

Number of Trucks Required = ________ (truck cycle time) ÷ ________ (total loading time) = ________

Production Rate = ________ (truck capacity) yd^3 × ________ (# of trucks) ÷ ________ (cycle time) min = ________ yd^3/min

Hourly Production = ________ (production rate) yd^3/min × 50 min/hr (work hour factor) = ________ yd^3/hr

Hours Required = ________ (volume to be moved) yd^3 ÷ ________ (hourly production) yd^3/hr = ________ hrs

Data Sources:

Project ____________

Date ____________

WORKSHEET NO. 10

PRODUCTIVITY FOR HYDRAULIC EXCAVATOR USE (BACKHOE OR POWER SHOVEL)

Earthmoving Activities:

Characterization of the Excavator Used (type, size, etc.):

Description of Excavator Used (loading geometry, materials, etc.):

Productivity Calculations:

Net bucket capacity = ________ yd^3 × ________ = ________ yd^3
(heaped bucket capacity) (fill factor)

Net Hourly Production = ________ yd^3 × ________ min/hr ÷ ________ min = ________ yd^3/hr
(net bucket capacity) (work hour factor) (cycle time)

Hours Required = ________ yd^3 ÷ ________ yd^3/hr = ________ hrs
(volume to be handled) (net hourly production)

Data Sources:

Project ____________

Date ____________

WORKSHEET NO. 11

PRODUCTIVITY FOR SCRAPER USE

Earthmoving Activity:

Characterization of Scraper Used (type, capacity, etc.):

Description of Scraper Route (haul distance, % grade, etc.):

Cycle time = ____ min (load time) + ____ min (loaded trip time) + ____ min (maneuver and spread time) + ____ min (return trip time) = ____ min

Cycles/Hour = 50 min/hr (work hour factor) ÷ ____ min/cycle = ____ cycles/hr

Hourly Production = ____ yd^3 (adjusted load) x ____ cycles/hr = ____ yd^3/hr

Hours Required = ____ yd^3 (volume to be handled) ÷ ____ yd^3/hr (net hourly production) = ____ hrs

Data Sources:

Project ____________

Date ____________

WORKSHEET NO. 12

PRODUCTIVITY AND HOURS REQUIRED FOR MOTORGRADER USE--GRADING

Earthmoving Activity:

Characterization of Grader Used (type, size capacity, etc.):

Description of Grader Route (push distance, % grade, blade effective length, operating speed, etc.):

Productivity Calculations:

Contour Grading:

Hourly Production = _____ mi/hr (speed) x _________ ft (eff. blade width) x 5280 ft/mi x 1 ac/43,560 ft^2 x

_____ (work hour factor) = _______ ac/hr

Scarification:

Hourly Production = _____ mi/hr (work speed) x _________ ft (scarifier width) x 5280 ft/mi x 1 ac/43,560 ft^2 x

_________ (work hour factor) = _______ ac/hr

Hours Required = _______ ac ÷ _______ ac/hr = _______ hrs

Data Sources:

Project ____________

Date ____________

WORKSHEET NO. 13

SUMMARY CALCULATION OF EARTHMOVING COSTS

Equipment Type	Owning and Operating Cost ($/hr) Equipment + Accessories		Labor Cost ($/hr)		Total Hrs Req'd		Total Cost ($)
	[(	) +		] x		=	
	[(	) +		] x		=	
	[(	) +		] x		=	
	[(	) +		] x		=	
	[(	) +		] x		=	
	[(	) +		] x		=	
	[(	) +		] x		=	
	[(	) +		] x		=	
	[(	) +		] x		=	
	[(	) +		] x		=	
	[(	) +		] x		=	
	[(	) +		] x		=	

Total Cost = ________

Equipment and Accessory Identification:

Data Sources:

Project ____________

Date ____________

WORKSHEET NO. 14

REVEGETATION COSTS

Name and Description of Area to be Revegetated:

Description of Revegetation Activities:

Reseeding:

______ acres x ($______ per acre + $______ per acre) = $______

(# of acres to be reseeded) ($/acre for seedbed preparation) ($/acre for seeding, fertilizing, and mulching) (costs for reseeding)

Planting Trees and Shrubs:

______ acres x $______ per acre = $______

(# of acres for planting ($/acre for planting trees and shrubs) (costs for planting)

Other Revegetation Activity for this Area (e.g., Soil Sampling):

(Describe and provide cost estimate with documentation; use additional sheets if necessary.)

