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OFFICE OF SURFACE MINING
RECLAMATION AND ENFORCEMENT
DIRECTIVES SYSTEM**

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Subject: Handbook for Calculation of Reclamation Bond Amounts

Exhibit 64

Approval: *Margy White*

Title: Acting Director

1. PURPOSE. This directive establishes the Handbook for Calculation of Reclamation Bond Amounts (Handbook) as guidance for the calculation of reclamation bond amounts by the Office of Surface Mining Reclamation and Enforcement (OSM).

2. SUMMARY OF CHANGES. The 1987 Handbook has been updated and revised to reflect recent information and policy guidance. The major changes included in this revision are:

Chapter 1 has been expanded to describe applicable situations involving the calculation or recalculation of reclamation costs, including the statutory and regulatory requirements.

Guidance for bond calculations for subsidence damage repair costs and water supply replacement was added to Chapter 1, Chapter 2 (Step 2: IV. Other Direct Reclamation Costs) and related Worksheet 15.

Guidance for bond calculations for long-term treatment of unanticipated, pollutional discharges was added to Chapter 1, Chapter 2 (Step 2: IV. Other Direct Reclamation Costs) and related Worksheet 15.

Chapter 2, Step 3, adjustment of direct costs for inflation, was added to the bond calculation procedures and related Worksheet 16.

Chapter 2, Step 4, estimates of indirect costs for contingency allowances, engineering redesign costs, profit and overhead, and project management fee, were reviewed and adjusted to reflect the current range of costs. Graphs 1 and 2 related to profit and overhead, and project management fee were updated.

Chapter 3: "Special Considerations for Calculation of Incremental, Cumulative, and Phase Bonds," was added to give guidance in cases where an applicant elects to post bond under one of these situations.

Chapter 4: "Bond Release" and related Worksheets 17 and 18 were added.

All references cited in Chapters 1-4 are contained on one page following Chapter 4.

Appendix A - Bond Calculation Worksheets - was updated to reflect all text changes.

Appendix B - Examples - was updated to reflect the new worksheets and any new information available, such as equipment specifications.

Appendix C - Guidance for Equipment Selection - was updated to reflect current information.

Appendix D - Calculation of Bond Amounts for Long-Term Treatment of Pollutational Discharges - was added.

Appendix E - Metric Conversion Table - was added.

3. DEFINITIONS. None.

4. POLICY/PROCEDURES.

a. Policy.

(1) OSM personnel must use the Handbook, established by this Directive, when calculating bonds or determining bond amounts under a Federal program, Federal lands program or whenever OSM issues a permit for surface coal mining operations.

(2) OSM personnel may use the Handbook during oversight of approved State programs as a technical guide when assessing the adequacy of bonds. However, such use is limited to that approved in oversight procedures and guidance. The Handbook must not be used to compel States to adhere to the methods in the Handbook.

b. Responsibilities.

(1) The Assistant Director, Program Support, is responsible for developing and maintaining the Handbook.

(2) The Regional Directors are responsible for ensuring use of the Handbook in the assessment of bond adequacy as part of the Federal permitting process. The Handbook may be used as a guide during oversight of approved State programs.

c. Procedures. Procedures to calculate bonds are contained in the Handbook. Revisions/modifications to the Handbook will be made as needed using the Directives System process.

5. REPORTING REQUIREMENTS. None.

6. REFERENCES.

a. The Surface Mining Control and Reclamation Act of 1977 (SMCRA), Sections 509 and 519.

b. 30 CFR Part 800.

c. OSM Policy Statement - "Policy Goals and Objectives on Correcting, Preventing and Controlling Acid/Toxic Mine Drainage," March 31, 1997.

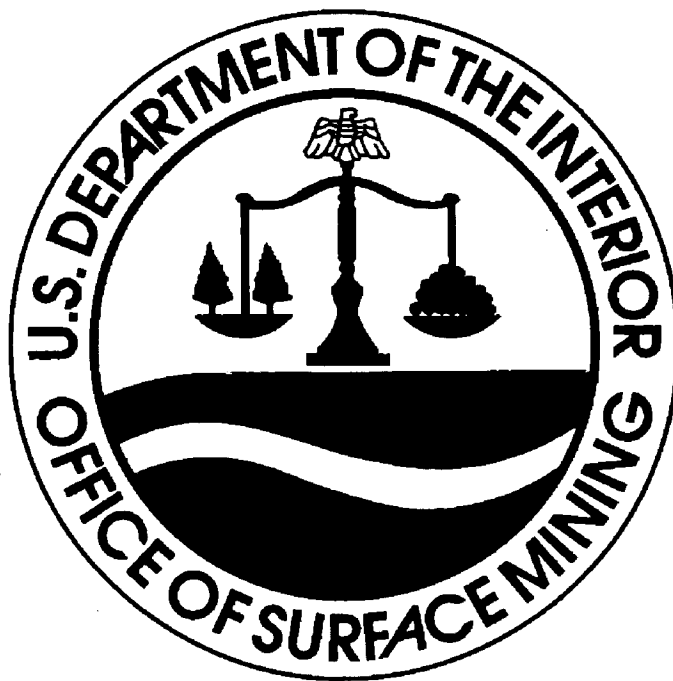
7. EFFECT ON OTHER DOCUMENTS. The Handbook supersedes all other OSM guides for determining bond amounts where OSM is the regulatory authority, including prior versions of TSR-1, Transmittal Number 360, dated 07/21/87 and related change notice TSR-1-1, Transmittal Number 758, dated 1/13/93.

8. EFFECTIVE DATE. Upon Issuance.

9. CONTACT. Program Support Directorate, (202) 208-4264.

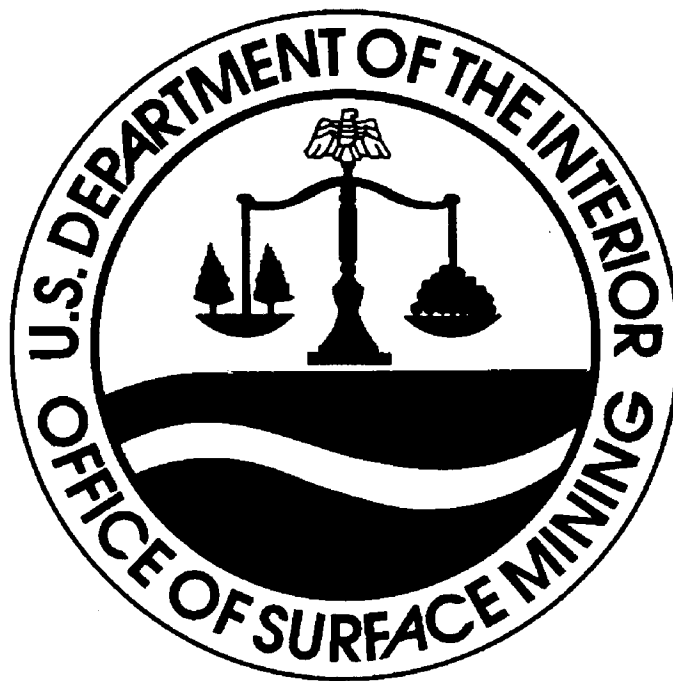
10. KEYWORDS. Performance Bond, Bond Calculation, Bond Release.

HANDBOOK
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Calculation
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Reclamation Bond Amounts



Revised April 2000

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PREFACE

This Handbook establishes a technically sound, consistent methodology to calculate the amount of performance bond required for surface coal mining operations under the Surface Mining Control and Reclamation Act of 1977 (SMCRA or the Act) when the Office of Surface Mining Reclamation and Enforcement (OSM) is the regulatory authority. OSM first adopted the Handbook as policy guidance in 1987, with minor revisions in 1993. The current version, which was developed by an OSM work group comprised of representatives from each region and headquarters, contains substantial updates and revisions in response to management direction and user recommendations.

Several other Federal agencies, numerous companies in the coal industry, the coal-producing states, and states with non-coal mining use the Handbook as an organized approach to cost estimation. Also, many individuals have attended OSM's bonding workshop on cost estimation. Consulting engineers in both the U.S. and Canada have requested and received copies of the Handbook, and training was provided to the Indonesian environmental agency on its use.

Because the Handbook relies upon standard engineering cost-estimating procedures to develop site-specific costs for each reclamation activity, users should be familiar with standard engineering principles, equipment productivity guidebooks, and construction cost reference manuals. The mention of trade names of commercial equipment and products in this Handbook is for illustrative purposes only and does not constitute endorsement or recommendation by OSM.

Handbook users are encouraged to submit suggested revisions to OSM work group members for consideration in future editions. Members and the OSM offices they represent are:

Paul Behum	Mid-Continent Region, Alton, IL
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CHAPTER 1

INTRODUCTION

BACKGROUND AND PURPOSE

One of the major purposes of the Surface Mining Control and Reclamation Act of 1977 (SMCRA or the Act) is to ensure adequate reclamation of all areas disturbed by surface coal mining operations. Section 509 of the Act and its implementing regulations at 30 CFR Part 800 require that, prior to permit issuance, the applicant file a performance bond with the regulatory authority in an amount determined by the regulatory authority. The performance bond provides a guarantee that funds will be available to the regulatory authority to complete the approved reclamation plan in the event that the permittee fails to do so.

This Handbook establishes a bond calculation methodology for use when OSM is the regulatory authority. Since neither SMCRA nor the Federal regulations require adherence to a specific methodology, State regulatory authorities are free to use the Handbook or any other method of bond calculation that results in the establishment of performance bond amounts that meet all regulatory program requirements.

This Handbook applies to all situations involving the calculation or recalculation of reclamation costs when OSM is the regulatory authority, including:

- Determination of the amount of bond initially required for permit issuance. See 30 CFR 773.15(d) and 800.11.
- Determination of the amount of bond required before mining advances into any succeeding increments (under incremental bonding) or operational stages (under cumulative bonding) of the permit area. See 30 CFR 800.11(b) and (c).
- Determination of any increases in bond required as a result of a permit revision that alters the calculations or assumptions underlying the reclamation cost estimate for the existing permit and bond. See 30 CFR 800.15(d).
- Determination of any decrease in the amount of bond that may be approved as a result of a change in the operation plan that reduces the future cost of reclaiming mined land. See 30 CFR 800.15(c).

- Evaluation of bond adequacy at the time of permit renewal. See 30 CFR 774.15(b)(2)(iii) and (c)(1)(v). Unless the renewal application also includes a request for a permit revision, the rules do not expressly require this evaluation. However, the regulatory authority may reasonably interpret 30 CFR 774.15(c)(1)(i), when read in conjunction with 800.4(g), as authorizing an evaluation of bond adequacy at that time.
- At the discretion of the regulatory authority, evaluation of bond adequacy at the time of mid-term permit review or as part of the process of reviewing requests for temporary cessation of operations.
- Determination of the amount of bond to be retained at the time of Phase I or Phase II bond release. See 30 CFR 800.40(c).
- Determination of the amount of bond that must be posted to guarantee correction of material damage from subsidence or replacement of a water supply damaged by underground mining. See 30 CFR 817.121(c)(5).
- Determination of the amount of bond that must be posted to guarantee treatment if an unanticipated pollutional postmining discharge requiring long-term treatment develops. See OSM's March 31, 1997, statement entitled "Policy Goals and Objectives on Correcting, Preventing and Controlling Acid/Toxic Mine Drainage."

In addition, if a State regulatory authority uses the Handbook or a variation thereof to calculate bond amounts, OSM may use the Handbook to conduct oversight evaluations of bond adequacy, but only after making necessary State-specific modifications such as replacement of Davis-Bacon wage rates with whatever rates apply under State law. When conducting oversight in States that do not rely upon the Handbook to calculate bond amounts, OSM may use the Handbook as a tool to estimate reclamation costs.

Because the Handbook relies upon standard engineering cost-estimating procedures to develop site-specific costs for each reclamation activity, users should be familiar with standard engineering principles, equipment productivity guidebooks, and construction cost reference manuals.

The mention of trade names of commercial equipment and products in this Handbook is for illustrative purposes only and does not constitute endorsement or recommendation by OSM.

STATUTORY AND REGULATORY REQUIREMENTS

Section 507(d) of SMCRA requires each applicant to submit, as part of the permit application, a reclamation plan in sufficient detail to demonstrate compliance with the reclamation standards of the applicable regulatory program. Section 509(a) of the Act and its implementing regulations at 30 CFR 800.14(b) require that the applicant file a bond in an amount sufficient to cover the cost of reclamation in accordance with the approved plan should the regulatory authority have to perform the reclamation in the event of bond forfeiture.

Under 30 CFR 773.15(d) and 800.11(a), a permit applicant must file a bond or bonds before the regulatory authority may issue a permit. According to 30 CFR 800.11(b)(1), the bond or bonds must cover either the entire permit area or an identified increment of land within the permit area upon which the operator will initiate and conduct surface coal mining operations during the initial term of the permit. Under 30 CFR 800.11(d)(2), the applicant also has the option of filing a cumulative bond. As provided in 30 CFR 800.11(d)(1), a permit applicant's choice of bonding scheme (entire permit area, incremental, or cumulative) is subject to regulatory authority approval.

Incremental and cumulative bonds are similar in that the permittee or permit applicant initially posts bond for only part of the proposed operation within the permit area. However, under the incremental method, each bond applies only to a specific increment of the permit area, while under the cumulative method each bond applies to the entire permit area even though the permittee may be authorized to disturb only a specified portion of the permit area. Under both the cumulative and the incremental methods, the permit application must identify the amount of bond required for the land to be disturbed by each stage of the operation (when using cumulative bonding) or increment of the permit area (when using incremental bonding). The permittee must file any additional bond or bonds required for each successive stage of the operation or increment of the permit area before beginning that stage of the operation or disturbing that increment of the permit area (30 CFR 800.11(b)(2), (b)(3), (b)(4), and (c)).

Under 30 CFR 800.11(b)(4), independent increments must be of sufficient size and configuration to provide for efficient reclamation operations should bond forfeiture occur.

Under 30 CFR 800.13(a)(2), the regulatory authority has the discretion (but not the obligation) to accept a separate bond or bonds for each phase of reclamation as defined in 30 CFR 800.40(c).

Under 30 CFR 800.14(a), the regulatory authority must determine the amount of the bond based upon:

- The requirements of the approved permit and reclamation plan;
- The probable difficulty of completing reclamation, giving consideration to factors such as topography, geology, hydrology, and revegetation; and
- The applicant's estimate of the cost of completing the reclamation plan, although the regulatory authority is not limited by this estimate.

Paragraph (b) of 30 CFR 800.14 requires that the bond amount be sufficient to ensure completion of the reclamation plan if the work has to be performed by the regulatory authority in the event of forfeiture. In no case may the bond amount be less than \$10,000.

Under 30 CFR 800.15 and section 509(e) of SMCRA, the regulatory authority must re-evaluate bond adequacy and adjust bond amounts as appropriate whenever the permit acreage increases or decreases or the cost of future reclamation changes. However, any bond reduction requested as a result of reclamation work performed must be processed as an application for bond release under 30 CFR 800.40.

A bond reduction under 30 CFR 800.15(c) must be justified solely upon a demonstration that the reclamation cost estimates that form the basis for the existing bond amount are no longer valid for reasons other than the performance of reclamation work. Situations that qualify for bond reduction through the bond adjustment process include deletion of undisturbed acreage from the permit area (unless deletion of the acreage would not lower the maximum reclamation cost liability for the permit or increment), technological advances that reduce the unit costs of reclamation, changes in the mining plan (such as a decision not to remove the lowest coal seam) that result in an operation of more limited extent than originally approved and bonded, and an alteration in the postmining land use that reduces reclamation costs.

Completion of reclamation activities such as backfilling or topsoil replacement does not qualify as a change in the cost of future reclamation. See 48 FR 32944-45, July 19, 1983. The permittee must apply for bond release to obtain a bond reduction under these circumstances.

Under 30 CFR 800.15(d), the regulatory authority must conduct a bond adequacy review whenever the approved permit is revised. The regulatory authority must require adjustment of the bond amount to reflect any increase in reclamation costs resulting from the permit revision.

Under section 519(c) of the Act and 30 CFR 800.40(c), the regulatory authority may reduce bond amounts in accordance with a phased release schedule as reclamation is completed. However, the amount of bond remaining after each of the first two phases must be sufficient to assure completion of remaining reclamation obligations, which means that, after conducting the inspection and evaluation required by 30 CFR 800.40(b)(1), the regulatory authority must recalculate reclamation costs to determine how much bond to retain and how much, if any, may be released.

Under 30 CFR 817.121(c)(5), the regulatory authority must require the permittee to obtain additional performance bond to cover the costs of repairing, replacing, or providing compensation for material damage to protected structures when the damage is a result of subsidence caused by underground mining operations. The same requirement applies to subsidence-related material damage to surface lands and to certain drinking, domestic, or residential water supplies adversely impacted by underground mining operations. Both requirements apply only if the permittee fails to correct the damage within a specified time and the damage is not fully covered by the permittee's liability insurance policy.

Finally, OSM's March 31, 1997, acid mine drainage policy statement clarifies that the performance bond or an equivalent form of financial assurance must be adequate to ensure completion of the hydrologic reclamation plan approved in the permit. In essence, whenever unanticipated pollutional discharges requiring long-term treatment develop, the regulatory authority must adjust the bond amount (or require equivalent financial assurance) to cover all future costs of monitoring, evaluating, abating, and treating those discharges to the extent necessary to avoid causing material damage to the hydrologic balance.

ASSUMPTIONS

The Handbook's bond calculation methodology assumes that:

- The bond amount will reflect the cost of engaging a third-party contractor to complete the reclamation plan.

- The bond amount will reflect the "worst case scenario;" i.e., the cost of reclaiming the site if the permittee forfeits the bond at the point of maximum reclamation cost liability, under the reclamation and operation plans approved as part of the permit. Calculating the bond amount in this manner should ensure the availability of adequate reclamation funds at all times during the life of the operation.
- The reclamation and operation plans submitted as part of the permit application and any special permit conditions imposed by the regulatory authority will serve as the basis for determining the amount of performance bond required. The regulatory authority will independently calculate reclamation cost estimates; it will consider but not rely upon cost estimates supplied by the permit applicant.
- The permittee will be in compliance with the approved reclamation and operation plans, permit conditions, and performance standards at all times.
- The regulatory authority will routinely reevaluate bond adequacy and require bond adjustments as authorized or mandated by 30 CFR 800.15.
- The initial calculation of bond amounts will not include remediation costs for events such as acid mine drainage and landslides that are not anticipated in the approved permit or reclamation plan. Should an unanticipated event occur, the regulatory authority must require a permit revision and adjust the bond amount to include any additional reclamation costs.

METHODOLOGY

The methodology in this Handbook reflects standard construction industry cost-estimating procedures for determining demolition, earthmoving, and revegetation costs, which are the most significant elements of the reclamation cost estimate.

Equipment productivity data, hourly rates and other costs used in the examples in Appendix B are taken from the sources referenced throughout this document. Rounding was applied in preparing the examples as follows:

- Equipment productivity hours are rounded to the nearest hour, and
- Total bond amounts are rounded to three significant digits.

DATA SOURCES

There are four major sources of the information needed to calculate bond amounts:

- The reclamation and operation plans in the permit or permit application.
- Equipment productivity and performance guidebooks.
- Construction cost reference manuals.
- Contract and cost data from State and Federal abandoned mine land and bond forfeiture reclamation programs; the Tennessee Valley Authority; the Natural Resources Conservation Service (formerly the Soil Conservation Service); State, Bureau of Indian Affairs, Tribal and Federal forestry and wildlife agencies; the Cooperative Extension Service; and the Department of Labor for wage rates. These sources may provide local costs for tasks or materials.

The reclamation and operation plans in the permit or permit application provide essential information on the type of mining to be conducted, the sequence of mining and reclamation activities within the permit area, spoil and topsoil handling, haul distances, extent of areas to be disturbed, structures needed during the mining operations, final surface configuration, revegetation standards and techniques, and postmining land use considerations (such as retention of roads, ponds, and other structures).

Equipment productivity and performance guidebooks are extremely useful when estimating earthmoving costs. Most heavy equipment manufacturers publish guidebooks containing performance data. For example, the *Caterpillar Performance Handbook* includes data on tractors, loaders, scrapers, haulage vehicles, small hydraulic shovels and excavators, in addition to a variety of other information such as estimating methodologies and heavy equipment cost accounting.

To calculate bond amounts, these guidebooks should be used in combination with a comprehensive equipment cost reference manual, such as the PRIMEDIA Information, Inc. (formerly K-III Directory Corp. and Dataquest, Inc.) *Cost Reference Guide for Construction Equipment* or the *Contractors Equipment Cost Guide*. These reference manuals, which are updated periodically, provide hourly

ownership and non-wage operating costs for a wide range of heavy equipment. Because all contracts awarded by OSM to reclaim lands for which it is the regulatory authority are direct Federal contracts, labor costs for equipment operation must reflect Davis-Bacon wage rates as established by the Department of Labor. Any wage rates provided by the Department of Labor, which are used in the reclamation estimate, should be documented to include the date, state, county, construction type and wage number.

The R. S. Means Company, Inc., also publishes construction-related cost data including *Means Building Construction Cost Data*, *Means Heavy Construction Cost Data*, and *Means Site Work and Landscape Cost Data*. Means guides contain an extensive array of line-item costs for building construction. These reference manuals, which are updated annually, are especially useful for estimating material acquisition costs and the costs of specific reclamation tasks such as structure demolition. Because the Handbook provides for a separate determination of profit and overhead (see *Chapter 2 and Worksheet 16*), only use "bare cost" data from the reference manuals. Bare costs do not include profit and overhead.

CHAPTER 2

BOND CALCULATION PROCEDURES

There are five major steps in the bond calculation process:

- Determine the point of maximum reclamation cost liability.
- Estimate direct reclamation costs such as earthmoving, revegetation, and the removal and demolition of structures not to be retained as part of the postmining land use.
- Adjust direct costs for inflation.
- Estimate indirect reclamation costs, including contractor and equipment mobilization and demobilization charges, contingency allowances, redesign expenses (including surveying, aerial photography, and monitoring in support of this effort), profit and overhead, and contract management fees.
- Calculate the total bond amount.

Appendix A contains worksheets for the orderly completion and documentation of each step. Appendix B provides examples of completed worksheets. Appendix E contains a metric conversion table for use when permitting information is submitted in metric units.

STEP 1: DETERMINE POINT OF MAXIMUM RECLAMATION COST LIABILITY

Since this is the most important step in the cost-estimating procedure, complete *Worksheet 1* only after carefully studying the operation and reclamation plans in the permit application.

This point will differ for each operation depending on the nature and complexity of the operation, the number of factors present, and the operation and reclamation plans. Generally, the greatest reclamation cost liability occurs at the point in the permit term at which 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. For multiple-seam mining operations, this is the point at which coal extraction from the lowest coal seam is complete, most of the overburden removed to that point has been placed in excess spoil fills, and little or no backfilling has occurred.
- The longest haul distance between spoil or topsoil storage areas and the final placement location.
- The greatest number of on-site structures.
- The point at which refuse piles require the largest amount of cover material.
- Maximum disturbance of areas with special reclamation needs or special materials handling plans, such as sites with prime farmland soils, acidic or toxic materials, difficult topographic situations, or underground mine workings that must be sealed.

As with all engineering estimates, the bond calculation should be supported by documentation of all assumptions, references, and data sources.

STEP 2: ESTIMATE DIRECT RECLAMATION COSTS

Reclamation of most surface coal mining operations includes the following sequence of activities:

- Structure demolition and disposal, including the removal of mining-related buildings and other structures and facilities that are not approved for retention as part of the postmining land use.
- Earthmoving, including backfilling and rough grading, spoil ridge reduction, highwall elimination, final pit elimination, pond and road reclamation, final grading, and topsoil replacement.
- Revegetation.

In addition, other tasks such as sealing mine portals and pumping and treating impounded water may be necessary as part of the reclamation process.

This section describes how to estimate the cost of each of these activities.

I. Structure Demolition and Disposal (Worksheet 2)

With the exception of structures approved for retention as part of the postmining land use, the regulations require the reclamation of all haul and access roads and the removal and disposal of all mining-related buildings, crushers, coal storage bunkers and silos, conveyor systems, fences, foundations, power lines, rail spurs, utilities, storage facilities for equipment and supplies, and other similar structures within the permit area.

For cost estimation purposes, removal of a structure means demolition of the structure. Below-grade foundations and buried utilities may be left in place when compatible with the approved postmining land use.

With respect to the reclamation of roads that are not approved for retention as part of the postmining land use, the structure demolition cost category includes expenses associated with the removal and disposal of bridges and culverts, as well as any road-surfacing materials that are incompatible with the postmining land use or revegetation requirements. Other road reclamation costs such as grading and scarification are more properly included in the earthmoving and revegetation cost categories.

Unless the reclamation plan documents that the pertinent solid waste disposal authority has approved on-site disposal, all structure demolition cost estimates must include transportation expenses, landfill disposal fees, and other costs associated with the disposal of demolition debris in an approved solid waste disposal facility. The approval of the solid waste disposal authority may not be necessary for the disposal of loose road-surfacing materials (shale, gravel, or crushed stone) in the backfill.

Include costs for disposal of abandoned equipment and supplies. Because there is no reasonable means of predicting whether equipment and supplies or other materials with potential resale value will be left on site at the time of bond forfeiture, do not allow credit for the salvage value of building materials or abandoned equipment and supplies.

Use *Worksheet 2* and appropriate reference manuals such as the Means guides to calculate costs associated with the demolition and removal of structures. When using reference manuals, avoid data that incorporate overhead and profit. The Handbook provides a different method for estimating overhead and profit (see *Worksheet 16* and Graph 2).

II. Earthmoving (Worksheets 3 through 13)

A. Introduction

For most surface mining operations, earthmoving is the major reclamation cost. Necessary earthmoving activities most commonly include backfilling, grading, placement of cover materials (especially on coal refuse disposal sites), and topsoil redistribution. Backfilling consists of the mass transport of spoil to eliminate spoil piles, pits, and highwalls.

Grading commonly includes:

- Removing diversions and siltation structures,
- Reshaping road cut-and-fill slopes,
- Reconstructing stream channels,
- Recontouring all disturbed areas to restore appropriate drainage patterns and facilitate the postmining land use,
- Preparing the site for topsoil redistribution, and
- Ripping or scarifying the regraded overburden necessary to ensure topsoil adhesion.

To estimate costs for earthmoving activities, complete *Worksheets 3 through 13*, following the instructions below and the examples in Appendix B. *Worksheet 3*, the materials handling plan, identifies and describes each type of earthmoving activity needed at the point of anticipated maximum reclamation cost liability. *Worksheets 4A and 4B* provide two alternatives for calculating the volumes of materials to be handled. *Worksheets 5 through 12* provide a means of calculating site-specific equipment productivity data for various types and models of equipment, using the equipment productivity and performance guidebooks listed in Chapter 1.

B. Materials Handling Plan (*Worksheet 3*)

Use *Worksheet 3* to identify and describe each specific earthmoving activity required as a result of the configuration of the operation at the point of maximum reclamation liability. The determination of equipment needs, productivity, and

costs will depend on the information provided on this worksheet. Development of the materials handling plan requires determination of the volume of material to be handled, haul distances and grades, and the types of equipment to be used, as discussed below:

- Material Volume Estimates

Using the reclamation and operation plans in the permit application, compare the pre-reclamation and post-reclamation topography of the site to determine the amount of material that must be handled. Use standard engineering methods to calculate earthmoving volumes. For example, a series of pre-reclamation and post-reclamation cross sections can be used to calculate volumes by the average-end-area method (see *Worksheet 4A*). Alternatively, use *Worksheet 4B* to estimate earthmoving needs by calculating the volume of a series of geometric shapes that resemble the difference between pre- and post-reclamation topography. Appendix B contains examples of these two approaches. You may also determine earthmoving volumes using computer programs such as Dynamic Graphics, Inc's, *earthVision*, Carlson Software's *SurvCADD*, and Civil Software Design's *SEDCAD* programs. This software is available from OSM's Technical Information System (TIPS). Document all calculations regardless of the method selected.

Material volume is defined according to its state in the earthmoving process. The three measures of volume are bank cubic yards (BCY), loose cubic yards (LCY), and compacted cubic yards (CCY). Swell is the increase in volume resulting from a change from bank state to loose state; i.e., the increase in volume caused by excavation. Excavation causes fragmentation, which results in an increase in void spaces.

All excavated materials settle over time, reducing both the void spaces and overall volume. In addition, mechanical compaction results in some immediate volume shrinkage. Hence, the loose volume of material required to backfill an open pit is greater than the pit void space (pit volume) because of the shrinkage and compaction of the loose backfill material that occurs during and after placement in the pit.

One cubic yard of material lying in its undisturbed, geologic state is 1 BCY. One cubic yard of material that has been excavated and has expanded in volume as a result of the fragmentation that occurs during excavation is 1

LCY. One cubic yard of excavated material that has been subsequently compacted during placement is 1 CCY.

Most equipment productivity calculations are based on moving loose volumes of material. Therefore, convert in-place volumes to be moved to loose volumes.

The reclamation and operation plans in the permit application identify the type of overburden materials present within the permit area. Generally, they also specify swell and shrinkage factors for these materials. Verify this information by comparison with swell and shrinkage factors in appropriate equipment guidebooks or other standard engineering reference materials.

Some equipment manuals refer to a load factor, which is the loose density divided by the bank density. Multiply the loose volume of material by the load factor to determine bank volume. This calculation is necessary to estimate productivity and payloads in terms of bank cubic yards (BCY). Use the following equation to determine the swell factor using a load factor:

$$\text{Swell Factor} = (100 \div \text{load factor}) - 100$$

- Haul Distance Estimates

Using the reclamation and operation plans in the permit application (including designated haul roads and routes), determine haul distances for each area where backfilling, grading, topsoil replacement, or other earthmoving activities will occur. Identify the approximate centroid (surface expression of the center of mass) of each source material and its destination and determine the centroid-to-centroid distance.

- Grade Estimates

Haul grades and surface conditions greatly impact equipment productivity and may limit the type of equipment that can be used. Most equipment productivity and performance guides express these limitations in terms of the total resistance of the haul, which is the sum of the rolling resistance and grade resistance. The guides contain tables that convert rolling resistance to an equivalent percent grade for various types of road and surface conditions.

- Equipment Selection

Equipment selection for cost estimation purposes is a two-step process:

First, select the type of equipment (for example, bulldozer or scraper) based on the guidance in this Handbook, information in equipment productivity and performance guides, the reclamation and operation plans in the permit application, and experience.

Second, select the model and size of equipment based on information contained in the materials handling plan (*Worksheet 3*), the reclamation and operation plans in the permit application, and equipment productivity and performance guides.

For both the first and second steps, complete *Worksheets 5 through 12* for several types and models of readily available equipment to determine the most cost-effective equipment type and model or combination of equipment types and models for each earthmoving activity.

When completing *Worksheet 13* (earthmoving costs), use an industry publication containing recent cost data for construction equipment to determine hourly equipment ownership costs. PRIMEDIA Information, Inc.'s *Cost Reference Guide for Construction Equipment (CRG)* is one example of such a publication.

Use regional Davis-Bacon wage rates from the Department of Labor to determine hourly labor costs (see the examples in Appendix B). In some cases other local costs may be appropriate and can be substituted for the *CRG* and Davis-Bacon rates. The Department of the Interior's Acquisition Regulations (DIAR) require compliance with the Indian Self-Determination and Education Assistance Act (25 U.S.C. 452) when reclamation contracts are let on Indian lands. Thus, local tribal wage rates must be considered when calculating the potential cost of reclamation. This information can be obtained from regional Bureau of Indian Affairs offices or on Navajo lands, through the Office of Navajo Labor Relations. Justify and document any substitutions from the regional Davis-Bacon wage rates.

Do not automatically select the equipment listed in the operation and reclamation plans submitted by the applicant. In the event of forfeiture, equipment such as draglines, large shovels and equipment unique to the permittee most likely will not be available to potential contractors. Before

calculating earthmoving costs for operations that plan to use this type of equipment, check with several regional earthmoving contractors to determine what equipment may be available. To maintain compliance with Federal procurement requirements, do not base calculations on equipment available to only one contractor.

Appendix C provides additional guidance on equipment selection, operation, and productivity.

Equipment needs for typical earthmoving activities are described below:

Spoil Ridge Reduction: Operations that use area mining methods normally rely upon bulldozers to move the tops of the spoil ridges into the valleys between the ridges.

Final Pit /Highwall Elimination: Bulldozers are usually the equipment of choice to fill the last pit with material obtained from adjacent spoil ridges or the area above the highwall (when approved in the permit). When the mining method requires the use of stockpiled overburden, scrapers or a combination of trucks and loaders are typically used to move stockpiled materials to the pit. When trucks and loaders are used, bulldozers spread the material in the pit area. If the pit is to be reconfigured for retention as a permanent impoundment, bulldozers are normally used to reduce the highwall and spoil slopes to acceptable grades.

In some cases the reclamation plan may not address this reclamation need. For example, the reclamation and operation plans for a mountaintop removal operation would assume complete removal of the top of the mountain, meaning that no highwall elimination would be necessary. However, if a highwall exists at the time of bond forfeiture, we would need to use methods such as ripping or blasting to eliminate the highwall.

Final Grading: Scrapers, bulldozers, and motor graders are commonly used to recontour backfilled areas, excess spoil disposal structures, and other disturbed areas to facilitate proper drainage and the approved postmining land use and to prepare disturbed areas for topsoil redistribution. In some cases, especially for sites formerly used as roads or support facilities, ripping with bulldozers may be required to reduce compaction in the root zone and provide a slightly rough surface to promote topsoil adhesion.

Topsoil Redistribution: Topsoil redistribution involves the use of scrapers, front-end loaders, trucks, bulldozers, and/or graders. The choice of equipment depends on grade, the haul distance between stockpiles and placement areas, and the volume of material to be moved. Prime farmland requires more attention to equipment selection and material handling to ensure proper soil horizon placement, soil depth, and compaction.

Removal of Diversions and Siltation Structures: Bulldozers are generally adequate to grade out diversions and excavated siltation structures. In some cases, a hydraulic backhoe excavator or small dragline is required to dredge accumulated sediment.

Covering Exposed Coal Mine Waste or Other Acid- or Toxic- Forming Materials: When the reclamation and operation plans require the application of cover material prior to revegetation, the same equipment considerations as those discussed under "Topsoil Redistribution" apply to the transport and distribution of this material. Examples include the covering of coarse coal mine refuse, slurry impoundments and coal stockpile pads.

C. Equipment Productivity and Costs (*Worksheets 5 through 13*)

As discussed above, development of the materials handling plan requires a determination of equipment productivity and earthmoving costs. Use *Worksheets 5 through 12* to calculate the production of individual pieces of equipment and the hours required for the job. Use *Worksheet 13* to calculate earthmoving costs.

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.

Reclamation jobs do not operate at 100% efficiency. Complex factors such as operator skill, repairs and adjustments, and personnel and job layout delays are either addressed individually as part of the "Operator Factor" (see *Worksheet 5*) or combined in an "Efficiency Factor" (see *Worksheets 5 through 12*). When site-specific data are not available use the information below as guidance.

EFFICIENCY FACTOR

<u>Conditions</u>	<u>Crawler Equipment</u>	<u>Rubber-tired Equipment</u>
Excellent	0.92 55 min/hr	0.83 50 min/hr
Average	0.83 50 min/hr	0.75 45 min/hr
Unfavorable or Night	0.75 45 min/hr	0.67 40 min/hr

To calculate the number of hours that the equipment is needed, apply productivity rates to the amount of material that must be moved. To determine the hourly cost of equipment during the reclamation operation, adjust the components of the hourly costs in the *CRG* for the number of shifts, fuel costs, etc., as applicable.

III. Revegetation (Worksheet 14)

Use *Worksheet 14* to calculate costs associated with revegetation efforts. The initial revegetation process generally consists of seedbed preparation, including such tasks as soil sampling, application of soil amendments (fertilizer, lime, etc.), seeding, planting, and mulching. *Worksheet 14* refers to this as "Initial Seeding." Calculate this cost for all disturbed areas within the worst-case scenario. The reclamation plan will specify the soil condition and species mix. It will also clarify whether irrigation and the planting of trees and shrubs are necessary. Potential sources of cost information for these requirements include the Cooperative Extension Service; agricultural supply firms; agricultural publications; revegetation contractors; landscaping services; Federal, State and Tribal forestry agencies; and State, Federal and Tribal abandoned mine land and bond forfeiture reclamation contracts and programs.

Weather and site conditions may result in complete or partial failure of an initial revegetation effort. The cost estimate must also include reseeding and replanting expenses associated with vegetative failures, including all disturbed lands within the permit area not yet released. This reseeding and replanting cost is based on site conditions and historic vegetative failure rates for the operation being evaluated, or similar operations on similar sites. This reseeding and planting cost

estimate must include an allowance for any soil sampling, regrading and earthmoving costs necessary to evaluate and repair the site as part of the reseeding/replanting effort.

Worksheet 14 covers the following aspects of revegetation:

- Initial seeding and planting of the worst-case scenario area.
- Vegetative failure of the worst-case scenario area (i.e., reseeding and replanting needed).
- Vegetative failure for any other unreleased disturbed areas within the permit area (i.e., reseeding and replanting needed).

IV. Other Direct Reclamation Costs (Worksheet 15)

Depending upon site conditions and applicable requirements of the reclamation and operation plans, other necessary reclamation activities may include:

- Pumping and treating impounded waters.
- Replacing wetlands.
- Sealing underground mine entries and openings.
- Plugging auger holes.
- Sealing monitoring wells and other drilled holes.
- Constructing rock drains.
- Disposing of toxic, hazardous, and other solid (noncoal) waste in accordance with state and Federal laws and local ordinances.
- Maintaining roads during reclamation including grading, surfacing, ditches and culverts, and snow removal.
- Maintaining ponds.

- Water sampling and monitoring to the extent required to comply with any necessary Federal, State, or local permits.
- Evaluating and rehabilitating structures to be retained as part of the postmining land use (ponds, roads, diversions, etc.).

In addition, two other potential cost considerations may arise after permit issuance:

- Under 30 CFR 817.121(c)(5), unless the permittee corrects the damage within a specified time or has sufficient insurance coverage, the regulatory authority must require the permittee to obtain additional performance bond to cover the cost of (1) correcting subsidence-related material damage to surface lands and protected structures, and (2) replacing certain water supplies adversely impacted by underground mining operations.
- If an unanticipated polluttional discharge requiring long-term treatment develops, the regulatory authority must adjust the bond or require the permittee to post equivalent financial assurance to cover all foreseeable abatement and future treatment costs.

Since there is no established method of estimating costs for most of the activities listed under this heading, use best professional judgement to calculate bond amounts on a case-by-case basis. In some instances, the construction cost reference manuals listed in Chapter 1 may prove useful. Use *Worksheet 15* to explain the basis for all cost estimates for these activities.

Use Means guides or obtain estimates from several local contractors to determine the amount of bond required to guarantee repair of subsidence-related damage to surface lands and protected structures. Similarly, use estimates from local drilling and plumbing contractors to estimate the bond amount required to guarantee replacement of damaged water supplies and delivery systems.

Appendix D provides general guidance on the calculation of bond amounts needed to cover abatement and long-term treatment costs associated with unanticipated polluttional discharges.

STEP 3: ADJUST DIRECT COSTS FOR INFLATION

This step addresses anticipated inflationary increases in reclamation costs during the permit term and after permit expiration but before final bond release.

I. During a Permit Term

There are two approaches for addressing inflation during a permit term. One approach uses an inflation factor to increase the initial bond amount to reflect inflation for the full permit term. The other approach does not include inflation as an element of the initial bond calculation. Instead, it requires recalculation and adjustment of bond amounts on a fixed schedule (at a minimum during the mid-term permit review process and at permit renewal) to cover any reclamation cost increases due to inflation.

Adjustment Using 5-Year Permit Term

To calculate the inflation factor for a 5-year permit term under the first approach, use the formula below and an index such as the *Construction Cost Indexes* (CCI) in the Engineering News Record (ENR) (<http://www.enr.com>). We recognize that other cost indexes may be appropriate to use in lieu of the one suggested, but for purposes of this example, we chose the CCI. For further information on the construction cost index, see "Cost History, Keeping Track of a Moving Target," *Engineering News Record*, March 30, 1992, pages 42-47.

Divide the CCI for the current month and year by the CCI for the same month five years earlier, assuming the term of the permit is five years. For example, if the current month and year is February 1999, divide the CCI for February 1999 by the CCI for February 1994.

Example: CCI (February 1999): 5992 CCI (February 1994): 5371

Inflation factor: $5992 \div 5371 = 1.11562$ [Enter on *Worksheet 16*.]

Total inflation (5 years): 11.562%

Multiply the Total Direct Costs from *Line 5* of *Worksheet 16* by the inflation factor to compute the Inflated Total Direct Costs.

Adjustment Using a Schedule

Under the bond adjustment schedule approach, we must periodically either recalculate all reclamation cost estimates or use an appropriate inflation factor to adjust the previous reclamation cost estimates to account for inflation since the time of the previous bond calculation. When using this approach, *Lines 5 and 6 of Worksheet 16* will be the same. Add a footnote describing the bond adjustment schedule.

Adjustments for inflation also may be considered when permit revisions change the costs of reclamation.

II. After Permit Expiration

We also must consider inflation when calculating the amount of bond to be retained after Phase I or II bond release. For these calculations, use a base period equal to the minimum revegetation responsibility period under 30 CFR 816/817.116(c), since there is no permit required for reclamation and hence no midterm permit reviews or permit renewals. See *Worksheets 17 and 18*. As an alternative, you may establish a periodic bond adjustment schedule during the revegetation responsibility period. The bond would then be adjusted for inflation in accordance with the schedule.

STEP 4: ESTIMATE INDIRECT RECLAMATION COSTS

Use *Worksheet 16*, standard reference materials, and the procedures set forth below to calculate indirect costs, which include contract preparation costs and other administrative expenses that the regulatory authority would not incur in the absence of forfeiture. Explain any deviations from the standard reference materials in an attachment to the worksheet. Compute indirect costs as a percentage of the inflated direct costs as shown on *Worksheet 16*, Lines 7 through 11.

I. 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.

Consider whether a separate mobilization/demobilization will be necessary to remove sedimentation ponds and associated diversions at a later date and calculate costs accordingly.

Mobilization and demobilization costs normally range up to 10 percent of the total direct costs. Unusual time constraints, a need for special equipment, the presence of non-standard features or conditions that hinder equipment mobility, or a remote location may require actual cost estimates that could result in the use of a higher percentage. Enter this cost estimate on Line 7 of *Worksheet 16*. Explain the basis for the estimate on the worksheet or in an attachment.

II. Contingency Allowances

The bond amount must include a contingency allowance to cover unanticipated costs resulting from unexpected natural events and uncertainties associated with the assumptions that form the basis for the operation and reclamation plans and reclamation cost estimates. This category does not include any activity for which the reclamation and operation plans provide sufficient information to enable calculation as a direct cost. The contingency allowance covers only truly unexpected and unforeseeable events.

Calculate the contingency allowance as a percentage of the total direct costs on Line 8 of *Worksheet 16*. Based on the *1998 Means Heavy Construction Cost Data*, this allowance should range between 3 and 5 percent of the total direct costs.

III. Engineering Redesign Costs

For various reasons, the reclamation and operation plans in the permit application may not reflect site conditions at the time of bond forfeiture. In addition, they may not be sufficiently detailed to serve as contract plans and specifications. Therefore, in the event of bond forfeiture, the regulatory authority may have to supplement or modify these plans. Necessary activities may include:

- Preparing maps and plans to show the extent of required reclamation.
- Surveying topsoil and overburden stockpiles to determine the amount of material available.
- Analyzing topsoil and overburden stockpiles to determine whether special handling is necessary.

- Evaluating structures to assess the difficulty of demolition and removal.
- Evaluating impoundments and roads to determine any special reclamation needs (such as the presence of toxic materials), the feasibility of leaving those structures in place, and the rehabilitation needed to ensure stability and facilitate the postmining land use.
- Assessing the condition of areas reclaimed by the permittee to determine whether additional work is needed to complete the reclamation plan.
- Preparing contract documents.

Calculate the engineering redesign costs as a percentage of the total direct costs on Line 9 of *Worksheet 16*. Based on the *1998 Means Building Cost Data*, the allowance for these engineering fees (landscape and site development) should range between 2.5% and 6% of the total direct costs. If you deviate from the recommended percentages, include an explanation on *Worksheet 16*.

IV. Profit and Overhead

Because we contract with a third party to perform the actual reclamation work, the bond amount must include an allowance for the contractor's profit and overhead. As noted in Chapter 1 under "Data Sources," all data used to estimate direct reclamation costs in Step 2 of Chapter 2 include only bare costs, which exclude any allowance for contractor's profit and overhead expenses.

A reasonable profit margin may range from a minimum of 10% of the total direct costs for very large jobs to as high as 30% of the total direct costs for very small jobs.

Because reclamation operations differ greatly in size and complexity, overhead costs will vary greatly depending on the assets, operating techniques, business structure, and financial condition of individual contractors. For example, to complete the same job, some contractors may not need field offices, shops, or site-specific office personnel, while other contractors will have complete on-site support facilities.

However, all construction and reclamation contractors have overhead costs in addition to the direct costs of equipment, labor and materials that we have already calculated in Step 2 of this chapter. These additional costs normally

include field support staff and services, labor benefits (at 35% of labor and supervisory costs, these costs may range between 1% and 7% of the total direct costs), costs of temporary facilities or company offices, office equipment and utilities, security, storage, insurance, taxes, and bonds (including the cost of obtaining and posting a contract performance bond), permits, and company vehicles.

A reasonable allowance for generally accepted overhead costs is a minimum of 5% of the total direct costs.

To simplify the process, Graph 1, Profit and Overhead, combines profit and overhead into a single cost allowance, calculated as a percentage of the total inflated direct costs on *Worksheet 16*. This graph is based on the *1998 Means Building Construction Cost Data*.

V. Project Management Fee

This fee covers the cost of hiring a project management firm to inspect and supervise the work performed by the reclamation contractor. Additional management tasks may include dam inspection. Use Graph 2, Project Management Fee, to calculate this fee. This graph reflects the construction cost data in *1998 Means Building Construction Cost Data*.

STEP 5: CALCULATE THE TOTAL PERFORMANCE BOND AMOUNT

Add all entries for direct and indirect reclamation costs on *Worksheet 16* to determine the amount of bond required.

At the bottom of *Worksheet 16*, there is a space to record a construction cost index. In the absence of major changes to the reclamation and operation plans, this index allows the inflation factor portion of the bond estimate to be updated periodically without redoing the direct cost calculations needed to establish the initial bond amount. The cost index referenced is the "Construction Cost Index" published monthly in the *Engineering News Record* (McGraw-Hill, NY).

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CHAPTER 3

SPECIAL CONSIDERATIONS FOR CALCULATION OF INCREMENTAL, CUMULATIVE, AND PHASE BONDS

The bond calculation methodology in Chapter 2 and the assumptions in Chapter 1 presume that the permit applicant will post bond for the entire permit area prior to permit issuance. However, the same methodology and assumptions apply when the applicant elects to post bond on an incremental or cumulative basis, or use phase bonds.

INCREMENTAL BONDS

If the applicant selects the incremental method of bonding, use Chapter 2 to estimate reclamation costs and determine the amount of bond required for each increment, rather than for the entire permit area. Because the bond posted for each increment applies only to that increment, treat each increment as a separate mining and reclamation unit with its own maximum reclamation cost liability. When using incremental bonding, the permittee may not transfer bond coverage from reclaimed acreage in one increment to land in another increment.