TOTAL REVEGETATION COST FOR THIS AREA = $______

Data Sources:

Project ____________________

Date ______________________

WORKSHEET NO. 15

OTHER RECLAMATION ACTIVITY COSTS

Descriptions of Reclamation Activity:

Assumptions:

Cost Estimate Calculations:

TOTAL = $__________

Other Documentation or Notes:
(Include additional sheets, maps, calculations, etc., as necessary to document estimate.)

Data Sources:

Project ____________

Date ____________

WORKSHEET NO. 16

RECLAMATION BOND SUMMARY SHEET

1.	Total Facility and Structure Removal Costs	$ ________
2.	Total Earthmoving Costs	________
3.	Total Revegetation Costs	________
4.	Total Other Reclamation Activities Costs	________
5.	Subtotal: Total Direct Costs	________
6.	Mobilization and Demobilization (at ____% of Item 5) (1% to 5% of Item 5)	________
7.	Contingencies (at ____% of Item 5) (see Table 4)	________
8.	Engineering Redesign Fee (at ____% of Item 5) (see Graph 1)	________
9.	Contractor Profit and Overhead (at ____% of Item 5) (see Graph 2)	________
10.	Reclamation Management Fee (at ____% of Item 5) (see Graph 3)	________
11.	GRAND TOTAL BOND AMOUNT (Sum of Items 5 through 10)	$ ________

Engineering News Record Cost Index: ____________ Date: ____________

Appendix B
EXAMPLES

OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT
BOND AMOUNT COMPUTATION

Applicant Underground Example

Permit Number Example No. 1

Date May 1986

Number of Acres 20 Acres

Type of Operation Underground

Location U.S.A.

Prepared by M.V. Bond

Project Underground Example

Date May 1986

WORKSHEET NO. 1

DESCRIPTION OF THE WORST-CASE RECLAMATION SCENARIO

The worst-case situation for forfeiture would be after all the improvements have been built. This would require the third-party contractor the greatest time and dollars to reclaim.

The mine plan outlines the proposed development sequence for the underground operation, starting with the installation of an off-stream sedimentation pond near the lower boundary of the site. Following the installation of the sediment pond, the applicant plans to install all the site culverts, diversion ditches, roads, benches, and topsoil stockpiles. Next, the applicant proposes to install the coal processing equipment. Concurrently, the operator plans to start three underground entries for the manway, materials/conveyor, and ventilation. Each entry will receive corrugated arches for about 50 feet into the mountainside. In addition, a series of highwalls must be constructed to form benches due to the steep slopes of the mountain in this area. These manmade benches provide the needed work space to access the mine.

Most of these improvements are required for the life of the coal mine. An administration/change facility and a shop/warehouse facility will be constructed during the first 3 years of operations. During the construction period, portable units will house these early facilities.

The following discussion will present the tasks needed to be performed for returning the mine site to the original premining condition. (See Figures B-1 through B-3 at end of document.)

1. Structure Demolition

When returning the site to the postmining land use, most surface mine-related structures and facilities will be removed. This includes all buildings and other manmade items not identified for postmining land use.

Buildings and Facilities

a. A two-story administration building, sized 60'x60'x18', will be constructed of concrete block on a poured thin, reinforced concrete slab floor. The second floor will be of plywood floor over wood floor joists. The cost of demolition includes the cost of removing the thin slab.

b. One shop building, sized 60'x120'x18', will be constructed of insulated sheet metal, high enough to accommodate the mine and haul equipment. The 6-inch thick concrete floor is designed of 4,000 psi concrete, reinforced with No. 5 rebar @ 12 inches o.c., e.w. Two reinforced concrete aprons of 60'x50'x6" thick are planned at each end of the building. The demolition size will be: building--60'x120'x18'; floor--60'x220'x6" thick.

c. Two explosive magazines are planned. These steel MSHA-approved buildings will be set on a thin concrete slab and must be removed to meet the postmining land use. Two steel buildings: 10'x10'x8' high. The demolition cost includes removal of the slab.