Under 30 CFR 800.11(b)(3), the permit applicant must identify both the initial and successive bonding increments, together with the amount of bond proposed to be provided for each increment. However, the regulations do not apply this requirement to the regulatory authority. Instead, they provide only that, at the time of permit application approval, the regulatory authority must calculate the amount of bond required for the initial increment. The regulatory authority must then calculate the required bond amount for each successive increment at the time that the permittee proposes to disturb that increment. At its discretion, the regulatory authority may calculate the amount of bond required for each successive increment at the same time that it calculates the amount of bond required for the initial increment.

CUMULATIVE BONDS

If the applicant selects the cumulative method of bonding, use Chapter 2 to estimate reclamation costs and determine the amount of bond required for the initial stage of operations. As with incremental bonding, treat this initial stage of operations as a separate mining and reclamation unit with its own maximum

reclamation cost liability. However, legal liability under the bond posted for the initial stage applies to the entire permit area, as do bonds posted for all successive operational stages. Hence, unlike incremental bonding, the reclamation cost estimates and bond calculations for each successive operational stage must include all previously bonded operational stages.

For example, a permittee may choose to post bond annually for the term of the permit based on anticipated disturbance during each year of the permit term. Under this scenario, the permittee initially would post a bond in an amount sufficient to cover the maximum reclamation cost liability that would be encountered during the first year of the permit term under the approved reclamation plan. The permittee would then supplement that bond with additional bonds during each of the following years until the amount of bond on file is sufficient to cover the maximum reclamation cost liability for the entire permit area. The annual supplement plus the amount of bond posted for previous years must always be sufficient to cover the maximum reclamation cost liability associated with both the upcoming year and all previous years. The bond amount may not be reduced unless the reduction occurs through the bond release process.

As with incremental bonding, under 30 CFR 800.11(b)(3), a permit applicant proposing to use the cumulative method of bonding must identify both the initial and all successive portions of the permit area for which bond will be posted, together with the amount of bond proposed to be provided for each portion. However, the regulations do not apply this requirement to the regulatory authority. Instead, they provide only that, at the time of permit application approval, the regulatory authority must calculate the amount of bond required for the initial portion. The regulatory authority must then calculate the required bond amount for each successive portion at the time that the permittee proposes to disturb that portion. At its discretion, the regulatory authority may calculate the amount of bond required for each successive portion at the same time that it calculates the amount of bond required for the initial portion.

In summary, under the cumulative method of bonding, when the permittee proposes to advance beyond the initial operational stages, we must calculate maximum reclamation cost liabilities for both the entire permit area and the portion of the permit area proposed for disturbance. Once the operation reaches the point of maximum reclamation cost liability for the permit area as a whole, we may not need to require any additional bond for subsequent disturbance, but neither may we return any of the bond already posted unless we and the permittee adhere to the bond release criteria and procedures of 30 CFR 800.40.

PHASE BONDS

Under 30 CFR 800.13(a)(2), the regulatory authority has the discretion to either accept or reject use of the phase bonding method.

When using phase bonding, the permit applicant posts separate bonds for each phase of reclamation as defined in 30 CFR 800.40. The applicant has the choice of posting these bonds for the entire permit area or using either the incremental or cumulative method of bonding. In all cases, the applicant or permittee must post bonds sufficient to cover all reclamation phases for the land to be disturbed prior to initial disturbance. For example, the permittee may not delay submission of a Phase II bond until Phase I reclamation is completed.

Under 30 CFR 800.13(a)(2), each phase bond must specify in detail the scope of work that it guarantees. This requirement is important because, with a few exceptions, 30 CFR 800.40 does not clearly specify the permitting requirements and performance standards that each phase covers. Nor does it establish bright-line liability distinctions. For example, topsoil replacement may be either a Phase I or Phase II activity. Therefore, before we can calculate reclamation cost estimates using the worksheets in Appendix A, we need to know which of those reclamation activities will be covered by which phase bond.

At a minimum, each Phase I bond must cover backfilling, regrading, and structure demolition. Each Phase II bond must cover topsoil replacement (when not included in Phase I), removal of temporary erosion and sedimentation control structures, and establishment of revegetation. Phase III has no clearly defined liabilities apart from demonstration of revegetation success and reestablishment of vegetation in the event of failure. Therefore, we recommend that Phases II and III be covered by a single bond.

Use the methods in Chapter 2 to estimate the maximum reclamation cost liability and calculate the amount of bond required for each phase of reclamation. The area to which this calculation applies depends upon whether the permittee posts bond for the entire permit area or selects an incremental or cumulative approach.

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CHAPTER 4

BOND RELEASE

REGULATORY BACKGROUND

Under 30 CFR 800.40(b)(1) and section 519(b) of the Act, the regulatory authority must, upon receipt of a bond release application, inspect and evaluate the reclamation work, including an assessment of the degree of difficulty in completing any remaining reclamation. This evaluation also must determine whether pollution of surface and ground water is occurring, the probability of future occurrence, and the estimated cost of abating this pollution.

Under 30 CFR 800.40(c)(1) and section 519(c)(1) of the Act, the regulatory authority may release up to 60 percent of the bond upon completion of Phase I reclamation, which includes backfilling, regrading, and drainage control. As a practical matter, Phase I bond release includes structure demolition and removal, as necessary. Phase I bond release is discretionary on the part of the regulatory authority, depending upon the results of the evaluation required under 30 CFR 800.40(b)(1) and an evaluation of remaining reclamation costs.

Under 30 CFR 800.40(c)(2) and section 519(c)(2) of the Act, for lands other than prime farmland, the regulatory authority may release an additional amount of bond after establishment of revegetation, provided the lands are not contributing suspended solids to streamflow or runoff outside the permit area in excess of State and Federal water quality requirements. Normally, this phase (Phase II) also includes topsoil replacement and removal of temporary erosion and sedimentation control structures. At this phase, the regulatory authority must retain sufficient bond to cover the cost of having a third party reestablish revegetation during the revegetation responsibility period in accordance with the approved reclamation plan.

For prime farmland, Phase II bond release is contingent upon proof of soil productivity as determined by crop yields equivalent to yields from non-mined lands. For all practical purposes, this results in a combination of Phase II and III bond release.

Finally, under 30 CFR 800.40(c)(3) and section 519(c)(3) of the Act, the regulatory authority may release the remainder of the bond once the revegetation responsibility period expires and the permittee meets all reclamation

requirements of the permit and approved regulatory program. This action is sometimes referred to as Phase III bond release.

DISTINCTION BETWEEN BOND ADJUSTMENT AND BOND RELEASE

As discussed in Chapter 1, reduction of bond amounts using the bond adjustment provisions of 30 CFR 800.15 is allowable only if the reclamation cost estimates that form the basis for the existing bond amount are no longer valid for reasons other than the performance of reclamation work. To obtain a reduction in bond amount on the basis of reclamation work performed, the permittee must apply for bond release in accordance with 30 CFR 800.40.

CALCULATION OF ALLOWABLE BOND RELEASE AMOUNTS

Upon receipt of a bond release application, we must calculate the cost of completing all remaining reclamation requirements for the entire permit area (or, if the permittee used the incremental bonding method, for the entire increment). Use *Worksheet 17* to calculate remaining reclamation costs when considering Phase I bond release. Use *Worksheet 18* to calculate these costs when considering Phase II bond release. Complete *Worksheets 1 through 15* as necessary to support these computations.

In all cases, we must retain sufficient funds to complete all remaining reclamation obligations, including those identified as a result of the inspection and evaluation conducted under 30 CFR 800.40(b)(1). In addition, at Phase I we may not release more than 60 percent of the total amount of bond posted for the area to which the release application applies. See 30 CFR 800.40(c)(1). Therefore, even when the permittee uses phase bonding, we may not release more than 60 percent of the total amount of bond posted for all phases for the applicable area. Although liability under the Phase I bond is limited to Phase I reclamation activities, we must retain at least 40 percent of the total bond posted for the area until Phase II reclamation has been completed and a Phase II liability release approved.

FINANCIAL CONSIDERATIONS FOR POLLUTIONAL DISCHARGES

If pollutional discharges or other conditions causing material damage to the hydrologic balance outside the permit area exist at the time of application for bond release, we must retain a sufficient amount of bond at each phase of release to cover long-term treatment and remediation costs. See Appendix D for guidance on calculating bond amounts for long-term treatment of pollutional

discharges. This bond may not be released until treatment is no longer necessary to prevent material damage to the hydrologic balance.

In lieu of retention of existing bond, the permittee may, subject to regulatory authority approval, establish a separate financial guarantee under 30 CFR Part 800 to cover all foreseeable discharge treatment and material damage remediation costs. This is a type of bond to cover one aspect of the operation. As stated above, the bond release for this aspect would not occur until treatment is no longer necessary to prevent material damage to the hydrologic balance.

Depending on individual circumstances, acceptable financial assurance instruments may include surety bonds, trust funds, pollution liability insurance, general liability insurance, environmental liability insurance, and site liability environmental exposure insurance. At the time of this publication, examples of firms that offer the insurance products mentioned above include:

American International Group, Inc. (AIG)	http://www.aig.com
Beacon Hill Associates, Inc.	http://www.b-h-a.com
National Environmental Coverage Corp.	http://www.necc.com
Smith-Manus Agency, Inc.	http://www.smith-manus.com

We do not endorse any of these insurers or products and we do not guarantee the accuracy of the information posted at Internet sites.

Finally, the permittee has the option of addressing this obligation outside the bonding process and the requirements of 30 CFR Part 800 by entering into an enforceable contract with another party to assume treatment or remediation responsibilities. See the preamble to 30 CFR 700.11(d)(1)(ii) at 53 FR 44362, col. 1, November 2, 1988.

RELEASE OF BOND POSTED TO GUARANTEE WATER SUPPLY REPLACEMENT OR CORRECTION OF SUBSIDENCE DAMAGE

Under 30 CFR 817.121(c)(5), in certain situations, the regulatory authority must require the permittee to obtain additional performance bond to cover the costs of repairing, replacing, or providing compensation for material damage to protected structures when the damage is a result of subsidence caused by underground mining operations. The same requirement applies to subsidence-related material damage to surface lands and to certain drinking, domestic, or residential water supplies adversely impacted by underground mining operations.

The preamble to this rule states that the release procedures of 30 CFR 800.40 apply to bond posted under this rule. However, land, structures, and water supplies covered by this bond generally lie outside the permit area. Hence, there is no revegetation responsibility period and no need for a phased bond release. Provided all other release criteria and procedural requirements of 30 CFR 800.40 are met, we may release the entire bond amount posted under 30 CFR 817.121(c)(5) once the water supply is replaced, the damage to surface lands or protected structures is repaired, or the owner is compensated for damage to protected structures.

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"Construction Cost Index," *Engineering News Record*, McGraw-Hill, New York, published monthly.

"Cost History, Keeping Track of a Moving Target," *Engineering News Record*, McGraw-Hill, New York, March 30, 1992, pp. 42-47.

Cost Reference Guide (CRG) for Construction Equipment, PRIMEDIA Information, Inc., Machinery Information Division, San Jose, CA, 1998.

Note: Various sections of this reference are updated quarterly; overall the book is updated annually.

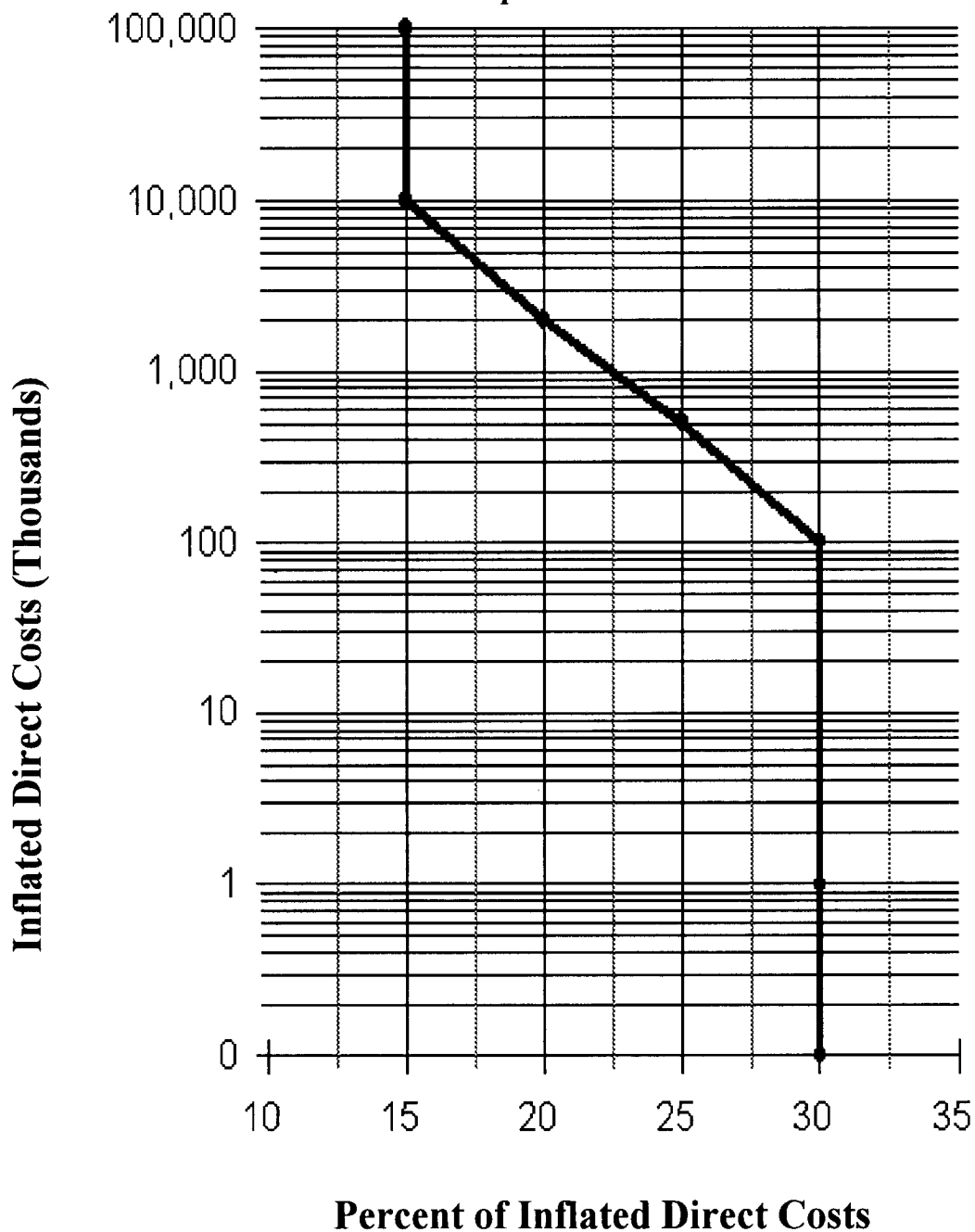
Means Building Construction Cost Data, R.S. Means Company, Inc., Kingston, MA, 1998.

Means Heavy Construction Cost Data, R.S. Means Company, Inc., Kingston, MA, 1998.

Means Site Work and Landscape Cost Data, R.S. Means Company, Inc., Kingston, MA, 1998.

Profit and Overhead

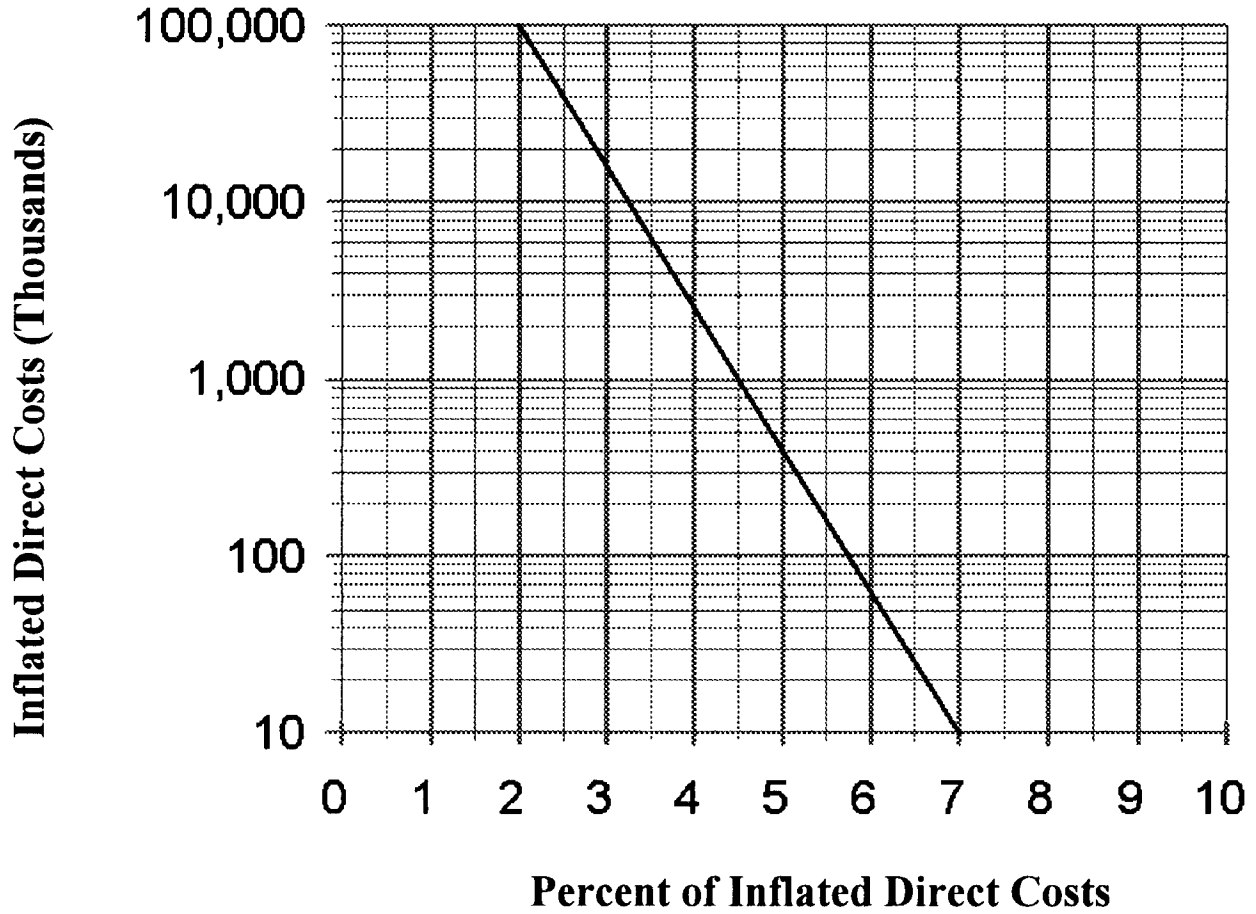
Graph 1



Graphical representation of
Reference lines 010 000 062 0300 through 0450
From Means 1998 *Building Construction Cost Data*,
Copyright R.S. Means Co., Inc., Kingston, MA,
781-585-7880, all rights reserved.

Project Management Fee

Graph 2



Graphical extension of
Reference lines 010 000 016 0050 and 0300
From Means 1998 *Building Construction Cost Data*,
Copyright R.S. Means Co., Inc., Kingston, MA,
781-585-7880, all rights reserved.

**A. Bond Calculation
Worksheets**

APPENDIX A
BOND CALCULATION WORKSHEETS

04/05/00

BOND AMOUNT COMPUTATION

Applicant: _____

Permit Number: _____ **Permitted Acreage:** _____

Bonding Scheme (permit area, incremental, cumulative): _____

If Incremental:

Increment Number: _____

Increment Acreage: _____

If Cumulative:

Acres previously authorized for disturbance: _____

New acres proposed for disturbance: _____

Type of Operation: _____

Location: _____

Prepared by: _____

Date: _____

Total Bond Amount: \$ _____

Project: _____
Date: _____
Prepared by: _____

WORKSHEET 1
DESCRIPTION OF THE WORST-CASE RECLAMATION SCENARIO

Assumptions:

Data Source(s):

Project: _____
 Date: _____
 Prepared by: _____

**WORKSHEET 2
 STRUCTURE DEMOLITION AND DISPOSAL COSTS**

Structures to be demolished:

Item	Construction Material	Volume (cubic feet)	Unit Cost Basis (\$)	Demolition Cost (\$)
Subtotal				

Other items to be demolished (paved roads, conveyors, utility poles, rail spurs, etc.):

Subtotal = \$ _____

Debris Handling and Disposal Costs:

Subtotal = \$ _____

TOTAL DEMOLITION AND DISPOSAL = \$ _____

Data Source(s):

Project: _____
Date: _____
Prepared by: _____

**WORKSHEET 4B
EARTHWORK QUANTITY**

Data Source(s):

Project: _____
 Date: _____
 Prepared by: _____

**WORKSHEET 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:

$$\text{Operating Adjustment Factor} = \frac{\text{operator factor}}{\text{operator factor}} \times \frac{\text{material factor}}{\text{material factor}} \times \frac{\text{efficiency factor}}{\text{efficiency factor}} \times \frac{\text{grade factor}}{\text{grade factor}}$$

$$\times \frac{\text{weight correction factor}}{\text{weight correction factor}} \times \frac{\text{production method/blade factor}}{\text{production method/blade factor}} \times \frac{\text{visibility factor}}{\text{visibility factor}} \times \frac{\text{elevation factor}}{\text{elevation factor}} = \text{_____}$$

$$\text{Net Hourly Production} = \frac{\text{normal hourly production}}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{\text{operating adjustment factor}}{\text{operating adjustment factor}} = \text{_____ LCY/hr}$$

$$\text{Hours Required} = \frac{\text{volume to be moved}}{\text{volume to be moved}} \text{ LCY} \div \frac{\text{net hourly production}}{\text{net hourly production}} \text{ LCY/hr} = \text{_____ hr}$$

Data Source(s):

Project: _____
 Date: _____
 Prepared by: _____

**WORKSHEET 6
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE--GRADING**

Earthmoving Activity:

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

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

Productivity Calculations:

$$\text{Operating Adjustment Factor} = \frac{\text{_____}}{\text{operator factor}} \times \frac{\text{_____}}{\text{material factor}} \times \frac{\text{_____}}{\text{efficiency factor}} \times \frac{\text{_____}}{\text{grade factor}}$$

$$\times \frac{\text{_____}}{\text{weight correction factor}} \times \frac{\text{_____}}{\text{production method/blade factor}} \times \frac{\text{_____}}{\text{visibility factor}} \times \frac{\text{_____}}{\text{elevation factor}} = \text{_____}$$

$$\begin{aligned} \text{Hourly Production} &= \frac{\text{_____}}{\text{average speed}} \text{ mi/hr} \times \frac{\text{_____}}{\text{effective blade width}} \text{ ft} \times 5,280 \text{ ft/mi} \times 1 \text{ ac}/43,560 \text{ ft}^2 \\ &= \text{_____} \text{ ac/hr} \end{aligned}$$

$$\text{Net Hourly Production} = \frac{\text{_____}}{\text{hourly production}} \text{ ac/hr} \times \frac{\text{_____}}{\text{operating adjustment factor}} = \text{_____} \text{ ac/hr}$$

$$\text{Hours Required} = \frac{\text{_____}}{\text{area to be graded}} \text{ ac} \div \frac{\text{_____}}{\text{net hourly production}} \text{ ac/hr} = \text{_____} \text{ hr}$$

Data Source(s):

Project: _____
Date: _____
Prepared by: _____

WORKSHEET 7
PRODUCTIVITY AND HOURS REQUIRED FOR RIPPER-EQUIPPED DOZER USE

Ripping Activity:

Characterization of Dozer and Ripper Use:

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

Productivity Calculation:

$$\text{Cycle Time} = \left(\frac{\text{_____ ft}}{\text{cut length}} \div \frac{88 \text{ ft/min}}{\text{[speed]}} \right) + \frac{\text{_____ min}}{\text{fixed turn time}^*} = \text{_____ min/pass}$$

$$\text{Passes/Hour} = 60 \text{ min/hr} \div \frac{\text{_____ min/pass}}{\text{cycle time}} \times \frac{\text{_____}}{\text{efficiency factor}} = \text{_____ passes/hr}$$

$$\begin{aligned} \text{Volume Cut/Pass} &= \left(\frac{\text{_____ ft}}{\text{tool penetration}} \times \frac{\text{_____ ft}}{\text{cut spacing}} \times \frac{\text{_____ ft}}{\text{cut length}} \right) \div 27 \text{ ft}^3/\text{yd}^3 \\ &= \text{_____ BCY/pass} \end{aligned}$$

$$\text{Hourly Production} = \text{_____ BCY/pass} \times \text{_____ passes/hr} = \text{_____ BCY/hr}$$

$$\text{Hours Required} = \frac{\text{_____ BCY}}{\text{bank volume to be ripped}^{**}} \div \frac{\text{_____ BCY/hr}}{\text{hourly production}} = \text{_____ hr}$$

* Fixed turn time depends upon dozer used. 0.25 min/turn is normal.

** Remember to use the swell factor to convert from bank cubic yards to loose cubic yards when applying these data to *Worksheet 5*. Calculate separate dozer hauling of ripped material for each lift on that worksheet.

Data Source(s):

Project: _____
Date: _____
Prepared by: _____

**WORKSHEET 8
PRODUCTIVITY AND HOURS REQUIRED FOR LOADER USE**

Earthmoving Activity:

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

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

Productivity Calculations:

$$\text{Cycle time} = \frac{\text{haul time (loaded)}}{\text{min}} + \frac{\text{return time (empty)}}{\text{min}} + \frac{\text{basic cycle time}}{\text{min}} = \text{min}$$

$$\text{Net Bucket Capacity} = \frac{\text{heaped bucket capacity}}{\text{LCY}} \times \frac{\text{bucket fill factor}^*}{\text{LCY}} = \text{LCY}$$

$$\text{Hourly Production} = \frac{\text{net bucket capacity}}{\text{LCY}} \div \frac{\text{cycle time}}{\text{min}} \times \frac{\text{efficiency factor}}{\text{LCY/hr}} \times 60 \text{ min/hr} = \text{LCY/hr}$$

$$\text{Hours Required} = \frac{\text{volume to be moved}}{\text{LCY}} \div \frac{\text{hourly production}}{\text{LCY/hr}} = \text{hr}$$

* See loader section of equipment manual.

Data Source(s):

Project: _____
 Date: _____
 Prepared by: _____

**WORKSHEET 9
 PRODUCTIVITY AND HOURS REQUIRED FOR TRUCK USE**

Earthmoving Activity:

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

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

Productivity Calculations:

$$\text{No. Loader Passes/Truck} = \frac{\text{LCY}}{\text{truck capacity} * \text{LCY}} \div \frac{\text{LCY}}{\text{loader bucket net capacity}} = \frac{\text{passes}}{\text{(round down to nearest whole number)}}$$

$$\text{Net Truck Capacity} = \frac{\text{LCY}}{\text{loader bucket net capacity}} \times \frac{\text{LCY}}{\text{no. loader passes/truck}} = \text{LCY}$$

$$\text{Loading Time/Truck} = \frac{\text{min}}{\text{loader cycle time (from Worksheet 8 or 10)}} \times \frac{\text{min}}{\text{no. loader passes/truck}} = \text{min}$$

$$\text{Truck Cycle Time} = \frac{\text{min}}{\text{haul time}} + \frac{\text{min}}{\text{return time}} + \frac{\text{min}}{\text{loading time}} + \frac{\text{min}}{\text{dump and maneuver time}} = \text{min}$$

$$\text{No. Trucks Required} = \frac{\text{min}}{\text{truck cycle time}} \div \frac{\text{min}}{\text{total loading time}} = \text{trucks}$$

$$\text{Production Rate} = \frac{\text{LCY}}{\text{net truck capacity}} \times \frac{\text{LCY}}{\text{no. trucks}} \div \frac{\text{min}}{\text{truck cycle time}} = \text{LCY/min}$$

$$\text{Hourly Production} = \frac{\text{LCY/min}}{\text{production rate}} \times 60 \text{ min/hr} \times \frac{\text{LCY/hr}}{\text{efficiency factor}} = \text{LCY/hr}$$

$$\text{Hours Required} = \frac{\text{LCY}}{\text{volume to be moved}} \div \frac{\text{LCY/hr}}{\text{hourly production}} = \text{hr}$$

* Use the average of the struck and heaped capacities.

Data Source(s):

Project: _____
Date: _____
Prepared by: _____

WORKSHEET 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:

$$\text{Net Bucket Capacity} = \frac{\text{_____ LCY}}{\text{heaped bucket capacity}} \times \frac{\text{_____}}{\text{bucket fill factor}^*} = \text{_____ LCY}$$

$$\text{Hourly Production} = \frac{\text{_____ LCY}}{\text{net bucket capacity}} \times 60 \text{ min/hr} \div \frac{\text{_____ min}}{\text{cycle time}^{**}} \times \frac{\text{_____}}{\text{efficiency factor}} = \text{_____ LCY/hr}$$

$$\text{Hours Required} = \frac{\text{_____ LCY}}{\text{volume to be handled}} \div \frac{\text{_____ LCY/hr}}{\text{net hourly production}} = \text{_____ hr}$$

* See loader section of the equipment manual.

** See excavator section of equipment manual.

Data Source(s):

Project: _____
Date: _____
Prepared by: _____

WORKSHEET 11A
PRODUCTIVITY OF PUSH-PULL OR SELF-LOADING SCRAPER USE

Earthmoving Activity:

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

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

Productivity Calculations:

$$\text{Cycle Time} = \frac{\text{load time}}{\text{(push-pull is per pair)}} \text{ min} + \frac{\text{loaded trip time}}{\text{min}} + \frac{\text{maneuver and spread time}}{\text{min}} + \frac{\text{return trip time}}{\text{min}} = \frac{\text{min}}{\text{(push-pull is per pair)}}$$

$$\text{Hourly Production} = \frac{\text{LCY}}{\text{capacity}^*} \times 60 \text{ min/hr} \div \frac{\text{min}}{\text{cycle time}} \times \frac{\text{efficiency factor}}{\text{factor}} = \frac{\text{LCY/hr}}{\text{(push-pull is per pair)}}$$

$$\text{Hours Required} = \frac{\text{LCY}}{\text{volume to be handled}} \div \frac{\text{LCY/hr}}{\text{net hourly production}} = \text{hr}$$

* The average of the struck and heaped capacities; use total for two scrapers for push-pull.

Data Source(s):

Project: _____
 Date: _____
 Prepared by: _____

**WORKSHEET 11B
 PRODUCTIVITY OF DOZER PUSH-LOADED SCRAPER USE**

Earthmoving Activity:

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

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

List Pusher Tractor(s) Used:

Describe Push Tractor Loading Method (see figure on next page):

Scraper Productivity Calculations:

$$\text{Cycle Time} = \frac{\text{_____}}{\text{load time}} \text{ min} + \frac{\text{_____}}{\text{loaded trip time}} \text{ min} + \frac{\text{_____}}{\text{maneuver and spread time}} \text{ min} + \frac{\text{_____}}{\text{return trip time}} \text{ min} = \text{_____} \text{ min}$$

$$\text{Hourly Production} = \frac{\text{_____}}{\text{capacity}^*} \text{ LCY} \times 60 \text{ min/hr} \div \frac{\text{_____}}{\text{cycle time}} \text{ min} \times \frac{\text{_____}}{\text{efficiency factor}} = \text{_____} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{\text{_____}}{\text{volume to be handled}} \text{ LCY} \div \frac{\text{_____}}{\text{hourly production}} \text{ LCY/hr} = \text{_____} \text{ hr}$$

* Use the average of the struck and heaped capacities.

Push Tractor Productivity Calculations:

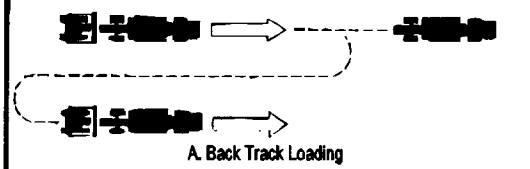
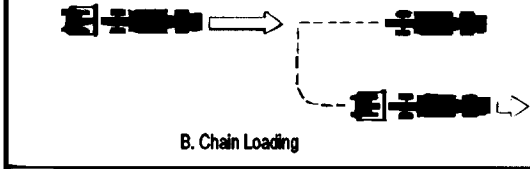
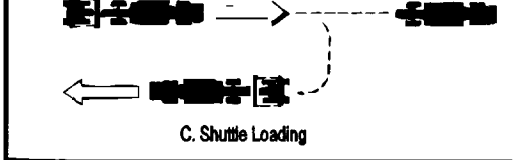
$$\text{Pusher Cycle Time} = \frac{\text{_____}}{\text{scraper load time}} \text{ min} \times \frac{\text{_____}}{\text{pusher factor}} = \text{_____} \text{ min}$$

$$\text{Scrapers/Pusher} = \frac{\text{_____}}{\text{scraper cycle time}} \text{ min} \div \frac{\text{_____}}{\text{pusher cycle time}} \text{ min} = \text{_____} \text{ scrapers}$$

$$\text{Pusher Hours Required} = \frac{\text{_____}}{\text{scraper hours}} \text{ hr} \div \frac{\text{_____}}{\text{scrapers per pusher}} = \frac{\text{_____}}{\text{(round up)}} \text{ hr}$$

Data Source(s):

WORKSHEET 11B (continued)
PRODUCTIVITY OF DOZER PUSH-LOADED SCRAPER USE

PUSHER FACTORS	Single Push	Tandem Push
 <p>A. Back Track Loading</p>	1.5	2.0
 <p>B. Chain Loading</p>	1.3	1.5
 <p>C. Shuttle Loading</p>	1.3	1.5

Modified from Terex, 1981.

The following disclaimer pertains to the above illustration from Terex, "Production and Cost Estimating of Material Movement and Earthmoving Equipment."

This manual is a fundamental text on estimating the production and cost of moving materials. It is intended for people associated with the construction industry who prepare job estimates or who evaluate the performance of earthmoving equipment and related costs.

The manual can be used as a supplementary text in those schools and colleges offering formal training in earthmoving techniques. A metric version of this manual is also available.

It will also serve as a reference for those professional consulting engineers who prepare complete job analyses, of which the earthmoving fundamentals covered in this text are only one element.

Estimating the production and costs of earthmoving equipment is not an exact science. While this manual outlines the basic factors or parameters on which estimates can be made, the user must make judgements, and must apply his own experience and know-how to temper the estimate.

This manual, prepared by TEREX, deals with rubber-tired and track-laying equipment, and does not attempt to deal with other forms of earthmoving or production. While the formulas and other guides in this manual are entirely satisfactory for most earthmoving jobs, the reader should note that more sophisticated haulage analyses can be quickly accomplished through the use of a computer.

While efforts have been made to utilize percentages, formulas, and other notations in this manual which reflect actual on-the-job conditions, none of the statements in this manual, or the illustrative figures given for machine life, or the costs for owning and operating earthmoving equipment, or the production of such earthmoving equipment should be construed as any form of guarantee that these machines will have any such specific service life, or production capabilities, or that costs related to their ownership and operation will be as indicated.

Data Source(s): TEREX AMERICAS, Tulsa, OK 74107, (918) 445-5802.

Project: _____
Date: _____
Prepared by: _____

WORKSHEET 12
PRODUCTIVITY AND HOURS REQUIRED FOR MOTORGRADER USE

Earthmoving Activity:

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

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

Productivity Calculations:

Grading

$$\begin{aligned} \text{Hourly Production} &= \frac{\text{_____ mi/hr}}{\text{average speed}} \times \frac{\text{_____ ft}}{\text{effective blade width}} \times 5,280 \text{ ft/mi} \times 1 \text{ ac}/43,560 \text{ ft}^2 \\ &\times \frac{\text{_____}}{\text{efficiency factor}} = \text{_____ ac/hr} \end{aligned}$$

$$\text{Hours Required} = \frac{\text{_____ ac}}{\text{area to be graded}} \div \frac{\text{_____ ac/hr}}{\text{hourly production}} = \text{_____ hr}$$

Scarification

$$\begin{aligned} \text{Hourly Production} &= \frac{\text{_____ mi/hr}}{\text{average speed}} \times \frac{\text{_____ ft}}{\text{scarifier width}} \times 5,280 \text{ ft/mi} \times 1 \text{ ac}/43,560 \text{ ft}^2 \\ &\times \frac{\text{_____}}{\text{efficiency factor}} = \text{_____ ac/hr} \end{aligned}$$

$$\text{Hours Required} = \frac{\text{_____ ac}}{\text{area to be scarified}} \div \frac{\text{_____ ac/hr}}{\text{hourly production}} = \text{_____ hr}$$

Total Hours Required

$$\text{Total Hours} = \frac{\text{_____}}{\text{grading hours required}} + \frac{\text{_____}}{\text{scarification hours required}} = \text{_____ hr}$$

Data Source(s):

Project: _____
 Date: _____
 Prepared by: _____

**WORKSHEET 13
 SUMMARY CALCULATION OF EARTHMOVING COSTS**

Equipment *	Ownership & Operation Cost (\$/hr)	Labor Cost (\$/hr)	Total Hours Required **	Total Cost *** (\$)
Grand Total				
<p>* Include all necessary attachments and accessories for each item of equipment. Also, add support equipment such as water wagons and graders to match total project time as appropriate.</p> <p>** Account for multiple units in truck and/or scraper teams.</p> <p>*** To compute Total Cost: Add Ownership & Operation Cost and Labor Cost columns then multiply by Total Hours Required column.</p>				

Data Source(s):

Project: _____
 Date: _____
 Prepared by: _____

**WORKSHEET 14
 REVEGETATION COSTS**

Name and Description of Area To Be Revegetated:

Description of Revegetation Activities:

Cost Calculation for Individual Revegetation Activities:

Initial Seeding

$$\frac{\text{area to be seeded}}{\text{ac}} \times \left(\$ \frac{\text{seedbed preparation}}{\text{ac}} + \$ \frac{\text{seeding, fertilizing \& mulching}}{\text{ac}} \right) = \$ \underline{\hspace{2cm}}$$

Planting Trees and Shrubs

$$\frac{\text{area to be planted}}{\text{ac}} \times \left(\$ \frac{\text{planting}}{\text{ac}} + \$ \frac{\text{herbicide treatment}}{\text{ac}} \right) = \$ \underline{\hspace{2cm}}$$

Reseeding

$$\frac{\text{area to be seeded \& unreleased \& undisturbed areas}}{\text{ac}} \times \frac{\text{failure rate}^*}{\text{failure rate}^*} \times \left(\$ \frac{\text{seedbed preparation}}{\text{ac}} + \$ \frac{\text{seeding, fertilizing \& mulching}}{\text{ac}} \right) = \$ \underline{\hspace{2cm}}$$

Replanting Trees and Shrubs

$$\frac{\text{area to be planted \& unreleased \& undisturbed areas}}{\text{ac}} \times \frac{\text{failure rate}^*}{\text{failure rate}^*} \times \left(\$ \frac{\text{planting}}{\text{ac}} + \$ \frac{\text{herbicide treatment}}{\text{ac}} \right) = \$ \underline{\hspace{2cm}}$$

Other Necessary Revegetation Activities

(Examples of other activities that may be necessary include soil sampling, irrigation, and rill and gully repair. Describe each activity and provide a cost estimate with documentation. Use additional worksheets if necessary.)

Other Costs = \$ _____

TOTAL REVEGETATION COST = \$ _____

* Identify failure rate and basis. If anticipated failure rates vary within the area proposed for disturbance, use a separate worksheet for the area subject to each failure rate.

Data Source(s):

Project: _____
Date: _____
Prepared by: _____

**WORKSHEET 15
OTHER RECLAMATION ACTIVITY COSTS**

(Subsidence damage repair costs, water supply replacement costs, funds required to support long-term treatment of unanticipated acid or ferruginous mine drainage, etc.)

Description of Reclamation, Repair or Pollution Abatement Activity:

Assumptions:

Cost Estimate Calculations:

TOTAL COSTS = \$ _____

Other Documentation or Notes:

(Include additional sheets, maps, calculations, etc., as necessary to document estimate.)

Data Source(s):

Project: _____
 Date: _____
 Prepared by: _____

**WORKSHEET 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. | Total Direct Costs
(sum of Lines 1 through 4) | \$ _____ |
| 6. | <u>Inflated Total Direct Costs</u>
(Line 5 x inflation factor *) | \$ _____ |
| 7. | Mobilization/Demobilization (____% of Line 6)
(1% to 10% of Line 6) | \$ _____ |
| 8. | Contingencies (____% of Line 6)
(3% to 5% of Line 6) | \$ _____ |
| 9. | Engineering Redesign Fee (____% of Line 6)
(2.5% to 6% of Line 6) | \$ _____ |
| 10. | Contractor Profit/ Overhead (____% of Line 6)
(see Graph 1) | \$ _____ |
| 11. | Project Management Fee (____% of Line 6)
(see Graph 2) | \$ _____ |
| 12. | <u>Total Indirect Costs</u>
(sum of Lines 7 through 11) | \$ _____ |
| 13. | GRAND TOTAL BOND AMOUNT
(sum of Lines 6 and 12) | \$ _____ |

* Inflation factor = $\frac{\text{ENR Construction Cost Index (CCI) for current mo/yr}}{\text{ENR CCI for mo/yr 5 years prior to current mo/yr}}$ = _____ = _____

Identify current month/year used in formula above: _____
 Identify prior month/year used in formula above: _____

ENR = *Engineering News Record*, McGraw-Hill Construction Information Group, New York, NY; <http://www.enr.com>.

Formula assumes permit term or time until next bond adequacy evaluation is 5 years. Adjust timeframe as necessary.

Project: _____
 Date: _____
 Prepared by: _____

**WORKSHEET 17
 SUMMARY SHEET FOR DETERMINING
 AMOUNT OF BOND TO RETAIN AT PHASE I RELEASE**

- | | | |
|-----|--|----------|
| 1. | Remaining Structure Removal Costs | \$ _____ |
| 2. | Remaining Earthmoving Costs | \$ _____ |
| 3. | Remaining Revegetation Costs | \$ _____ |
| 4. | Remaining Other Reclamation Activities Costs | \$ _____ |
| 5. | Remaining Total Direct Costs
(sum of Lines 1 through 4) | \$ _____ |
| 6. | <u>Remaining Inflated Total Direct Costs</u>
(Line 5 x inflation factor *) | \$ _____ |
| 7. | Mobilization/ Demobilization (____% of Line 6)
(1% to 10% of Line 6) | \$ _____ |
| 8. | Contingencies (____% of Line 6)
(3% to 5% of Line 6) | \$ _____ |
| 9. | Engineering Redesign Fee (____% of Line 6)
(2.5% to 6% of Line 6) | \$ _____ |
| 10. | Contractor Profit and Overhead (____% of Line 6)
(see Graph 1) | \$ _____ |
| 11. | Project Management Fee (____% of Line 6)
(see Graph 2) | \$ _____ |
| 12. | <u>Total Indirect Costs</u>
(sum of Lines 7 through 11) | \$ _____ |
| 13. | AMOUNT OF BOND TO RETAIN AFTER PHASE I RELEASE
(sum of Lines 6 and 12) | \$ _____ |

* Inflation factor = $\frac{\text{ENR Construction Cost Index (CCI) for current mo/yr}}{\text{ENR CCI for mo/yr } x \text{ years prior to current mo/yr}}$ = _____ = _____

Identify current month/year used in formula above: _____
 Identify prior month/year used in formula above: _____

ENR = *Engineering News Record*, McGraw-Hill Construction Information Group, New York, NY; <http://www.enr.com>.

x years = minimum revegetation responsibility period for site.

Project: _____
Date: _____
Prepared by: _____

WORKSHEET 17 (continued)
SUMMARY SHEET FOR DETERMINING
AMOUNT OF BOND TO RETAIN AT PHASE I RELEASE

14. Amount of Bond Required at Time of Application for Release (original bond amount as modified by any adjustments) \$ _____
15. Minimum Amount of Bond That Must Be Retained by Law ** (0.4 x Line 14) \$ _____
16. AMOUNT OF BOND TO RETAIN AFTER PHASE I RELEASE (enter Line 13 or Line 15, whichever is greater) \$ _____
17. PHASE I RELEASE AMOUNT (subtract Line 16 from Line 14) \$ _____

** Section 519(c)(1) of SMCRA limits Phase I bond release to no more than 60 percent of the amount of bond posted for the site. Therefore, we must retain at least 40 percent of the amount of bond required under 30 CFR 800.14, as modified by any adjustments under 30 CFR 800.15.

Project: _____
 Date: _____
 Prepared by: _____

**WORKSHEET 18
 SUMMARY SHEET FOR DETERMINING
 AMOUNT OF BOND TO RETAIN AT PHASE II RELEASE**

- | | | |
|-----|--|----------|
| 1. | Remaining Revegetation Costs | \$ _____ |
| 2. | Remaining Other Reclamation Activities Costs | \$ _____ |
| 3. | Remaining Total Direct Costs
(sum of Lines 1 and 2) | \$ _____ |
| 4. | <u>Remaining Inflated Total Direct Costs</u>
(Line 3 x inflation factor *) | \$ _____ |
| 5. | Mobilization/ Demobilization (____ of Line 4)
(1% to 10% of Line 4) | \$ _____ |
| 6. | Contingencies (____ % of Line 4)
(3% to 5% of Line 4) | \$ _____ |
| 7. | Engineering Redesign Fee (____ % of Line 4)
(2.5% to 6% of Line 4) | \$ _____ |
| 8. | Contractor Profit and Overhead (____ % of Line 4)
(see Graph 1) | \$ _____ |
| 9. | Project Management Fee (____ % of Line 4)
(see Graph 2) | \$ _____ |
| 10. | <u>Total Indirect Costs</u>
(sum of Lines 5 through 9) | \$ _____ |
| 11. | AMOUNT OF BOND TO RETAIN AFTER PHASE II RELEASE
(sum of Lines 4 and 10) | \$ _____ |
| 12. | Amount of Bond Remaining After Phase I Release | \$ _____ |
| 13. | PHASE II RELEASE AMOUNT
(subtract Line 11 from Line 12) | \$ _____ |

* Inflation factor = $\frac{\text{ENR Construction Cost Index (CCI) for current mo/yr}}{\text{ENR CCI for mo/yr } x \text{ years prior to current mo/yr}}$ = _____ = _____

Identify current month/year used in formula above: _____
 Identify prior month/year used in formula above: _____

ENR = *Engineering News Record*, McGraw-Hill Construction Information Group, New York, NY; <http://www.enr.com>.

x years = minimum revegetation responsibility period for site.

Note: Attach a separate sheet describing and documenting costs associated with any special or unusual conditions (such as prime farmland restoration) not already discussed on one of the other worksheets.

APPENDIX B

EXAMPLES

The examples do not represent active operations today. They are presented to show the application of the Handbook methodology to various types of operations.

BOND AMOUNT COMPUTATION

Applicant: Underground Example

Permit Number: Example No. 1 **Permitted Acreage:** 20

Bonding Scheme (permit area, incremental, cumulative): permit area

If Incremental:

Increment Number: _____

Increment Acreage: _____

If Cumulative:

Acres previously authorized for disturbance: _____

New acres proposed for disturbance: _____

Type of Operation: Underground

Location: USA

Prepared by: R. R. Bond

Date: December 2, 1999

Total Bond Amount: \$ 904,000

WORKSHEET 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 a 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 worksheets.)

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.