Data Sources: Mine plan

WORKSHEET NO. 1 (continued)

d. Four structures are included for coal primary and secondary processing, storage, and loadout. Each of these structures will be connected with a conveyor belt. This system transmits the coal from the mine to the loadout structure some 1300 feet from the mine mouth. The items that need to be removed are:

- 300' conveyor belt from the mine to the primary processing structure
- Primary processing structure = 35'x40'x60' high
- 480' conveyor belt from primary processing structure to the stacker
- Stacker = 15' diameter x 90'
15' diameter x 100'
- 290' conveyor from the stacker to the secondary-processing structure
- Secondary-processing structure = 30'x35'x40' high
- 230' conveyor belt from the secondary-processing structure to the loadout structure
- Loadout structure = 20'x20'x60' high

e. The applicant proposes a 2.3-mile powerline to a substation within the mine site. The primary entry lines consist of four wires sized 2/0 and attached to overhead poles spaced at 250 feet.

f. The water supply includes a 20'x30'x8' treatment building constructed of insulated sheet metal on a thin, reinforced concrete slab. The cost of demolition includes the cost of removing the thin slab.

g. The applicant proposes three corrugated metal pipe (CMP) culverts sized to handle the onsite drainage. The various riprap sections can remain as channel protection. The onsite culverts to be removed will be:

18" cmp - 132 LF
48" cmp - 307 LF
84" cmp - 3029 LF

2. Earthmoving Activities

During the mine development, the applicant plans to create several benches on the mountainside to create work platforms. Each of these benches will be eliminated when returning the site to the approximate original contour (AOC). Much of the earthwork associated with bench elimination will be by scrapers and bulldozers to create premining slopes. In addition, the bench/stockpile areas, the sedimentation pond, and the diversion-ditch area must be backfilled and graded prior to topsoiling and revegetation. The attached mine plan map shows the contours and cross-sections that give the various locations and grades of the proposed development. The earthwork activities will include backfilling and grading the site and preparing the site (ripping) for topsoil placement.

The off-stream dugout sedimentation pond includes all appurtenances necessary to make the pond function. The excavated materials will be stockpiled nearby. Removal of all piping and riprap will be necessary prior to backfilling and grading. Most appurtenances can be bulldozed into the pit and covered with backfill. The sediment pond is less than 20 acre feet in volume and less than 20 feet deep. The sediment pond area covers about 1 acre in size (32,300 cubic yards).

The applicant plans to rebuild about 2 miles of old logging road and about 0.5 miles on the mine site. The half-mile onsite road will be eliminated with the backfilling and grading portion of the reclamation. The mine plan states that a 20 percent swell can be expected of the earth material.

3. Topsoil Replacement

The topsoil stockpile is located about 500 feet below the sediment pond. The mine plan requires 6 inches of topsoil removed and stockpiled before any development could begin. The topsoil stockpile will be adequate to return a depth of 6 inches to the mine area. Topsoil volume is 16,133 cubic yards.

4. Revegetation

The entire permit area will need seedbed preparation, fertilization, seeding, and mulching. Because of the short growing season, the contractor will only have a few months per year when revegetation has a chance to survive. Local experience indicates a 50 percent failure of the revegetation due to the short growing season.

5. Other Reclamation Activities

Three underground entries need to be closed. Each entry has a corrugated arch support that extends about 50 feet into the mine. The ventilation access measures 10 feet in diameter, the material access is 12 feet in diameter, and the manway access measures 25 feet in diameter. A masonry wall will be erected to seal the entries prior to covering with the backfilling materials.

Project Underground Example

Date May 1986

WORKSHEET NO. 2A

STRUCTURE DEMOLITION AND DISPOSAL COST SUMMARY

Listing of Buildings to be Demolished:

Item	Type of Construction Material	Volume (cubic feet)	Unit Cost Basis	Demolition Cost
1) Admin. Building	Masonry block	64,800	$0.14	$ 9,072
2) Shop Building	Metal	129,600	0.14	18,144
3) Explosive Magazines	Metal	1,600	0.14	224
4) Water System Building	Metal	4,800	0.14	672

Other Items to be Demolished:

1) conveyor system***	Metal	1,300 LF	38.00	49,400
2) powerline**, 2.3 miles	4 wire	48,576 LF	3.00	145,728
3) power poles**, 50	Wood	50 each	250.00	12,500
4) shop slab	Reinforced concrete	13,200 SF	2.67	35,244

* Demolition including disposal

**David Radesevich, Electrical Engineer
Western Area Power Administrator
P.O. Box 3403
Golden, Colorado 80401

***Cost breakdown for mine plan

Removal of belt cover and steel pan =	$19.30/LF
Belt removal	$10.93/LF
Idler pulley removal	$ 3.19/LF
Removal of towers, concrete & site grading	$ 4.58/LF
Total costs for conveyor removal	$38.00/LF

TOTAL DEMOLITION AND DISPOSAL COST = $ continued on next sheet

Data Sources: Means, Building Construction Cost Data, 1986, page 17, item 25-001

Project Underground Example

Date May 1986

WORKSHEET NO. 2B

STRUCTURE DEMOLITION AND DISPOSAL COST SUMMARY

Listing of Buildings to be Demolished:

Item	Type of Construction Material	Volume (cubic feet)	Unit Cost Basis	Demolition Cost
1) Primary Processing	Metal	84,000	$0.14	11,760
2) Secondary Processing	Metal	42,000	0.14	5,880
3) Stacker	Concrete	33,575	0.17	5,708
4) Load Out	Metal	24,000	0.14	3,360
5)				

Other Items to be Demolished:

1) 18" culvert*	Metal	132 LF	2.50	330
2) 48" culvert*	Metal	307 LF	2.50	768
3) 84" culvert*	Metal	3,029 LF	2.50	7,573

*Cost breakdown from mine plan

Removal of culverts and construction of riprap channels = $2.50/LF

TOTAL DEMOLITION AND DISPOSAL COST = $ 306,363

Data Sources: Means, Building Construction Cost Data, 1986, page 17, item 25-001

Project Underground Example

Date May 1986

WORKSHEET NO. 3

MATERIAL HANDLING PLAN SUMMARY SHEET

Listing of All Earthmoving Activities:

Description	Volume	Origin	Destination	Haul Distance	Grade	Equipment to be Used
1) Site grading*	51,388 cy + 20% swell 61,665 cy	Benches	General Contouring	500' Avg	10%	See task breakdown below
2) a.	41,110 cy					627B Scraper D8L push tractor
3) b.	20,555 cy					D9L dozer
4) Sed Pond*	32,267 cy + 20% swell 38,720 cy	Embankment	Pond Area	500' Avg	10%	See task breakdown below
5) a.	25,814 cy					627B scraper D9L push tractor
6) b.	12,907 cy					D9L dozer
7) Topsoil	16,133 cy + 20% swell = 19,360 cy	Stockpile	Total Disturbed Area	1100'	10%	627B scraper D8L push tractor
8) Ripping	64,533 cy		Total Disturbed Area			D7G
9) Haul Road Maintenance Final grading			Total Disturbed Area			140G motorgrader
10)						
11)						

*It is assumed that D9L dozers and the 627B scrapers will be operating concurrently.

Project Underground Example

Date May 1986

WORKSHEET NO. 4

EARTHWORK QUANTITY WORKSHEET

CROSS-SECTION/ STATION	DIST. ft	END AREAS (ft^2) CUT	END AREAS (ft^2) FILL	VOLUMES (yds^3) CUT	VOLUMES (yds^3) FILL	ADJUST. VOLUMES (yd^3)* CUT	ADJUST. VOLUMES (yd^3)* FILL	MASS
0		0	0					0
	400			7777	5378			
B/D		1050	725					2399
	450			20,833	13,550			
C/D		1450	900					9682
	400			18,148	35,185			
D/D		1000	3850					-7355
	250			4,630	17,824			
Boundary		0	0					-20,549
TOTALS	1500			51,388	71,937			

Data sources: Randomly selected cross-sections through mine site for example only. For actual sites, use 50' or 100' stations and balance cut/fills for a zero balance on the mass.

Project Underground Example

Date May 1986

WORKSHEET NO. 5A

PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE

Earthmoving Activity:

1) Backfill and rough grade sediment pond; 2) rough grade bench site.