WORKSHEET 1 (continued)
DESCRIPTION OF THE WORST-CASE RECLAMATION SCENARIO

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 on-site drainage. The various riprap sections can remain as channel protection. The on-site 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 pre-mining 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

WORKSHEET 1 (continued)
DESCRIPTION OF THE WORST-CASE RECLAMATION SCENARIO

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 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 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 on the reclamation. The mine plan states that 20 percent swell can be expected on 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 mine 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 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 on the revegetation due to this 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 is 25 feet in diameter. A masonry wall will be erected to seal the entries prior to the covering with backfill materials.

NOTE: Worksheets 8, 9, 10, 11A, 17 and 18 are not applicable to this example.

Data Source(s): Mine plan.

**WORKSHEET 2A
 STRUCTURE DEMOLITION AND DISPOSAL COSTS**

Structures to be demolished:

Item	Construction Material	Volume (cubic feet)	Unit Cost Basis (\$)	Demolition Cost (\$)
1. Admin. Building	Masonry Block	64,800	0.18*	11,664
2. Shop Building	Metal	129,600	0.18*	23,328
3. Explosives Magazine	Metal	1,600	0.18*	288
4. Water System Bldg.	Metal	4,800	0.18*	864
5. Primary Processing	Metal	84,000	0.18*	15,120
Subtotal				\$51,264

Other items to be demolished (paved roads, conveyors, utility poles, rail spurs, etc.):

Item	Construction Material	Volume	Unit Cost Basis (\$)	Demolition Cost (\$)
1. Conveyor system**	Metal	1,300 LF	38/LF	49,400
2. Power line***, 2.3 mi	4-wire	48,576 LF	3/LF	145,728
3. Power poles***, 50	Wood	50	250/ea	12,500
4. Shop slab	Reinforced Concrete	13,200 SF	7.60/SF*	100,320
Subtotal				\$307,948

Debris Handling and Disposal Costs:

* Demolition includes disposal with up to 20 mi. haul.

** **Cost breakdown:**

Removal of belt cover and pan =	\$19.30/LF
Belt removal =	\$10.93/LF
Idler pully removal =	\$ 3.19/LF
Tower and concrete removal and site grading =	\$ 4.58/LF
Total conveyor removal costs =	\$38.00/LF

*** Personal communication, 1985, David Radesevich, Electrical Engineer, Western Power Administrator, P.O. Box 3403, Golden, CO 80401.

Continued on next page

Project: Underground Example
 Date: 12/02/99
 Prepared by: R.R. Bond

**WORKSHEET 2B
 STRUCTURE DEMOLITION AND DISPOSAL COSTS**

Structures to be demolished:

Item	Construction Material	Volume (cubic feet)	Unit Cost Basis (\$/cf)	Demolition Cost (\$)
1. Secondary Processing	Metal	42,000	0.18*	7,560
2. Stacker	Concrete	33,575	0.26*	8,730
3. Load Out	Metal	24,000	0.18*	4,320
Subtotal				\$20,610

Other items to be demolished (paved roads, conveyors, utility poles, rail spurs, etc.):

Item	Construction Material	Volume	Unit Cost Basis (\$)	Demolition Cost (\$)
1. 18" Culvert**	Metal	132 LF	2.50/LF*	330
2. 48" Culvert**	Metal	307 LF	2.50/LF*	768
3. 84" Culvert**	Metal	3,029 LF	2.50/LF*	7,573
Subtotal				\$8,671

Debris Handling and Disposal Costs:

* Demolition includes disposal with up to a 20 miles haul.

** Cost breakdown from Mine Plan.

TOTAL DEMOLITION AND DISPOSAL (from Worksheets 2A and 2B) = \$ 388,493

Data Source(s): Means *Site Work and Landscape Cost Data, 1998*; Mine plan.

Project: Underground Example
 Date: 12/02/99
 Prepared by: R.R. Bond

**WORKSHEET 3
 MATERIAL HANDLING PLAN SUMMARY**

Earthmoving Activity	Volume (LCY)	Origin	Destination	Haul Distance (ft)	Grade * (%)	Equipment To Be Used
1. Site Grading**	41,110	Benches	General Contouring	500 average	10	627F scraper with D8N push tractor
2. Site Grading**	20,555	Benches	General Contouring	500 average	8	D9R-SU dozer
3. Sedimentation Pond**	25,814	Embankment	Pond Area	500 average	10	627F scraper with D8N push tractor
4. Sedimentation Pond**	12,907	Embankment	Pond Area	500 average	8	D9R-SU dozer
5. Topsoil	16,133	Stockpile	Disturbed Area	1,100	10	627F scraper with D8N push tractor
6. Ripping	64,533		Disturbed Area			D7R-SU dozer with 3-shank ripper
7. Haul Road Maintenance			Disturbed Area			14G grader
* Record grade resistance here. (% grade) ** Scraper and Dozer (D9R-SU) work concurrently.						

Project: Underground Example
 Date: 12/02/99
 Prepared by: R.R. Bond

**WORKSHEET 4A
 EARTHWORK QUANTITY**

CROSS-SECTION/ STATION	DISTANCE BETWEEN STATIONS (ft)	END AREA (ft ²)	VOLUME (yd ³)*	ADJUST- MENT FACTOR (%)**	ADJUSTED VOLUME (LCY)
0		0			
	400		7,777	20	9,332
B/D		1,050			
	450		20,833	20	25,000
C/D		1,450			
	400		18,148	20	21,778
D/D		1,000			
	250		4,630	20	5,556
Boundary		0			
TOTALS			51,388		61,666

* Volume is BCY or LCY as appropriate.

** Select adjustment factor based on the state of material being moved.

Data Source(s): Mine plan.

Project: Underground Example
Date: 12/02/99
Prepared by: R.R. Bond

**WORKSHEET 4B
EARTHWORK QUANTITY**

Site Grading

Bench Cut Earthwork Volume = 61,666 LCY (see Worksheet 4A)

Estimate 1/3rd moved by scraper and the remainder by dozer:

Scraper Volume = $2/3 \times 61,666 \text{ LCY} = 41,111 \text{ LCY}$

Dozer Volume = $61,666 \text{ LCY} - 41,111 \text{ LCY} = 20,555 \text{ LCY}$

Sediment Pond Regrade

**Embankment Cut Volume = 32,267 BCY (from mine plan)
Swell = 20%**

Earthwork Volume = $32,267 \text{ BCY} \times 1.2 = 38,720 \text{ LCY}$

Estimate 1/3rd moved by scraper and the remainder by dozer:

Scraper Volume = $2/3 \times 38,720 \text{ LCY} = 25,814 \text{ LCY}$

Dozer Volume = $38,720 \text{ LCY} - 25,814 \text{ LCY} = 12,906 \text{ LCY}$

Topsoil Replacement

Cover depth for 20 ac. disturbed area = 0.5 ft. (from mine plan)

Earthwork Volume = $(20 \text{ ac.} \times 43560 \text{ SF /ac.} \times 0.5 \text{ ft}) / 27 \text{ CY/CF} = 16,133 \text{ LCY}$

Ripping

Ripping depth for 20 ac. disturbed area = 2.0 ft. (from mine plan)

Volume = $(20 \text{ ac.} \times 43560 \text{ SF /ac.} \times 2 \text{ ft}) / 27 \text{ CY/CF} = 64,533 \text{ BCY}$

Data Source(s): Mine plan.

Project: Underground Example
 Date: 12/02/99
 Prepared by: R.R. Bond

**WORKSHEET 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 + 12,906 CY (from *Worksheet 4B*)

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

D9R dozer with "Semi-U or SU" Blade = 250 cy/hr.

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

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

Productivity Calculations:

$$\begin{aligned} \text{Operating Adjustment Factor} &= \frac{.75}{\text{operator factor}} \times \frac{.95}{\text{material factor}} \times \frac{.83}{\text{efficiency factor}} \times \frac{.85}{\text{grade factor}} \\ &\times \frac{2,550}{\text{weight correction factor}} \times \frac{1.0}{\text{production method/blade factor}} \times \frac{1.0}{\text{visibility factor}} \times \frac{1.0}{\text{elevation factor}} = .51 \end{aligned}$$

$$\text{Net Hourly Production} = \frac{250}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{.51}{\text{operating adjustment factor}} = \underline{128} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{33,462}{\text{volume to be moved}} \text{ LCY} \div \frac{128}{\text{net hourly production}} \text{ LCY/hr} = \underline{261} \text{ hr}$$

Data Source(s): Caterpillar Performance Handbook, Edition 28.

**WORKSHEET 5B
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE**

Earthmoving Activity:
 Push tractor to assist loading scrapers.

Characterization of Dozer Used (type, size, etc.):
 D8N dozer with a "SU" Blade.

Description of Dozer Use (origin, destination, grade, haul distance, material, etc.):
 Scrapers loaded with Back-track Loading Method; equipment working @ 8000 feet, msl.

Productivity Calculations:

$$\text{Operating Adjustment Factor} = \frac{\text{operator factor}}{\text{operator factor}} \times \frac{\text{material factor}}{\text{material factor}} \times \frac{\text{efficiency factor}}{\text{efficiency factor}} \times \frac{\text{grade factor}}{\text{grade factor}}$$

$$\times \frac{\text{weight correction factor}}{\text{weight correction factor}} \times \frac{\text{production method/blade factor}}{\text{production method/blade factor}} \times \frac{\text{visibility factor}}{\text{visibility factor}} \times \frac{\text{elevation factor}}{\text{elevation factor}} = \underline{\hspace{2cm}}$$

$$\text{Net Hourly Production} = \frac{\text{normal hourly production}}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{\text{operating adjustment factor}}{\text{operating adjustment factor}} = \underline{\hspace{2cm}} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{\text{volume to be moved}}{\text{volume to be moved}} \text{ LCY} \div \frac{\text{net hourly production}}{\text{net hourly production}} \text{ LCY/hr} = \underline{116^*} \text{ hr}$$

*See Worksheets 11B-1 and 11B-2. (86 hr + 30 hr = 116 hr)

Data Source(s): Caterpillar Performance Handbook, Edition 28.

WORKSHEET 6
PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE--GRADING

Earthmoving Activity:
Final (contour) grading.

Characterization of Dozer Used (type, size, etc.):
D6R w/ an 11-foot wide "Straight or S"-blade.

Description of Dozer Use (% grade, effective blade width, operating speed, etc.):
Operates along contour at 0% average grade, 8,000-foot elevation.

Productivity Calculations:

$$\begin{aligned} \text{Operating Adjustment Factor} &= \frac{.75}{\text{operator factor}} \times \frac{1.0}{\text{material factor}} \times \frac{.83}{\text{efficiency factor}} \times \frac{1.0}{\text{grade factor}} \\ &\times \frac{1.0}{\text{weight correction factor}} \times \frac{1.0}{\text{production method/blade factor}} \times \frac{1.0}{\text{visibility factor}} \times \frac{1.0}{\text{elevation factor}} = .62 \end{aligned}$$

$$\begin{aligned} \text{Hourly Production} &= \frac{3.0}{\text{average speed}} \text{ mi/hr} \times \frac{11}{\text{effective blade width}} \text{ ft} \times 5,280 \text{ ft/mi} \times 1 \text{ ac/43,560 ft}^2 \\ &= \underline{4.0} \text{ ac/hr} \end{aligned}$$

$$\text{Net Hourly Production} = \frac{4.0}{\text{hourly production}} \text{ ac/hr} \times \frac{.62}{\text{operating adjustment factor}} = \underline{2.5} \text{ ac/hr}$$

$$\text{Hours Required} = \frac{20}{\text{area to be graded}} \text{ ac} \div \frac{2.5}{\text{net hourly production}} \text{ ac/hr} = \underline{8.0} \text{ hr}$$

Data Source(s): Caterpillar Performance Handbook, Edition 28.

**WORKSHEET 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.

Characterization of Dozer and Ripper Use:
 D7R w/ SU blade and 3-shank adjustable parallelogram ripper; ripper has a 39 inch (3.25-foot) pocket spacing

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

Ripping depth = 2 feet
 Ripping effective width = 3.25 feet X 3 = 9.75 feet

Productivity Calculation:

$$\text{Cycle Time} = \left(\frac{1,000 \text{ ft}}{\text{cut length}} \div \frac{88 \text{ ft/min}}{\text{[speed]}} \right) + \frac{0.3 \text{ min}}{\text{fixed turn time}^*} = 11.66 \text{ min/pass}$$

$$\text{Passes/Hour} = 60 \text{ min/hr} \div \frac{11.66 \text{ min/pass}}{\text{cycle time}} \times \frac{.83}{\text{efficiency factor}} = 4.27 \text{ passes/hr}$$

$$\begin{aligned} \text{Volume Cut/Pass} &= \left(\frac{2.0 \text{ ft}}{\text{tool penetration}} \times \frac{9.75 \text{ ft}}{\text{cut spacing}} \times \frac{1,000 \text{ ft}}{\text{cut length}} \right) \div 27 \text{ ft}^3/\text{yd}^3 \\ &= 722.2 \text{ BCY/pass} \end{aligned}$$

$$\text{Hourly Production} = 722.2 \text{ BCY/pass} \times 4.27 \text{ passes/hr} = 3,083.8 \text{ BCY/hr}^{**}$$

$$\text{Hours Required} = \frac{64,533 \text{ BCY}}{\text{bank volume to be ripped}} \div \frac{3,083.8 \text{ BCY/hr}}{\text{hourly production}} = 20.9 \text{ hr}$$

Use 231 hours***

- * Fixed turn time depends upon dozer used. 0.25 min/turn is normal.
- ** Remember to use the swell factor to convert from bank cubic yards to loose cubic yards when applying these data to *Worksheet 5*. Calculate separate dozer hauling of ripped material for each lift on that worksheet.
- *** The D7R bulldozer is to be for miscellaneous tasks during the life of the project (see *Worksheet 13*).

Data Source(s): Caterpillar Performance Handbook, Edition 28.

**WORKSHEET 11B-1
 PRODUCTIVITY OF DOZER PUSH-LOADED SCRAPER USE**

Earthmoving Activity: 1) Backfill and grade benches and 2) backfill sediment pond.
NOTE: Since these two tasks have similar grade and haul distances, the yardage can be added together and hours required determined. Total yardage = 41,111 cy + 25,814 cy (from Worksheet 4B). Site located 8,000 feet above sea level.

Characterization of Scraper Used (type, capacity, etc.):
 Cat 627F Non-push pull 14 cy (struck) + 20 cy (heaped) = 17 cy avg. capacity
Description of Scraper Route:
 500' haul @ 10% effective grade; 500' return @ (-)4% effective grade

List Pusher Tractor(s) Used: D8N dozer will assist the scraper in loading.

Describe Push Tractor Loading Method (see figure): Back-track loading method with 1 push tractor.

Scraper Productivity Calculations:

$$\text{Cycle Time} = \frac{.5}{\text{load time}} \text{ min} + \frac{.55}{\text{loaded trip time}} \text{ min} + \frac{.6}{\text{maneuver and spread time}} \text{ min} + \frac{.3}{\text{return trip time}} \text{ min} = \underline{1.95} \text{ min}$$

$$\text{Hourly Production} = \frac{17}{\text{capacity}^*} \text{ LCY} \times 60 \text{ min/hr} \div \frac{1.95}{\text{cycle time}} \text{ min} \times \frac{.75}{\text{efficiency factor}} = \underline{392} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{66,925}{\text{volume to be handled}} \text{ LCY} \div \frac{392}{\text{hourly production}} \text{ LCY/hr} = \underline{171} \text{ hr}$$

* Use the average of the struck and heaped capacities.

Push Tractor Productivity Calculations:

$$\text{Pusher Cycle Time} = \frac{.5}{\text{scraper load time}} \text{ min} \times \frac{1.5}{\text{pusher factor}} = \underline{.75} \text{ min}$$

$$\text{Scrapers/Pusher} = \frac{1.95}{\text{scraper cycle time}} \text{ min} \div \frac{.75}{\text{pusher cycle time}} \text{ min} = \underline{2.6} \text{ scrapers (Use 2)}$$

$$\text{Pusher Hours Required} = \frac{171}{\text{scraper hours}} \text{ hr} \div \frac{2}{\text{scrapers per pusher}} = \underline{86} \text{ hr (round up)}$$

Data Source(s): Caterpillar Performance Handbook, Edition 28.

**WORKSHEET 11B-2
 PRODUCTIVITY OF DOZER PUSH-LOADED SCRAPER USE**

Earthmoving Activity: Haul and spread topsoil; 16,133 cy; (from *Worksheet 4B*).

Characterization of Scraper Used (type, capacity, etc.): Cat 627F Non-push pull 14 cy (struck) + 20 cy (heaped) = 17 cy avg. capacity.

Description of Scraper Route: 1,100' haul @ 10% effective grade; 1,100' return @ (-)4% effective grade, site is located 8,000 feet above sea level.

List Pusher Tractor(s) Used: D8N dozer will assist the scraper in loading.

Describe Push Tractor Loading Method (see figure below): Back-track loading method with 1 push tractor.

Scraper Productivity Calculations:

$$\text{Cycle Time} = \frac{.5}{\text{load time}} \text{ min} + \frac{1.25}{\text{loaded trip time}} \text{ min} + \frac{.6}{\text{maneuver and spread time}} \text{ min} + \frac{.5}{\text{return trip time}} \text{ min} = \underline{2.85} \text{ min}$$

$$\text{Hourly Production} = \frac{17}{\text{capacity}^*} \text{ LCY} \times 60 \text{ min/hr} \div \frac{2.85}{\text{cycle time}} \text{ min} \times \frac{.75}{\text{efficiency factor}} = \underline{268} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{16,133}{\text{volume to be handled}} \text{ LCY} \div \frac{268}{\text{hourly production}} \text{ LCY/hr} = \underline{60} \text{ hr}$$

* Use the average of the struck and heaped capacities.

Push Tractor Productivity Calculations:

$$\text{Pusher Cycle Time} = \frac{.5}{\text{scraper load time}} \text{ min} \times \frac{1.5}{\text{pusher factor}} = \underline{.75} \text{ min}$$

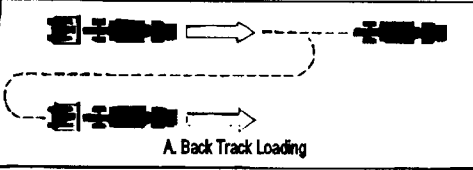
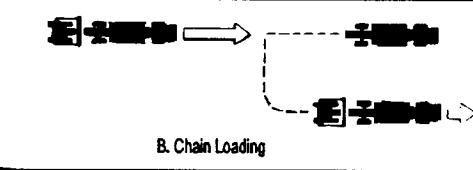
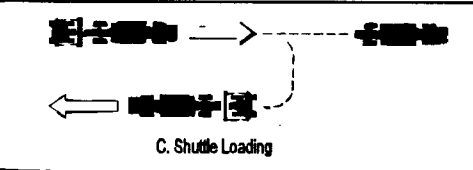
$$\text{Scrapers/Pusher} = \frac{2.85}{\text{scraper cycle time}} \text{ min} \div \frac{.75}{\text{pusher cycle time}} \text{ min} = \underline{3.8} \text{ scrapers}$$

$$\text{Pusher Hours Required} = \frac{60}{\text{scraper hours}} \text{ hr} \div \frac{2^{**}}{\text{scrapers per pusher}} = \underline{30} \text{ hr} \text{ (round up)}$$

** Two scrapers used to match *Worksheet 11B-1*.

Data Source(s): Caterpillar Performance Handbook, Edition 28.

WORKSHEET 11B (continued)
PRODUCTIVITY OF DOZER PUSH-LOADED SCRAPER USE

PUSHER FACTORS	Single Push	Tandem Push
 <p>A. Back Track Loading</p>	1.5	2.0
 <p>B. Chain Loading</p>	1.3	1.5
 <p>C. Shuttle Loading</p>	1.3	1.5

Modified from Terex, 1981

Data Source(s): Illustration from "Production and Cost Estimating of Material Movement and Earthmoving Equipment," TEREX AMERICAS, Tulsa, OK 74107, (918) 445-5802. See disclaimer in Appendix A, *Worksheet 11B*.

**WORKSHEET 12
 PRODUCTIVITY AND HOURS REQUIRED FOR MOTORGRADER USE**

Earthmoving Activity: The motorgrader will be used for maintaining haul roads, to assist in final grading prior to topsoil placement, final grading of topsoil prior to seeding, clean-up, and maintenance work around the site. The motorgrader, along with the D7R bulldozer/ripper will be used for the life of the reclamation contract (131 hours). This unit will be working at 8,000 feet, msl.

Characterization of Grader Used (type, size capacity, etc.): Caterpillar 14G, 215 horsepower, equipped with EROPS and scarifier.

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

Productivity Calculations:

Grading

$$\begin{aligned} \text{Hourly Production} &= \frac{\text{mi/hr}}{\text{average speed}} \times \frac{\text{ft}}{\text{effective blade width}} \times 5,280 \text{ ft/mi} \times 1 \text{ ac}/43,560 \text{ ft}^2 \\ &\times \frac{\text{efficiency factor}}{\text{efficiency factor}} = \text{ac/hr} \end{aligned}$$

$$\text{Hours Required} = \frac{\text{area to be graded}}{\text{area to be graded}} \text{ ac} \div \frac{\text{hourly production}}{\text{hourly production}} \text{ ac/hr} = \text{hr}$$

Scarification

$$\begin{aligned} \text{Hourly Production} &= \frac{\text{mi/hr}}{\text{average speed}} \times \frac{\text{ft}}{\text{scarifier width}} \times 5,280 \text{ ft/mi} \times 1 \text{ ac}/43,560 \text{ ft}^2 \\ &\times \frac{\text{efficiency factor}}{\text{efficiency factor}} = \text{ac/hr} \end{aligned}$$

$$\text{Hours Required} = \frac{\text{area to be scarified}}{\text{area to be scarified}} \text{ ac} \div \frac{\text{hourly production}}{\text{hourly production}} \text{ ac/hr} = \text{hr}$$

Total Hours Required

$$\text{Total Hours} = \frac{\text{grading hours required}}{\text{grading hours required}} + \frac{\text{scarification hours required}}{\text{scarification hours required}} = \text{231*} \text{ hr}$$

* Motorgrader is to be used for the project life of the reclamation contract (see *Worksheet 13*).

Data Source(s): Caterpillar Performance Handbook, Edition 28.

**WORKSHEET 13
 SUMMARY CALCULATION OF EARTHMOVING COSTS**

Equipment *	Ownership & Operation Cost (\$/hr)	Labor Cost (\$/hr)	Total Hours Required **	Total Cost *** (\$)
627F Scraper	115.72	24.61	171+60 = 231	32,416
D8N-SU Push Tractor	80.54	24.61	116	12,197
D6R-S Dozer	45.79	24.61	8	563
D7R-SU Dozer	76.62	24.61	231	23,384
D9R-SU Dozer	113.22	24.61	261	35,974
14G Grader	59.20	24.61	231	19,360
6,000 gal Water Tanker	69.98	18.50	231	20,439
Grand Total				\$144,333
<p>* Include all necessary attachments and accessories for each item of equipment. Also, add support equipment such as water wagons and graders to match total project time as appropriate. (Total scraper time.)</p> <p>** Account for multiple units in truck and/or scraper teams.</p> <p>*** To compute Total Cost: Add Ownership & Operation Cost and Labor Cost columns then multiply by Total Hours Required column.</p>				

Data Source(s): PRIMEDIA Information, Inc., Cost Reference Guide for Construction Equipment.

**WORKSHEET 14
 REVEGETATION COSTS**

Name and Description of Area To Be Revegetated: Total disturbed area = 20 acres.

Description of Revegetation Activities: The local NRCS office provided a cost of \$425 per acre for seeding, fertilizing, and mulching.

Cost Calculation for Individual Revegetation Activities:

Initial Seeding

$$\frac{20}{\text{area to be seeded}} \text{ ac} \times \left(\$ \frac{\quad}{\text{seedbed preparation}} / \text{ac} + \$ \frac{425}{\text{seeding, fertilizing \& mulching}} / \text{ac} \right) = \$ \underline{8,500}$$

Planting Trees and Shrubs

$$\frac{\quad}{\text{area to be planted}} \text{ ac} \times \left(\$ \frac{\quad}{\text{planting}} / \text{ac} + \$ \frac{\quad}{\text{herbicide treatment}} / \text{ac} \right) = \$ \underline{\quad}$$

Reseeding

$$\frac{20}{\text{area to be seeded}} \text{ ac} \times \frac{.50}{\text{failure rate}^*} \times \left(\$ \frac{**}{\text{seedbed preparation}} / \text{ac} + \$ \frac{425}{\text{seeding, fertilizing \& mulching}} / \text{ac} \right) = \$ \underline{4,250}$$

Replanting Trees and Shrubs

$$\frac{\quad}{\text{area to be planted}} \text{ ac} \times \frac{\quad}{\text{failure rate}^*} \times \left(\$ \frac{\quad}{\text{planting}} / \text{ac} + \$ \frac{\quad}{\text{herbicide treatment}} / \text{ac} \right) = \$ \underline{\quad}$$

Other Necessary Revegetation Activities

(Examples of other activities that may be necessary include soil sampling, irrigation, and rill and gully repair. Describe each activity and provide a cost estimate with documentation. Use additional worksheets if necessary.)

Other Costs = \$

TOTAL REVEGETATION COST = \$ 12,750

* A failure rate of 50 percent is assumed based on other reclamation in the area (see *Worksheet 1*). Assuming that no seedbed preparation is needed for reseeding effort.

** Cost included with earthmoving expense in initial seeding and not needed for reseeding.

Data Source(s): Mine plan; the local NRCS office.

Project: Underground Example
 Date: 12/02/99
 Prepared by: R.R. Bond

**WORKSHEET 15
 OTHER RECLAMATION ACTIVITY COSTS**

(Subsidence damage repair costs, water supply replacement costs, funds required to support long-term treatment of unanticipated acid or ferruginous mine drainage, etc.)

Description of Reclamation, Repair or Pollution Abatement Activity:

Sealing three mine entries: ventilation, manway, and material. The sealing will be as follows: 1) each entryway will be pneumatically filled for 50 feet and 2) a masonry wall will be installed at the entrance.

Assumptions:

	<u>Backfill</u>	<u>Masonry Wall</u>
1. Ventilation	1,964	39
2. Manway	12,272	245
3. Materials	<u>2,827</u>	<u>57</u>
	17,063 CF	341 SF

Cost Estimate Calculations:

Pneumatically filled materials 17,063 CF X \$1.11/CF = \$ 18,940
 Masonry walls 341 SF X \$4.36 /SF = \$ 1,487

TOTAL = \$ 20,427

Other Documentation or Notes:

(Include additional sheets, maps, calculations, etc., as necessary to document estimate.)

Data Source(s): Local AML contract figures.

**WORKSHEET 16
 RECLAMATION BOND SUMMARY SHEET**

1.	Total Facility and Structure Removal Costs	\$ <u>388,157</u>	
2.	Total Earthmoving Costs	\$ <u>144,333</u>	
3.	Total Revegetation Costs	\$ <u>12,750</u>	
4.	Total Other Reclamation Activities Costs	\$ <u>20,427</u>	
5.	Total Direct Costs (sum of Lines 1 through 4)	\$ <u>565,667</u>	
6.	<i>Inflated Total Direct Costs</i> (Line 5 x inflation factor *)		\$ <u>629,022</u>
7.	Mobilization/Demobilization (<u>5</u> % of Line 6) (1% to 10% of Line 6)	\$ <u>31,451</u>	
8.	Contingencies (<u>5</u> % of Line 6) (3% to 5% of Line 6)	\$ <u>31,451</u>	
9.	Engineering Redesign Fee (<u>5</u> % of Line 6) (2.5% to 6% of Line 6)	\$ <u>31,451</u>	
10.	Contractor Profit/ Overhead (<u>24</u> % of Line 6) (see Graph 1)	\$ <u>150,965</u>	
11.	Project Management Fee (<u>4.7</u> % of Line 6) (see Graph 2)	\$ <u>29,564</u>	
12.	<i>Total Indirect Costs</i> (sum of Lines 7 through 11)		\$ <u>274,882</u>
13.	GRAND TOTAL BOND AMOUNT (sum of Lines 6 and 12)		\$ <u>903,904</u> (round to \$ 904,000)

* Inflation factor = $\frac{\text{ENR Construction Cost Index (CCI) for current mo/yr}}{\text{ENR CCI for mo/yr 5 years prior to current mo/yr}} = \frac{6008}{5405} = 1.112$

Identify Month/Year used in formula above: current 4/99
 prior 4/94

ENR = *Engineering News Record*, McGraw-Hill Construction Information Group, New York, NY; <http://www.enr.com>.

Formula assumes permit term or time until next bond adequacy evaluation is 5 years. Adjust timeframe as necessary.

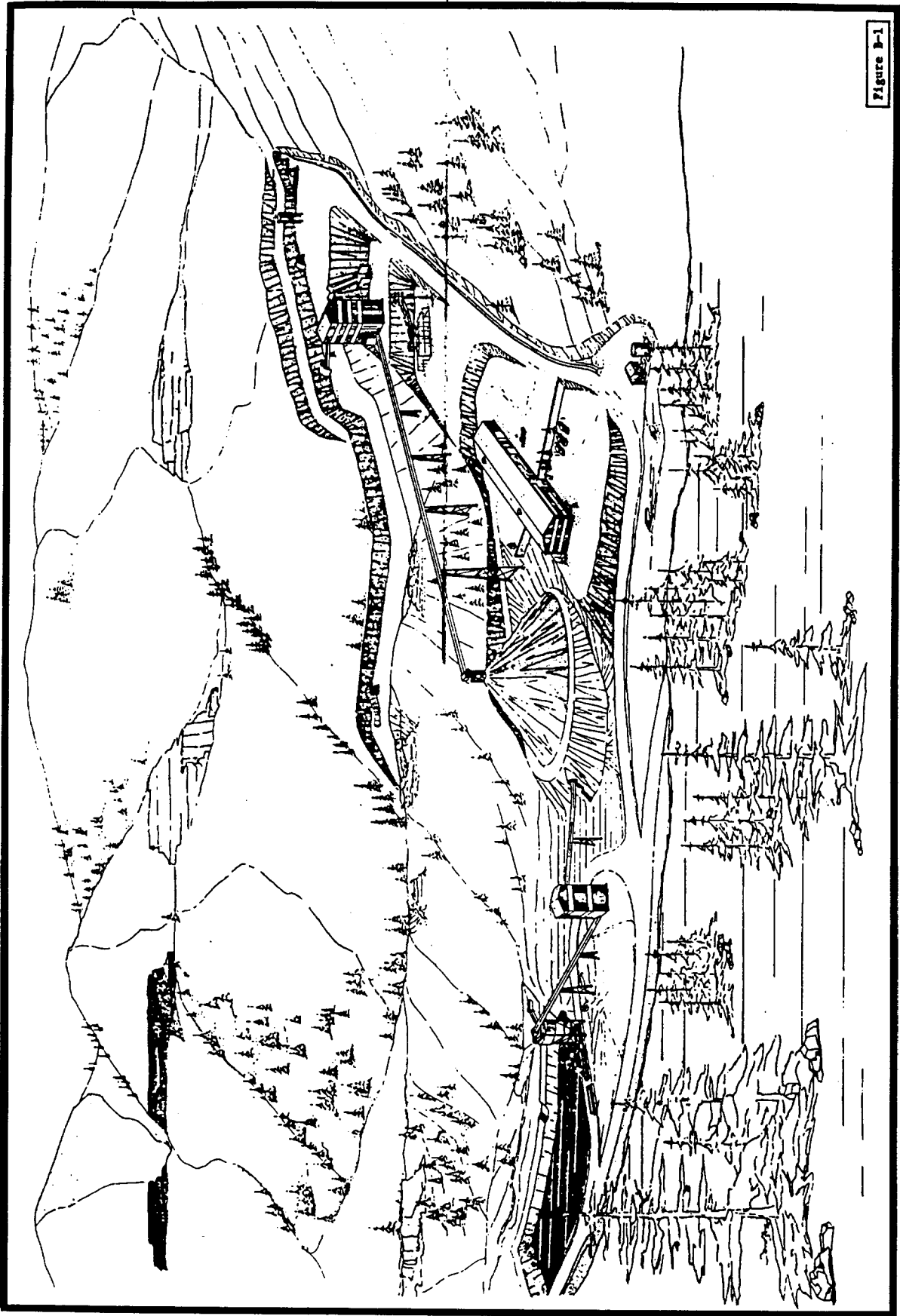


Figure P-1

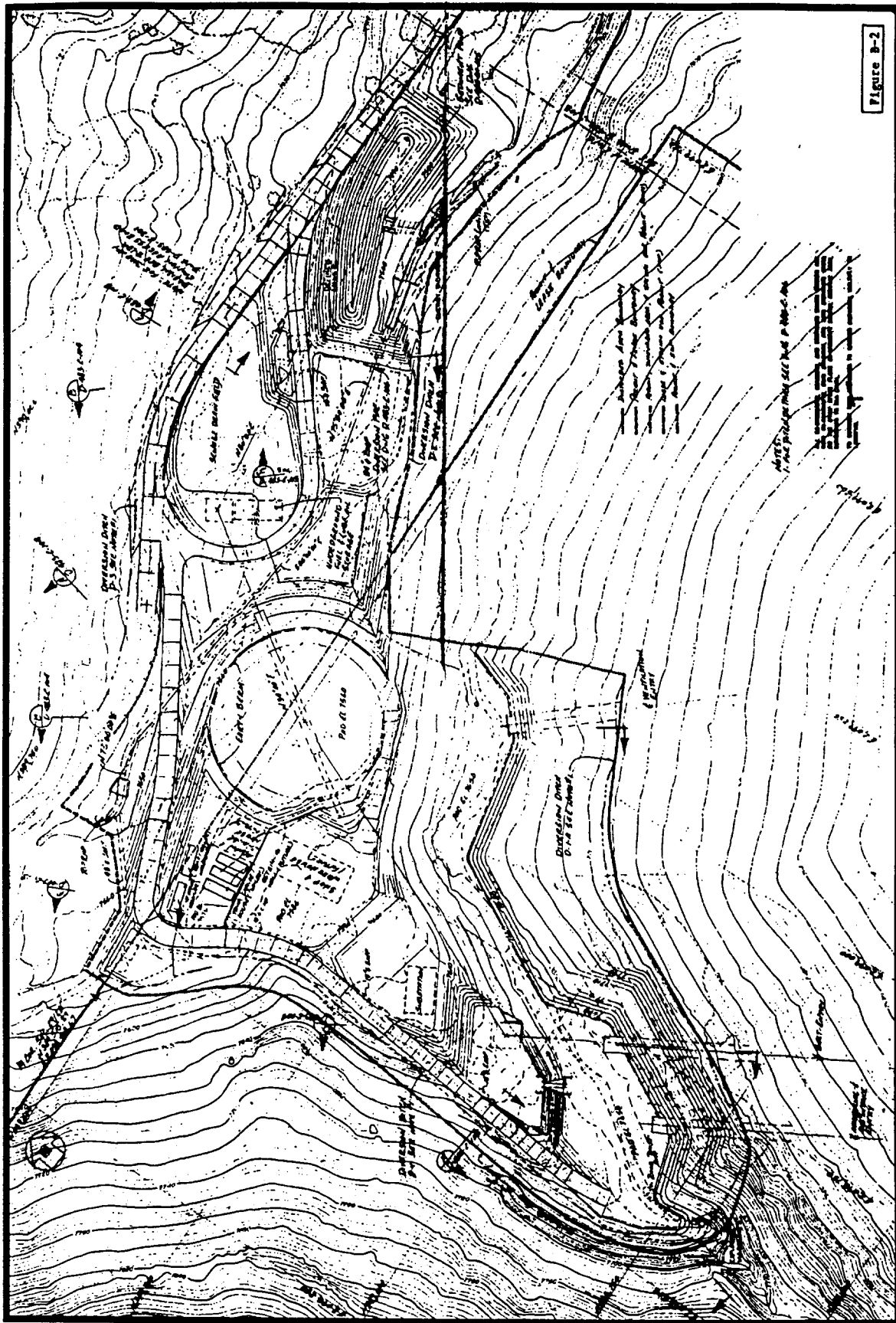
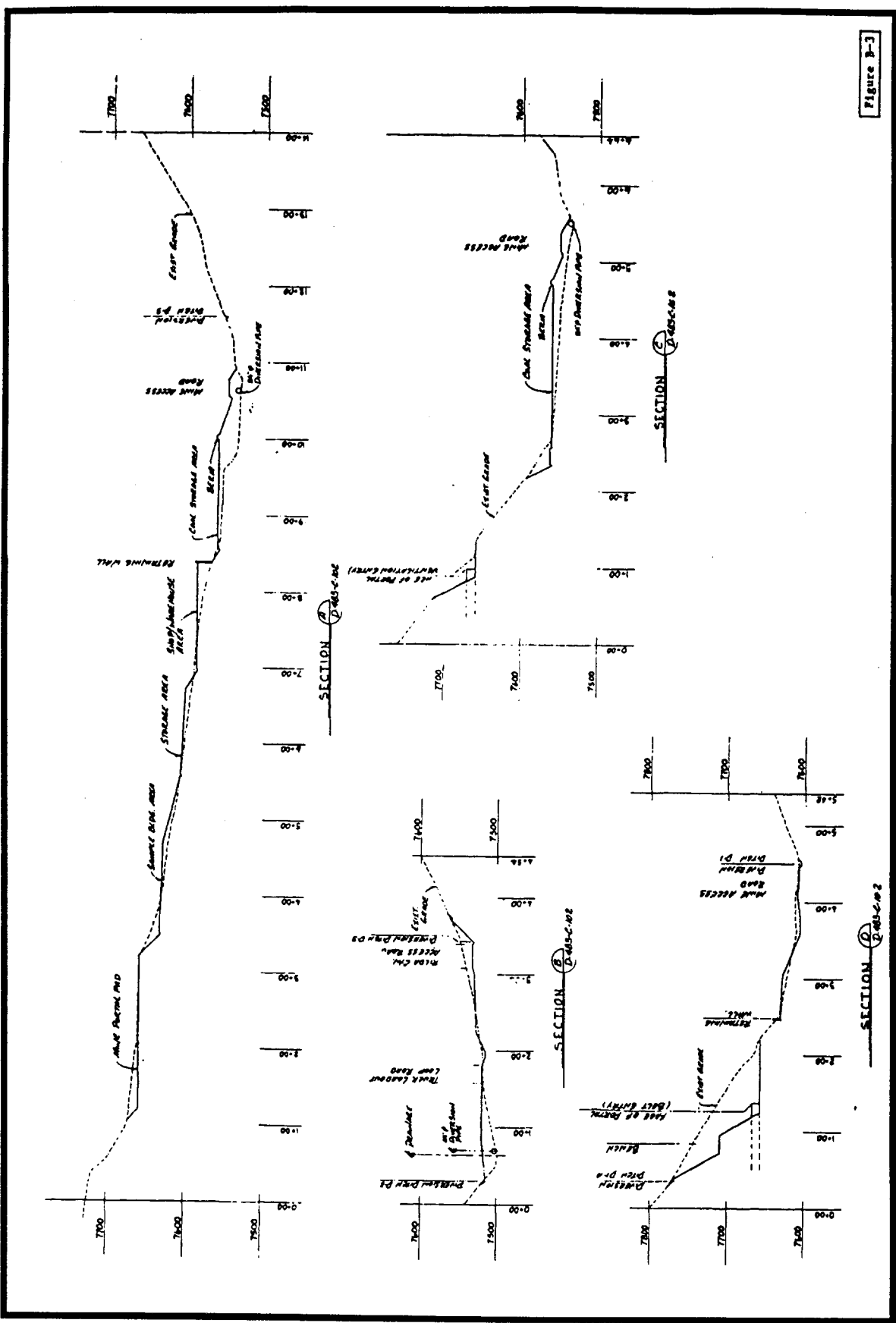


Figure B-2

Figure B-3



BOND AMOUNT COMPUTATION

Applicant: Area Mining - Dragline Example

Permit Number: Example No. 2 **Permitted Acreage:** 115.1

Bonding Scheme (permit area, incremental, cumulative): permit area

If Incremental:

Increment Number: _____

Increment Acreage: _____

If Cumulative:

Acres previously authorized for disturbance: _____

New acres proposed for disturbance: _____

Type of Operation: Area-type surface (dragline)

Location: U.S.A.

Prepared by: K. G. Bond

Date: 01/05/00

Total Bond Amount: \$ 961,000

WORKSHEET 1
DESCRIPTION OF THE WORST-CASE RECLAMATION SCENARIO

The reclamation and operation plans outline the following mining sequence for this dragline operation. (See Figure B-4 at end of worksheets.) Mining begins at the southern end of the property in non-prime farmland soils and progresses northward. The 6 inches of existing topsoil and the opening box-cut material will be stockpiled separately near the southern end of the permit boundary and outside the 120' buffer zone of the adjacent creek that runs along the south and east sides of the permit boundary. In addition, the operations plan identifies 71 acres of prime farmland for which 48 inches of prime farmland soils must be salvaged. The mine is located in Crawford County, Kansas. The worst-case situation will occur when there is:

1. The greatest disturbance of prime farmland,
2. The largest pit, and
3. The greatest exposure of non-vegetated land.

From inspection, the worst case was determined as occurring about midway through the mining operation when one of the longest pits is through prime farmland, four spoil ridges exist behind the open pit, and no revegetation has been initiated (see sketch on following page). Assuming this worst-case situation, the following reclamation tasks should be completed.

1. Structure Demolition

There are no facilities. One haul road and five ponds are to remain as part of the approved post mining land use.

2. Earthmoving Activities

One pit will be open at the time of forfeiture that will need to be backfilled and rough graded. The accompanying cross-section indicates about a 40-foot depth for the open pit. The mine plan indicates that the highwall will maintain a 1/4 h : 1 v slope and the spoil ridge side will maintain a slope of 1-1/2 h:1v (see sketch). It is assumed that four spoil ridges exist behind the open pit, which must be rough graded before rough backfilling and grading of the pit can begin. Once rough grading is accomplished, the whole area will be ripped prior to final grading and topsoil placement.

3. Topsoil Replacement

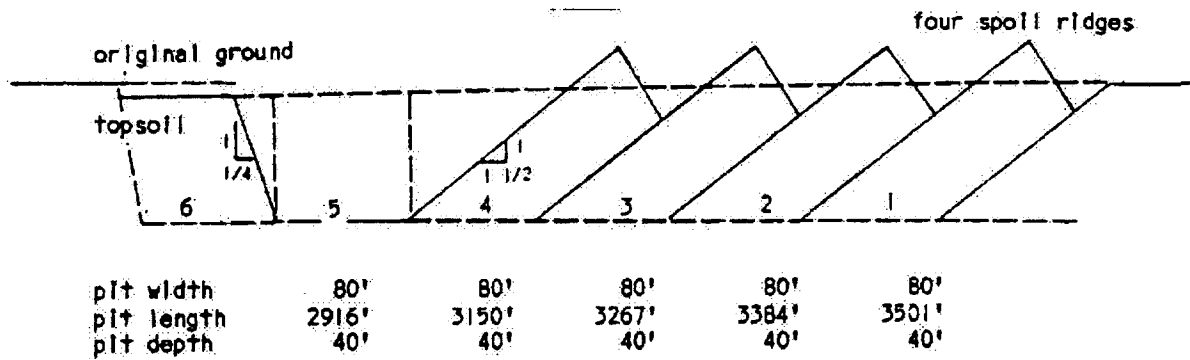
It is assumed that the next pit to be mined has had all topsoil stripped. All areas behind the open pit from the start of mining need topsoil replaced plus revegetation. The prime farmland areas will receive 48 inches of topsoil and subsoil and the non-prime land areas will receive 6 inches of topsoil. These areas will be final graded once the topsoil is placed.

4. Revegetation

The revegetation worst case would be if mining started in the fall of the year, as scheduled, with no revegetation having yet occurred within the permit. Therefore, the entire disturbed area of 40.5 acres will need seedbed preparation, fertilization, seeding, and mulching.

WORKSHEET 1 (continued)
DESCRIPTION OF THE WORST-CASE RECLAMATION SCENARIO

Sketch of Operations



NOTE: WORKSHEETS 2, 6, 8, 9, 10, 11A, 15, 17 and 18 are not applicable to this example.

Data Sources: Operation and reclamation plans in the approved permit.

Project: Area Mining/Dragline Example
 Date: 01/05/00
 Prepared by: K. G. Bond

**WORKSHEET 3
 MATERIAL HANDLING PLAN SUMMARY**

Earthmoving Activity	Volume (LCY)	Origin	Destination	Haul Distance (ft)	Grade * (%)	Equipment To Be Used
1. Backfilling and Grading	568,836	Box cut	Excess Spoil Area	1,900 ave	4	637E scraper with D9R push tractor**
2. Rough Grading	132,922	Spoil Ridges	Spoil Ridge Area	100 ave	3	D9R-SU dozer
3. Topsoil (non-prime)	15,972	Stockpile	Disturbed Area	1,000 ave	4	637E scraper with D9R push tractor**
4. Subsoil (prime)	116,886	Stockpile	Disturbed Area	1,000 ave	4	637E scraper with D9R push tractor**
5. Topsoil (prime)	16,698	Stockpile	Disturbed Area	1,000 ave	4	637E scraper with DR9 push tractor**
6. Ripping	131,003	Disturbed Area	Disturbed Area		0	D7R-SU dozer with 3-shank ripper
7. Scarification	40.5 ac	Disturbed Area	Disturbed Area		0	14H grader
8. Final Grading	40.5 ac	Disturbed Area	Disturbed Area		0	14H grader

* Record grade resistance (% grade) here.
 ** Scraper and dozer work concurrently

**WORKSHEET 4A
 EARTHWORK QUANTITY**

Cross-Section/ Station	Distance Between Stations (ft)	End Area (ft²)	Volume (yd³)*	Adjust- ment Factor * (%)	Adjusted Volume (LCY)
east end of pit		4,580			
	2,916		494,640	15	568,836
west end of pit		4,580			
TOTALS			494,640		568,836
* Select adjustment factor based on the state of the material to be moved.					

Data Source(s): Mine plan.