NOTE: Since these two tasks have similar characteristics in push distance and grade, the yardage are combined and the total hours required determined. Site located 8000 feet above sea level.
TOTAL YARDAGE = 20,555 cy + 12,907 cy (from Worksheet No. 3)

Characterization of Dozer Used (type, size, etc.):

D9L dozer with "U" Blade = 380 cy/hr

Description of Dozer Use (origin, destination, grade, haul distance, material, etc.):

500 LF + 10% effective grade; some material is blasted rock; however, the majority is assumed to be average.

Productivity Calculations:

Operating Adjustment Factor = .75 (operator factor) × .95 (material factor) × .84 (work hour factor) × .85 (grade factor) × $\frac{2550}{2550}$ (weight correction factor) × 1.0 (production method/blade factor) × 1.0 (visibility) × .95 (elevation) × 1.0 (direct drive transmission) = .483

Net Hourly Production = 380 (normal hourly production) yd^3/hr × .483 (operating adjustment factor) = 183.54 yd^3/hr

Hours Required = 33,462 (volume to be moved) yd^3 ÷ 183.5 (net hourly production) yd^3/hr = 182.4 hrs

Assume two D9L dozers are required for 91.2 hours. Therefore, rough backfilling and grading and tasks for the D9L dozers, and the scrapers from Worksheet No. 11A, will finish roughly the same time so that topsoiling can begin.

Data Sources: Caterpillar Performance Handbook, Edition 16

Project Underground Example

Date May 1986

WORKSHEET NO. 5B

PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE

Earthmoving Activity:

Push tractor to assist loading scrapers.
Equipment working @ 8000 feet, msl.

Characterization of Dozer Used (type, size, etc.):

Caterpillar D8L, equipped with push pad

Description of Dozer Use (origin, destination, grade, haul distance, material, etc.):

Productivity Calculations:

Operating Adjustment Factor = ______ x ______ x ______ x ______ x ______ x ______ x
(operator factor) (material factor) (work hour factor) (grade factor) (weight correction factor) (production method/blade factor)

______ x ______ x ______ = ______
(visibility) (elevation) (direct drive transmission)

Net Hourly Production = ______ yd^3/hr x ______ = ______ yd^3/hr
(normal hourly production) (operating adjustment factor)

Hours Required = ______ yd^3 ÷ ______ yd^3/hr = 119.8* hrs
(volume to be moved) (net hourly production)

*One-half the total required scraper hours (see Worksheet Nos. IIA and IIB).

Data Sources: Caterpillar Performance Handbook, Edition 16

Project Underground Example

Date May 1986

WORKSHEET NO. 7

PRODUCTIVITY AND HOURS REQUIRED FOR RIPPER-EQUIPPED DOZER USE

Ripping Activity:

This unit will be used for ripping the site prior to topsoil placement as well as additional miscellaneous site maintenance activities for the life of the reclamation contract. The ripping activity will involve 20 acres. Volume = 20 acres x 2 ft depth = 64,533 yd^3.

Characterization of Dozer and Ripper Used:

Caterpillar D7G bulldozer with rippers

Description of Ripping (ripping depth, cut spacing, cut length, and material to be ripped):

Ripping depth = 2 feet
Ripping effective width = 7 feet

Productivity Calculations:

Cycle time = (1000 [cut length] ft / 88 fpm [speed]) + 0.30 [turn time] = 11.67 min/pass

Passes/hour = 45 [work hour factor] min/hr ÷ 11.67 [cycle time] min/pass = 3.86 passes/hr

Volume cut per pass = 2 [tool penetration] ft x 7 [cut spacing] ft x 1000 [cut length] ft) / 27 ft^3/yd^3 = 518.5 bank yd^3/pass

Ripping Production = 518.5 bank yd^3/pass x 3.86 passes/hr = 2001 bank yd^3/hr

Hours Required = 64,533 [volume to be ripped] bank yd^3 ÷ 2001 [hourly production] bank yd^3/hr = 32.3* hrs

Calculate separate dozer hauling of ripped material in each lift on Worksheet No. 5, using material factor to account for swell.

*Of the proposed 120 hours of the reclamation contract, 32.3 hours will be spent on ripping. See Worksheet No. 13 for an explanation of the reclamation contract.

Data Sources: Caterpillar Performance Handbook, Edition 16