**WORKSHEET 4B
 EARTHWORK QUANTITY**

Pit Backfill Volume

End Area of Pit

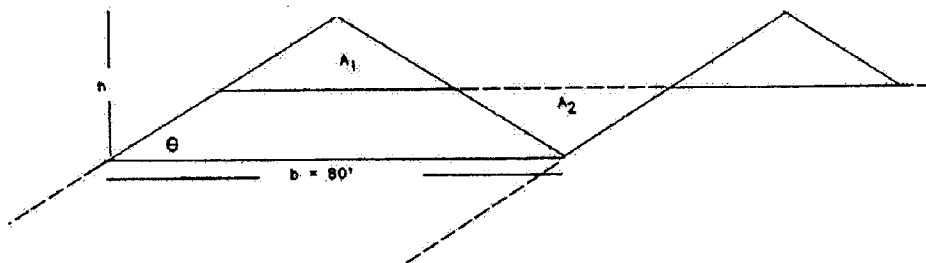
1.	0.5 x 10' x 40' =	200 ft ²
2.	80' x 40' =	3,200 ft ²
3.	0.5 x 40' x 59' =	<u>1,180 ft²</u>
	=	<u>4,580 ft²</u>

Spoil Ridge Volume

$A_1 = A_2$
 $A_1 = 1/4 \text{ total pile}$
 $A_1 = 1/4(1/2)(b)(h)$
 $h = 1/2 (\tan \theta)(b)$
 $A_1 = 1/16 (\tan \theta)(b)^2$
 $\theta = 34^\circ \text{ (given 1-1/2:1 slope)}$
 $b = 80'$
 $A_1 = 269.8 \text{ ft}^2 \text{ (area is per lineal foot of pit length)}$

Therefore:

Ridge 4:	269.8 ft ² / linear foot x 3,150 feet long ÷ 27 ft ³ /CY =	31,477
Ridge 3:	269.8 ft ² / linear foot x 3,267 feet long ÷ 27 ft ³ /CY =	32,646
Ridge 2:	269.8 ft ² / linear foot x 3,384 feet long ÷ 27 ft ³ /CY =	33,815
Ridge 1:	269.8 ft ² / linear foot x 3,501 feet long ÷ 27 ft ³ /CY =	<u>34,984</u>
		132,922 CCY



**WORKSHEET 4B (continued)
EARTHWORK QUANTITY**

Volume of Material to be Ripped

$$40.6 \text{ acres} \times 43,560 \text{ ft}^2/\text{acre} \times 2 \text{ ft deep} \div 27 \text{ ft}^3/\text{CY} = 131,003 \text{ BCY}$$

Topsoil Volume

Non-prime Farmland

19.8 acres to receive 6 inches of topsoil

$$19.8 \text{ acres} \times \frac{43560 \text{ ft}^2}{\text{acre}} \times 0.5 \text{ ft} \div \frac{27 \text{ ft}^3}{1 \text{ CY}} = 15,972 \text{ CY}$$

Prime Farmland

20.7 acres to receive 48" of topsoil and subsoil

Topsoil:

$$20.7 \text{ acres} \times \frac{43560 \text{ ft}^2}{\text{acre}} \times 0.5 \text{ ft} \div \frac{27 \text{ ft}^3}{1 \text{ CY}} = 16,698 \text{ CY}$$

Subsoil:

$$20.7 \text{ acres} \times \frac{43560 \text{ ft}^2}{\text{acre}} \times 3.5 \text{ ft} \div \frac{27 \text{ ft}^3}{1 \text{ CY}} = 116,886 \text{ CY}$$

Data Source(s): Mine plan.

**WORKSHEET 5A
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE**

Earthmoving Activity:
 Spoil ridge reduction.

Characterization of Dozer Used (type, size, etc.):
 D9R dozer with "Semi-U or SU" Blade.

Description of Dozer Use (origin, destination, grade, haul distance, material, etc.):
 Origin: in spoil ridge peak Destination: valley between spoil ridges
 100 ft. push at a + 3% effective grade; material is a mixture of earth and blasted limestone and shale rock.

Productivity Calculations:

$$\begin{aligned} \text{Operating Adjustment Factor} = & \frac{.75}{\text{operator factor}} \times \frac{.80}{\text{material factor}} \times \frac{.83}{\text{efficiency factor}} \times \frac{.95}{\text{grade factor}} \\ & \times \frac{.932}{\text{weight correction factor}^*} \times \frac{1.0}{\text{production method/blade factor}} \times \frac{1.0}{\text{visibility factor}} \times \frac{1.0}{\text{elevation factor}} = .441 \end{aligned}$$

$$\text{Net Hourly Production} = \frac{1,250}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{.441}{\text{operating adjustment factor}} = \underline{551.3} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{132,922}{\text{volume to be moved}} \text{ LCY} \div \frac{551.3}{\text{net hourly production}} \text{ LCY/hr} = \underline{241} \text{ hr}$$

* Weight Correction Factor = $\frac{2,300}{(2,700 + 2,600 + 2,100) + 3} = \frac{2,300}{2,466.7} = 0.932$
 (From Caterpillar Performance Handbook: Bulldozer production factors)

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 5B
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE**

Earthmoving Activity:
 Push tractor to assist loading scrapers.

Characterization of Dozer Used (type, size, etc.):
 D9R dozer with a "SU" Blade.

Description of Dozer Use (origin, destination, grade, haul distance, material, etc.):
 Scrapers loaded with back-track loading method.

Productivity Calculations:

$$\text{Operating Adjustment Factor} = \frac{\quad}{\text{operator factor}} \times \frac{\quad}{\text{material factor}} \times \frac{\quad}{\text{efficiency factor}} \times \frac{\quad}{\text{grade factor}}$$

$$\times \frac{\quad}{\text{weight correction factor}} \times \frac{\quad}{\text{production method/blade factor}} \times \frac{\quad}{\text{visibility factor}} \times \frac{\quad}{\text{elevation factor}} = \frac{\quad}{\quad}$$

$$\text{Net Hourly Production} = \frac{\quad}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{\quad}{\text{operating adjustment factor}} = \frac{\quad}{\quad} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{\quad}{\text{volume to be moved}} \text{ LCY} + \frac{\quad}{\text{net hourly production}} \text{ LCY/hr} = \underline{636^*} \text{ hr}$$

* See *Worksheet 13*. Dozer assists scrapers for total project time of 636 hours.

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 7
 PRODUCTIVITY AND HOURS REQUIRED FOR RIPPER-EQUIPPED DOZER USE**

Ripping Activity:

This unit will be used for ripping the 40.6 (approx. 1,330' x 1,330') acre site prior to topsoil and subsoil placement.

Characterization of Dozer and Ripper Use:

D7R w/ SU blade (Direct Steer) and 3-shank adjustable parallelogram ripper; ripper has a 39 inch (3.25-foot) pocket spacing.

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

Material to be ripped: Sandstone and Shale Ripping depth = 2 feet

Ripping effective width = 3.25 feet X 3 = 9.75 feet

Productivity Calculation:

$$\text{Cycle Time} = \left(\frac{1,330 \text{ ft}}{\text{cut length}} + \frac{88 \text{ ft/min}}{\text{[speed]}} \right) + \frac{.25}{\text{fixed turn time}^*} \text{ min} = \underline{15.36} \text{ min/pass}$$

$$\text{Passes/Hour} = 60 \text{ min/hr} + \frac{15.36}{\text{cycle time}} \text{ min/pass} \times \frac{.83}{\text{efficiency factor}} = \underline{3.24} \text{ passes/hr}$$

$$\begin{aligned} \text{Volume Cut/Pass} &= \left(\frac{2.0}{\text{tool penetration}} \text{ ft} \times \frac{9.75}{\text{cut spacing}} \text{ ft} \times \frac{1,330}{\text{cut length}} \text{ ft} \right) + 27 \text{ ft}^3/\text{yd}^3 \\ &= \underline{960.6} \text{ BCY/pass} \end{aligned}$$

$$\text{Hourly Production} = \underline{960.6} \text{ BCY/pass} \times \underline{3.24} \text{ passes/hr} = \underline{3,112.3} \text{ BCY/hr}$$

$$\text{Hours Required} = \frac{131,003 \text{ BCY}}{\text{bank volume to be ripped}^{**}} + \frac{3,112.3 \text{ BCY/hr}}{\text{hourly production}} = \underline{42.1} \text{ hr}$$

* Fixed turn time depends upon dozer used. 0.25 min/turn is normal.

** Remember to use the swell factor to convert from bank cubic yards to loose cubic yards when applying these data to *Worksheet 5*. Calculate separate dozer hauling of ripped material for each lift on that worksheet.

*** The D7R bulldozer is to be for miscellaneous tasks during the life of the project = 636 hours. (See *Worksheet No 13*)

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 11B-1
 PRODUCTIVITY OF DOZER PUSH-LOADED SCRAPER USE**

Earthmoving Activity:
 Backfill and grade final pit area.

Characterization of Scraper Used (type, capacity, etc.):
 Cat 637E Non-push pull 21CY (struck) + 31 CY (heaped) = (21CY + 31CY)/2 = 26 CY avg capacity.

Description of Scraper Use (origin, destination, grade, haul distance, capacity, etc.):
 1,900' haul @ 4% effective grade; 1,900' return @ 0% effective grade.

List Pusher Tractor(s) Used:
 D9R dozer will assist the scraper in loading.

Describe Push Tractor Loading Method (see figure following Worksheet 11B-3):
 Back-track loading method with a single push tractor.

Scraper Productivity Calculations:

$$\text{Cycle Time} = \frac{.6}{\text{load time}} \text{ min} + \frac{1.1}{\text{loaded trip time}} \text{ min} + \frac{.6}{\text{maneuver and spread time}} \text{ min} + \frac{.75}{\text{return trip time}} \text{ min} = \underline{3.05} \text{ min}$$

$$\text{Hourly Production} = \frac{26}{\text{capacity}^*} \text{ LCY} \times 60 \text{ min/hr} \div \frac{3.05}{\text{cycle time}} \text{ min} \times \frac{.75}{\text{efficiency factor}} = \underline{383.6} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{568,836}{\text{volume to be handled}} \text{ LCY} \div \frac{383.6}{\text{hourly production}} \text{ LCY/hr} = \underline{1,483} \text{ hr}$$

* Use the average of the struck and heaped capacities.

Push Tractor Productivity Calculations:

$$\text{Pusher Cycle Time} = \frac{.6}{\text{scraper load time}} \text{ min} \times \frac{1.5}{\text{pusher factor}} = \underline{.90} \text{ min}$$

$$\text{Scrapers/Pusher} = \frac{3.05}{\text{scraper cycle time}} \text{ min} \div \frac{.90}{\text{pusher cycle time}} \text{ min} = \underline{3.39} \text{ scrapers (use 3)}$$

$$\text{Pusher Hours Required} = \frac{1483}{\text{scraper hours}} \text{ hr} \div \frac{3}{\text{scrapers per pusher}} = \underline{495} \text{ hr (round up)}$$

Data Source(s): Caterpillar Performance Handbook, Edition 29.

Project: Area Mining/Dragline Example
 Date: 01/05/00
 Prepared by: K. G. Bond

**WORKSHEET 11B-2
 PRODUCTIVITY OF DOZER PUSH-LOADED SCRAPER USE**

Earthmoving Activity:

Replacing 42" (3.5') of prime farmland, subsoils over 20.7 acres.

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

Cat 637E Non-push pull 21CY (struck) + 31 CY (heaped) = (21CY + 31CY)/2 = 26 CY avg capacity.

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

1,000' haul at 4% effective grade; 1,000' return at 0% effective grade.

List Pusher Tractor(s) Used:

D9R dozer will assist the scraper in loading.

Describe Push Tractor Loading Method (see figure on next page):

Back-track loading method with a single push tractor.

Scraper Productivity Calculations:

$$\text{Cycle Time} = \frac{.6}{\text{load time}} \text{ min} + \frac{.6}{\text{loaded trip time}} \text{ min} + \frac{.6}{\text{maneuver and spread time}} \text{ min} + \frac{.4}{\text{return trip time}} \text{ min} = \underline{2.2} \text{ min}$$

$$\text{Hourly Production} = \frac{26}{\text{capacity}^*} \text{ LCY} \times 60 \text{ min/hr} \div \frac{2.2}{\text{cycle time}} \text{ min} \times \frac{.75}{\text{efficiency factor}} = \underline{531.8} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{116,886}{\text{volume to be handled}} \text{ LCY} \div \frac{531.8}{\text{hourly production}} \text{ LCY/hr} = \underline{220} \text{ hr}$$

* Use the average of the struck and heaped capacities.

Push Tractor Productivity Calculations:

$$\text{Pusher Cycle Time} = \frac{.6}{\text{scraper load time}} \text{ min} \times \frac{1.5}{\text{pusher factor}} = \underline{.9} \text{ min}$$

$$\text{Scrapers/Pusher} = \frac{2.2}{\text{scraper cycle time}} \text{ min} \div \frac{.9}{\text{pusher cycle time}} \text{ min} = \frac{2.44}{\text{(use 2)}} \text{ scrapers}$$

$$\text{Pusher Hours Required} = \frac{220}{\text{scraper hours}} \text{ hr} \div \frac{2}{\text{scrapers per pusher}} = \frac{110}{\text{(round up)}} \text{ hr}$$

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 11B-3
 PRODUCTIVITY OF DOZER PUSH-LOADED SCRAPER USE**

Earthmoving Activity:

Replacing 6" (0.5') of topsoil over 40.5 acres (19.8 acres on non-prime and 20.7 of prime farmland).

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

Cat 637E Non-push pull 21CY (struck) + 31 CY (heaped) = (21CY + 31CY)/2 = 26 CY avg capacity.

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

1,000' haul at 4% effective grade; 1,000' return at 0% effective grade.

List Pusher Tractor(s) Used:

D9R dozer will assist the scraper in loading.

Describe Push Tractor Loading Method (see figure on next page):

Back-track loading method with a single push tractor.

Scraper Productivity Calculations:

$$\text{Cycle Time} = \frac{.6}{\text{load time}} \text{ min} + \frac{.6}{\text{loaded trip time}} \text{ min} + \frac{.6}{\text{maneuver and spread time}} \text{ min} + \frac{.4}{\text{return trip time}} \text{ min} = \underline{2.2} \text{ min}$$

$$\text{Hourly Production} = \frac{26}{\text{capacity}^*} \text{ LCY} \times 60 \text{ min/hr} + \frac{2.2}{\text{cycle time}} \text{ min} \times \frac{.75}{\text{efficiency factor}} = \underline{531.8} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{32,670}{\text{volume to be handled}} \text{ LCY} + \frac{531.8}{\text{hourly production}} \text{ LCY/hr} = \underline{61} \text{ hr}$$

* Use the average of the struck and heaped capacities.

Push Tractor Productivity Calculations:

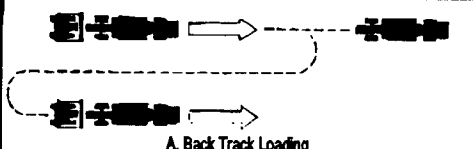
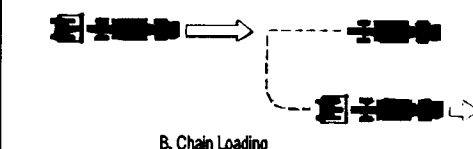
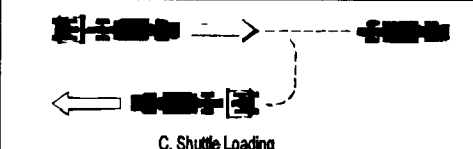
$$\text{Pusher Cycle Time} = \frac{.6}{\text{scraper load time}} \text{ min} \times \frac{1.5}{\text{pusher factor}} = \underline{.9} \text{ min}$$

$$\text{Scrapers/Pusher} = \frac{2.2}{\text{scraper cycle time}} \text{ min} + \frac{.9}{\text{pusher cycle time}} \text{ min} = \frac{2.44}{\text{(use 2)}} \text{ scrapers}$$

$$\text{Pusher Hours Required} = \frac{61}{\text{scraper hours}} \text{ hr} + \frac{2}{\text{scrapers per pusher}} = \frac{31}{\text{(round up)}} \text{ hr}$$

Data Source(s): Caterpillar Performance Handbook, Edition 29.

WORKSHEET 11B (continued)
PRODUCTIVITY OF DOZER PUSH-LOADED SCRAPER USE

PUSHER FACTORS	Single Push	Tandem Push
 <p>A. Back Track Loading</p>	1.5	2.0
 <p>B. Chain Loading</p>	1.3	1.5
 <p>C. Shuttle Loading</p>	1.3	1.5

Modified from Terex, 1981

Data Source(s): Illustration from "Production and Cost Estimating of Material Movement and Earthmoving Equipment," TEREX AMERICAS, Tulsa, OK 74107, (918) 445-5802. See disclaimer in Appendix A, *Worksheet 11B*.

**WORKSHEET 12
 PRODUCTIVITY AND HOURS REQUIRED FOR MOTORGRADER USE**

Earthmoving Activity:

The motorgrader will be used for maintaining haul roads, for final grading prior to topsoil placement, final grading of topsoil prior to seeding, clean-up, and maintenance work around the site. The motorgrader, along with the D7R bulldozer/ripper will be used for the life of the reclamation contract.

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

Caterpillar 14H, 215 horsepower, equipped with EROPS and scarifier.

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

Productivity Calculations:

Grading

$$\begin{aligned} \text{Hourly Production} &= \frac{\text{mi/hr}}{\text{average speed}} \times \frac{\text{ft}}{\text{effective blade width}} \times 5,280 \text{ ft/mi} \times 1 \text{ ac}/43,560 \text{ ft}^2 \\ &\times \frac{\text{efficiency factor}}{\text{efficiency factor}} = \text{ac/hr} \end{aligned}$$

$$\text{Hours Required} = \frac{\text{area to be graded}}{\text{area to be graded}} \text{ ac} \div \frac{\text{hourly production}}{\text{hourly production}} \text{ ac/hr} = \text{hr}$$

Scarification

$$\begin{aligned} \text{Hourly Production} &= \frac{\text{mi/hr}}{\text{average speed}} \times \frac{\text{ft}}{\text{scarifier width}} \times 5,280 \text{ ft/mi} \times 1 \text{ ac}/43,560 \text{ ft}^2 \\ &\times \frac{\text{efficiency factor}}{\text{efficiency factor}} = \text{ac/hr} \end{aligned}$$

$$\text{Hours Required} = \frac{\text{area to be scarified}}{\text{area to be scarified}} \text{ ac} \div \frac{\text{hourly production}}{\text{hourly production}} \text{ ac/hr} = \text{hr}$$

Total Hours Required

$$\text{Total Hours} = \frac{\text{grading hours required}}{\text{grading hours required}} + \frac{\text{scarification hours required}}{\text{scarification hours required}} = \underline{636^*} \text{ hr}$$

* Motorgrader is to be used for the life of the reclamation contract (see Worksheet 13) = 636 hours, including grading operations.

Data Source(s): Caterpillar Performance Handbook, Edition 29.

Project: Area Mining/Drayline Example
 Date: 01/05/00
 Prepared by: K. G. Bond

**WORKSHEET 13
 SUMMARY CALCULATION OF EARTHMOVING COSTS**

Equipment *	Ownership & Operation Cost (\$/hr)	Labor Cost (\$/hr)	Total Hours Required **	Total Cost *** (\$)
637E Scraper	173.84	8.05	(3 x 495)	270,107
637E Scraper	173.84	8.05	(2 X 110)	40,016
637E Scraper	173.84	8.05	(2 X 31)	11,277
D7R-SU Dozer	74.85	8.78	636*	53,189
D9R-SU Dozer	111.20	8.78	241	28,915
14H Grader	58.02	8.78	636*	42,485
6,000 Water Tanker	69.96	7.52	636*	49,277
D9R-SU Push Tractor	111.20	8.78	636*	76,307
Grand Total				571,573
<p>* Add support equipment such as water wagons and graders to match total project time as appropriate. Sum of dozer hours assisting scrapers is 636 (see <i>Worksheets 11B-1, -2, -3</i>).</p> <p>** Account for multiple units in truck and/or scraper teams.</p> <p>*** To compute Total Cost: Add Ownership & Operation Cost and Labor Cost columns then multiply by Total Hours Required column.</p>				

Data Source(s): PRIMEDIA Information, Inc., Cost Reference Guide for Construction Equipment (3Q99); Department of Labor, Davis-Bacon Wage Rates (General Decision KS990063, 10/08/99).

**WORKSHEET 14
 REVEGETATION COSTS**

Name and Description of Area To Be Revegetated:

The area consists of prime and non-prime farmlands. Both areas will be vegetated in the same manner. Alfalfa will be used as a cover crop.

Description of Revegetation Activities:

The following costs are indicated in the mining plan and confirmed by the local Natural Resource Conservation Service (formerly SCS) Office:

Seed @ \$150/Ac + Mulch @ \$250/Ac + Fertilizer @ \$40/Ac = TOTAL Revegetation Cost \$440/Ac

Cost Calculation for Individual Revegetation Activities:

Initial Seeding

$$\frac{40.5}{\text{area to be seeded}} \text{ ac} \times \left(\$ \frac{\quad}{\text{seedbed preparation}} / \text{ac} + \$ \frac{440}{\text{seeding, fertilizing \& mulching}} / \text{ac} \right) = \$ \underline{17,820}$$

Planting Trees and Shrubs

$$\frac{\quad}{\text{area to be planted}} \text{ ac} \times \left(\$ \frac{\quad}{\text{planting}} / \text{ac} + \$ \frac{\quad}{\text{herbicide treatment}} / \text{ac} \right) = \$ \underline{\quad}$$

Reseeding

$$\frac{40.5}{\text{area to be seeded \& unreleased \& disturbed areas}} \text{ ac} \times \frac{.30}{\text{failure rate}^*} \times \left(\$ \frac{\quad}{\text{seedbed preparation}} / \text{ac} + \$ \frac{440}{\text{seeding, fertilizing \& mulching}} / \text{ac} \right) = \$ \underline{5,346}$$

Replanting Trees and Shrubs

$$\frac{\quad}{\text{area to be planted \& unreleased \& disturbed areas}} \text{ ac} \times \frac{\quad}{\text{failure rate}^*} \times \left(\$ \frac{\quad}{\text{planting}} / \text{ac} + \$ \frac{\quad}{\text{herbicide treatment}} / \text{ac} \right) = \$ \underline{\quad}$$

Other Necessary Revegetation Activities

(Examples of other activities that may be necessary include soil sampling, irrigation, and rill and gully repair. Describe each activity and provide a cost estimate with documentation. Use additional worksheets if necessary.)

Other Costs: \$

TOTAL REVEGETATION COST = \$ 23,166

* Scarifying is done by motorgrader (Worksheet 12). Historical revegetative failure rate is 30%. There are no unreleased areas.

Data Source(s): Mine plan; local NRCS.

Project: Area Mining/Dragline Example
 Date: 01/05/00
 Prepared by: K. G. Bond

**WORKSHEET 16
 RECLAMATION BOND SUMMARY SHEET**

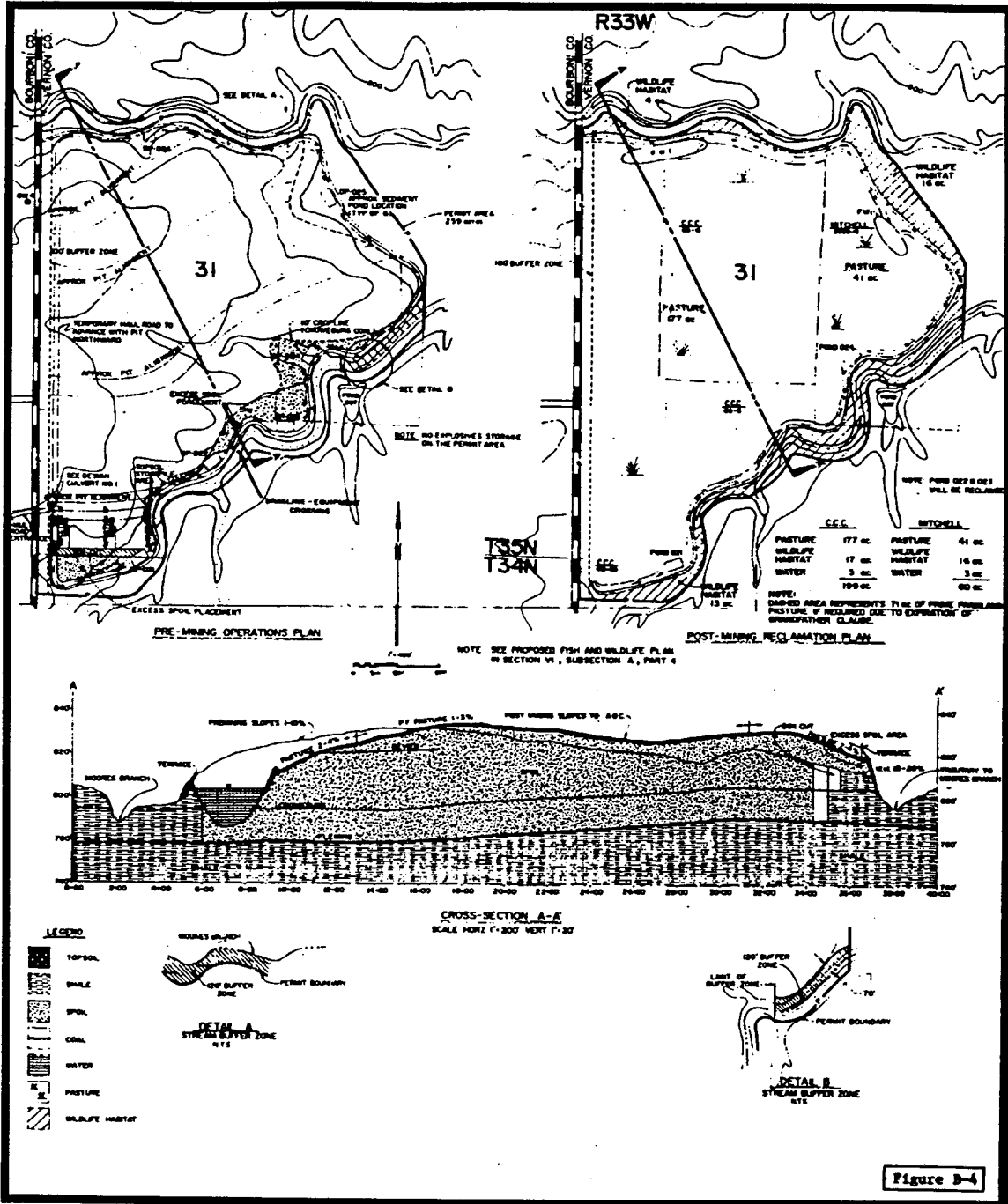
1.	Total Facility and Structure Removal Costs	\$ <u>0</u>	
2.	Total Earthmoving Costs	\$ <u>571,573</u>	
3.	Total Revegetation Costs	\$ <u>23,166</u>	
4.	Total Other Reclamation Activities Costs	\$ <u>0</u>	
5.	Total Direct Costs (sum of Lines 1 through 4)	\$ <u>594,739</u>	
6.	<u>Inflated Total Direct Costs</u> (Line 5 x inflation factor *)		\$ <u>672,055</u>
7.	Mobilization/Demobilization (<u>5</u> % of Line 6) (1% to 10% of Line 6)	\$ <u>33,603</u>	
8.	Contingencies (<u>5</u> % of Line 6) (3% to 5% of Line 6)	\$ <u>33,603</u>	
9.	Engineering Redesign Fee (<u>4.25</u> % of Line 6) (2.5% to 6% of Line 6)	\$ <u>28,562</u>	
10.	Contractor Profit/ Overhead (<u>24</u> % of Line 6) (see Graph 1)	\$ <u>161,293</u>	
11.	Project Management Fee (<u>4.7</u> % of Line 6) (see Graph 2)	\$ <u>31,587</u>	
12.	<u>Total Indirect Costs</u> (sum of Lines 7 through 11)		\$ <u>288,648</u>
13.	GRAND TOTAL BOND AMOUNT (sum of Lines 6 and 12)		\$ <u>960,703</u> (round to \$ 961,000)

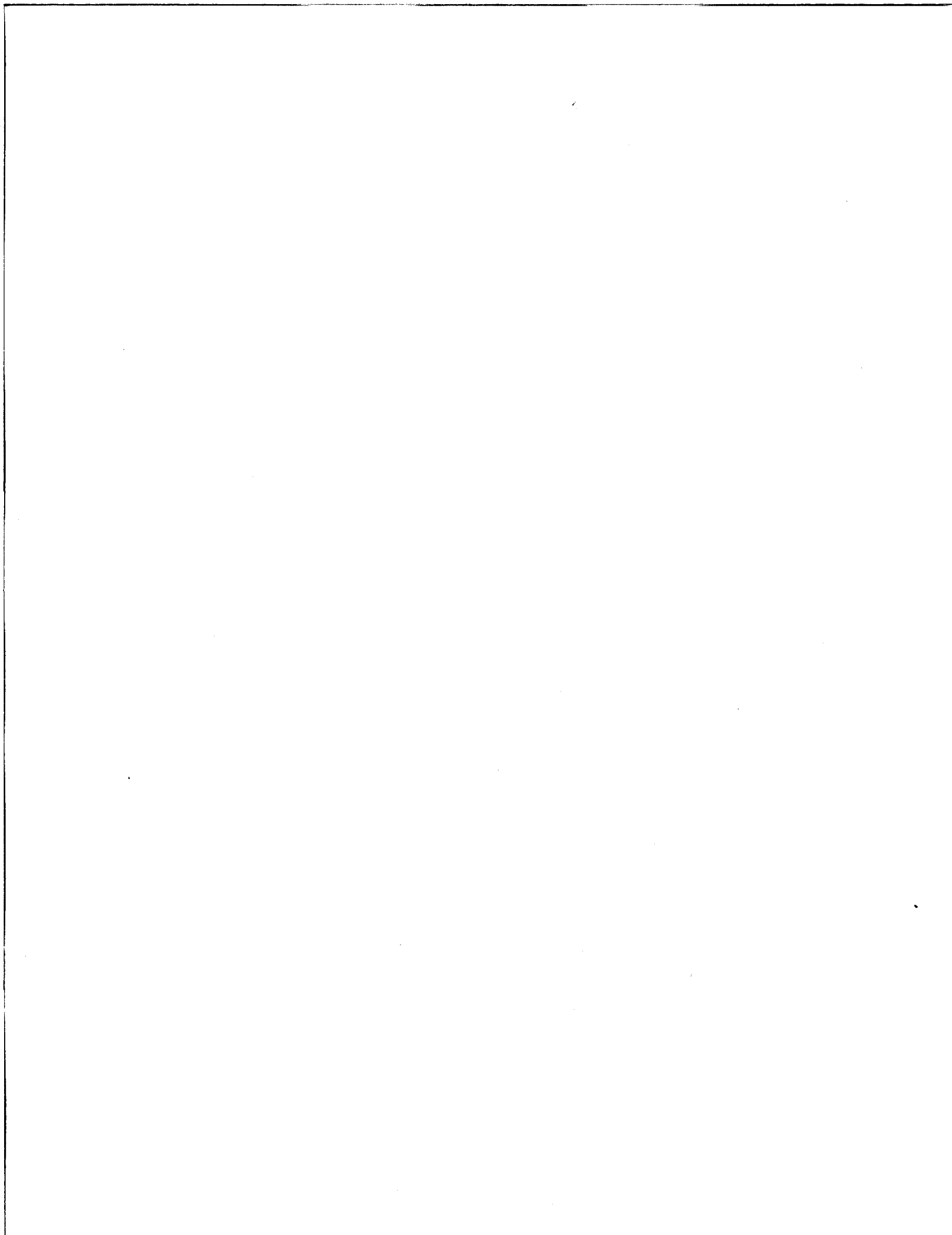
* Inflation factor = $\frac{\text{ENR Construction Cost Index (CCI) for current mo/yr}}{\text{ENR CCI for mo/yr 5 years prior to current mo/yr}} = \frac{6127}{5439} = 1.13$

Identify current month/year used in formula above: 12/99
 Identify prior month/year used in formula above: 12/94

ENR = *Engineering News Record*, McGraw-Hill Construction Information Group, New York, NY; <http://www.enr.com>.

Formula assumes permit term or time until next bond adequacy evaluation is 5 years. Adjust timeframe as necessary.





BOND AMOUNT COMPUTATION

Applicant: Haulback Example

Permit Number: Example No. 3 **Permitted Acreage:** 160

Bonding Scheme (permit area, incremental, cumulative): permit area

If Incremental:

Increment Number: _____

Increment Acreage: _____

If Cumulative:

Acres previously authorized for disturbance: _____

New acres proposed for disturbance: _____

Type of Operation: Contour-type surface (truck and loader)

Location: USA

Prepared by: K. J. Bond

Date: December 2, 1999

Total Bond Amount: \$ 387,000

WORKSHEET 1
DESCRIPTION OF THE WORST-CASE RECLAMATION SCENARIO

The mining sequence for this haul back operation begins with Pit #1 and progresses through Pit #66 (see Figure B-5 at end of worksheets). The topsoil from the box cut and the box-cut material will be stored separately in the four stockpiles located near Pits #4, #10, and #13. From inspection, the worst-case reclamation scenario will occur while Pit #21 is being mined due to the pit size and distance from these stockpiles. At this time, all additional stockpiles would not exist. The mine is located in Navajo County, AZ.

1. Structure Demolition

The mine plan indicates that the office is located at the southern end of the permit area. This facility is mobile therefore it would not be demolished. The office and coal pad area combined take up about 0.5 acres. There are no other structures located on the permit area.

2. Earthmoving Activities

The worst-case reclamation scenario assumes that Pit #21 is completely mined. However, the haul back mining sequence, once in full operation, is conducted such that spoil is hauled immediately behind the active coal mining face and placed within the previous mined-out area. Therefore, it is assumed that 50 percent of Pit #21 and 50 percent of Pit #22 require backfilling. The total volume contained in both stockpiles, plus 20 percent swell, and the volume of the haul-road surfacing is considered to be sufficient to fill the remaining open pit.

The main haul road is located along the western edge of the permit area, runs for 7000 feet and is 30 feet wide. The mine plan states that the haul road will be constructed out of crushed rock obtained from the initial box cut. The crushed rock will be 34 inches thick for the entire haul road length. This material will be removed and disposed of in the open pit by using the same equipment as used to move the spoil from the stockpiles to the open pit.

The mine plan indicates about a 30-foot overburden depth. The highwall is assumed to have a 1/4h:1v slope and the spoil side is assumed to have a 2h:1v slope based on field observation (see *Worksheet 4*). Because the mining operation uses scrapers, backfilling and rough grading is already accomplished. Therefore, Pits #17 through #22 require final grading prior to topsoil replacement.

Reclamation of the coal pad/office area will require that contaminated material be removed to a depth of 10 inches. This material will be disposed of in the open pit.

All existing ponds and the containment berm will be left as part of the approved postmining land use.

3. Topsoil Replacement

The mine plan indicates that 10 inches of topsoil will be salvaged. The topsoil from Pit #22 is assumed to have been removed and placed over Pit #16. The stockpiled topsoil will be used to cover Pits #17 through #22, the haul road, and the office/coal pad area.

WORKSHEET 1 (continued)
DESCRIPTION OF THE WORST-CASE RECLAMATION SCENARIO

The topsoiled areas will then be final graded. The topsoil stockpile located on the west side of Pit# 5 will be referred to as TSW on the worksheets and the topsoil stockpile located on the east side of Pit #10 will be referred to as TSE on the worksheets.

In addition, pits #17 through #22 will need to be ripped prior to topsoil placement. (See *Worksheet 7.*) There will also need to be final grading and scarifying of the topsoil prior to revegetation. (See *Worksheet 3*, item 9.)

4. Revegetation

The worst-case reclamation situation is assumed to occur during the first year of mining at the end of the winter period when approximately 6 months of winter weather would have inhibited the establishment of permanent revegetation. Therefore, Pits #11 through #22, the haul road, and the office and coal pad area would need seedbed preparation, fertilization, seeding, and mulching. No prime farmlands are identified in the mine plan.

Revegetation costs will include the cost for reseeding 5.6 acres of previously disturbed land which has been reclaimed, had an initial seeding applied, but which has not yet been released from liability.

NOTE: Worksheets 6, 10, 11A, 15, 17 and 18 are not applicable to this example.

Data Source(s): Mine plan.

**WORKSHEET 2
 STRUCTURE DEMOLITION AND DISPOSAL COSTS**

Structures to be demolished:

Item	Construction Material	Volume (cubic feet)	Unit Cost Basis (\$)	Demolition Cost (\$)
None*				
Subtotal				

Other items to be demolished (paved roads, conveyors, utility poles, rail spurs, etc.):

*Remove office trailer, 50' x 10'; same price as installation fee = \$545.

Subtotal = \$ 545**

Debris Handling and Disposal Costs:

**Demolition includes disposal with up to 20 miles haul.

TOTAL DEMOLITION AND DISPOSAL = \$ 545

Data Source(s): Means *Site Work and Landscape Cost Data*, 1998; Mine plan.

Project: Haul Back Example
 Date: 12/2/99
 Prepared by: K.J. Bond

**WORKSHEET 3
 MATERIAL HANDLING PLAN SUMMARY**

Earthmoving Activity	Volume (LCY)	Origin	Destination	Haul Distance (ft)	Grade * (%)	Equipment To Be Used
1. Fill Open Pit	60,315	West Overburden Stockpile	Pit #22	1,600 200	3 10	988F loader with 769D trucks
2. Fill Open Pit	60,315	East Overburden Stockpile	Pit #22	800 200	3 10	988F loader with 769D trucks
3. Fill Open Pit	22,037	Haul Road Area	Pit #22	1,800 200	3 10	988F loader with 769D trucks
4. Office Area	672	Coal Pad/Area	Pit #22	3,200 200	3 10	988F loader with 769D trucks
5. Rough Grading	30,326	Disturbed Area	Disturbed Area	100	3	D8R-SU dozer
6. Ripping of Backfill, Haul Road, and Office Areas	70,758	Disturbed Area	Disturbed Area		0	D8R-SU dozer with 3-shank ripper
7. Final Grading of Backfill, Haul Road, and Office Areas	16.2 acres	Disturbed Area	Disturbed Area		0	140H grader
8. Scarification and Final Grading	26.1 acres	Disturbed Area	Disturbed Area		0	140H grader
9. Replace Topsoil in Pits #17-22 Area	14,626	Topsoil Stockpiles	East and West Disturbed Areas	750	4	627F scraper with D8R push tractor
10. Replace Topsoil over Office and Haul Road	7,149	West Topsoil Stockpile	Disturbed Area	2,100	4	627F scraper with D8R push tractor

* Record grade resistance (% grade) here.

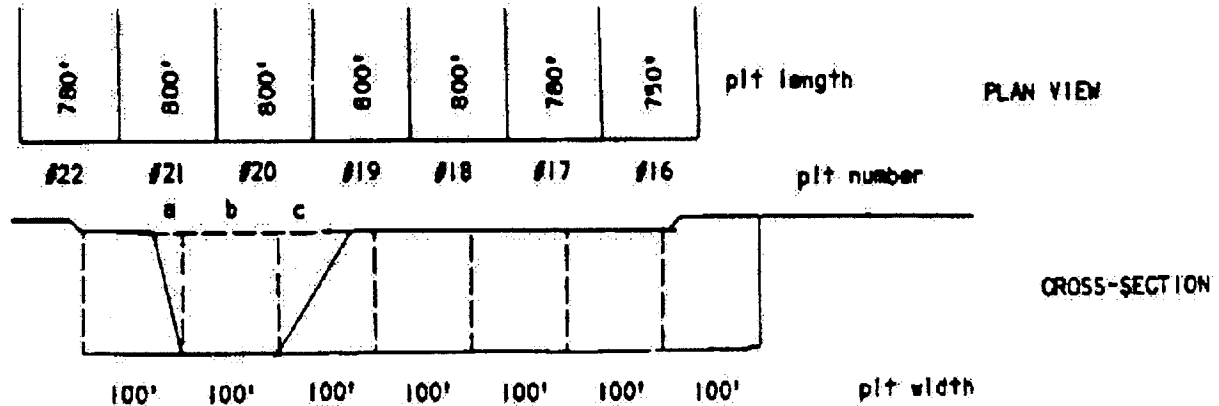
**WORKSHEET 4A
 EARTHWORK QUANTITY**

Cross-Section/ Station	Distance Between Stations (ft)	End Area (ft²)	Volume (yd³)	Adjust- ment Factor * (%)	Adjusted Volume (LCY)
east end of pit		4,031.4			
	800		119,449	1.2	143,339
west end of pit		4,031.4			
TOTALS			119,449		143,339
* Select adjustment factor based on the state of the material to be moved.					

Data Source: Mine plan.

**WORKSHEET 4B
 EARTHWORK QUANTITY**

Earthmoving Volume Area Calculations



Backfilling of Pits #21 and 22 - 50%

Area a: $0.5 \times 30' \times 7.5' = 112.5 \text{ ft}^2$
 Area b: $30' \times 100' = 3,000 \text{ ft}^2$
 Area c: $0.5 \times 30' \times 60' = 900 \text{ ft}^2$
 $= 4,012.5 \text{ ft}^2$

Backfill Volume Needed (Calculations on *Worksheet 4A*) = 143,339 LCY

Haul Road Haul Material

Total haul road volume = 22,037 LCY

The volume and haul distance (from centroid to centroid) for the northern half of the haul road = 12,622 BCY @ 2200'; for the southern half = 9,415 BCY @ 1700'. The total average haul distance = 2000'.

Spoil Ridge Volume = Pit Backfill Volume - Haul Road Volume
 $= 143,339 - 22,037 = 121,302 \text{ LCY}$

A dozer is needed to spread and rough grade this backfill material. Assume that 25% of the material is graded (3% average grade) = $121,302 \times .25 = 30,326$

Office Area, and Coal Pad Area Cleanup

Office / Coal

Pad Area: $0.5 \text{ acres} \times 43,560 \text{ sf/acre}$
 $\times .83' \text{ thick} \div 27 \text{ cf/cy} = 670 \text{ BCY}$

The total average haul distance = 3,400'.

**WORKSHEET 4B (continued)
EARTHWORK QUANTITY**

Topsoil Replacement - Pits #17 through #22, Haul Road, Office Area, and Coal Pad

Pits #17 through #22: 6 pits x 100' wide x 793' long
x .83' thick ÷ 27 cf/cy = 14,626 BCY

Haul Road: 7,000' long x 30' wide
x .83' thick ÷ 27 cf/cy = 6,477 BCY

**Office & Coal
Pad Area:** 0.5 acres x 43,560 sf/acre
x .83' thick ÷ 27 cf/cy = 670 BCY
Total 21,773 BCY

Topsoil Volume

Topsoil Haul Distance:

Assume that total topsoil volume is evenly distributed between the two stockpiles. Therefore,

West Topsoil Stockpile (TSW) = 10,888 cy
East Topsoil Stockpile (TSE) = 10,888 cy

The 7,149 BCY of topsoil required for the haul road, office/coal pad area will come from TSW. The remaining 3,739 topsoil in TSW and the topsoil in TSE will be placed over Pits #17- #22. The total average haul distance for TSW is 2100'. The total average haul distance for remaining TSW and TSE is 750'.

Final Grading/Scarification Area - Pits #11 through #22, Haul Road, Office Area, and Coal Pad

A SEDCAD was used to determine the area of Pits #11 through #22.

Pits #11 - #22	20.8 acres
Haul Road	4.8 acres
Office & Coal Pad Area	<u>0.5 acres</u>
	26.1 acres

Data Source: Mine plan.

**WORKSHEET 5A
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE**

Earthmoving Activity:
Spoil Rough Grading for Pits 17-22.

Characterization of Dozer Used (type, size, etc.):
D8R dozer with "Semi-U or SU" Blade.

Description of Dozer Use (origin, destination, grade, haul distance, material, etc.):
100 ft. push at a +3% effective grade; material is a mixture of earth and blasted sandstone and shale rock.

Productivity Calculations:

$$\begin{aligned} \text{Operating Adjustment Factor} &= \frac{.75}{\text{operator factor}} \times \frac{.80}{\text{material factor}} \times \frac{.83}{\text{efficiency factor}} \times \frac{.95}{\text{grade factor}} \times \\ &\frac{.94^*}{\text{weight correction factor}} \times \frac{1.0}{\text{production method/blade factor}} \times \frac{1.0}{\text{visibility factor}} \times \frac{1.0}{\text{elevation factor}} = \underline{.444} \end{aligned}$$

$$\text{Net Hourly Production} = \frac{870}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{.444}{\text{operating adjustment factor}} = \underline{386.3} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{30,326}{\text{volume to be moved}} \text{ LCY} + \frac{386.3}{\text{net hourly production}} \text{ LCY/hr} = \underline{78.5} \text{ hr}^{**}$$

$$* \frac{2300}{(2,700+2,550+2,100) / 3} = \frac{2,300}{2,450} = 0.94$$

**** Use 301 Total Hours.** Assume D8R-SU is available as support equipment during project life; see *Worksheet 13*.

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 5B
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE**

Earthmoving Activity:
 Pusher tractor to assist loading scrapers.

Characterization of Dozer Used (type, size, etc.):
 D8R dozer with a "SU" Blade.

Description of Dozer Use (origin, destination, grade, haul distance, material, etc.):
 Scrapers loaded with Back-track Loading Method.

Productivity Calculations:

$$\text{Operating Adjustment Factor} = \frac{\text{operator factor}}{\text{operator factor}} \times \frac{\text{material factor}}{\text{material factor}} \times \frac{\text{efficiency factor}}{\text{efficiency factor}} \times \frac{\text{grade factor}}{\text{grade factor}} \times \frac{\text{weight correction factor}}{\text{weight correction factor}} \times \frac{\text{production method/blade factor}}{\text{production method/blade factor}} \times \frac{\text{visibility factor}}{\text{visibility factor}} \times \frac{\text{elevation factor}}{\text{elevation factor}} = \underline{\hspace{2cm}}$$

$$\text{Net Hourly Production} = \frac{\text{normal hourly production}}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{\text{operating adjustment factor}}{\text{operating adjustment factor}} = \underline{\hspace{2cm}} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{\text{volume to be moved}}{\text{volume to be moved}} \text{ LCY} + \frac{\text{net hourly production}}{\text{net hourly production}} \text{ LCY/hr} = \underline{301^*} \text{ hr}$$

***Use 301 total hours for D8R-SU; see Worksheet 13.**

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 7A
 PRODUCTIVITY AND HOURS REQUIRED FOR RIPPER-EQUIPPED DOZER USE**

Ripping Activity:

This unit will be used for ripping Pits #16 through #22 prior to topsoil placement.

Characterization of Dozer and Ripper Use:

D8R w/ SU blade and 3-shank adjustable parallelogram ripper; ripper has a 43 inch (3.58-foot) pocket spacing.

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

Ripping depth = 2.6 feet ; Cut length = 793'
 Ripping effective width = 43"/12"per foot x 3 = 10.75 feet
 Volume = 6 pits x 100' wide x 2.6' deep x 793' long ÷ 27 cy/cf = 45,818 cy

Productivity Calculation*:

$$\text{Cycle time} = \left(\frac{793 \text{ ft}}{\text{cut length}} \div \frac{88 \text{ ft/min}}{\text{[speed]}} \right) + \frac{0.25 \text{ min}}{\text{fixed turn time**}} = 9.3 \text{ min/pass}$$

$$\text{Passes/hour} = 60 \text{ min/hr} \div \frac{9.3 \text{ min/pass}}{\text{cycle time}} \times \frac{.83}{\text{efficiency factor}} = 5.35 \text{ passes/hr}$$

$$\text{Volume cut per pass} = \left(\frac{2.6 \text{ ft}}{\text{tool penetration}} \times \frac{10.75 \text{ ft}}{\text{cut spacing}} \times \frac{793 \text{ ft}}{\text{cut length}} \right) \div 27 \text{ ft}^3/\text{yd}^3 = 820.9 \text{ BCY/pass}$$

$$\text{Hourly Production} = 820.9 \text{ BCY/pass} \times 5.35 \text{ passes/hr} = 4,391.8 \text{ BCY/hr}$$

$$\text{Hours Required} = \frac{45,818 \text{ BCY}}{\text{bank volume to be ripped}} \div \frac{4,391.8 \text{ BCY/hr}}{\text{hourly production***}} = 10 \text{ hrs***}$$

* Remember to use the swell factor to convert from bank cubic yards to loose cubic yards when applying these data to *Worksheet 5*. Calculate separate dozer hauling of ripped material for each lift on *Worksheet 5*.

** Fixed turn time is dependent on dozer used. Normally 0.25 min. per turn is used.

*** Use 301 hours (support equipment, see *Worksheet 13*)

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 7B
 PRODUCTIVITY AND HOURS REQUIRED FOR RIPPER-EQUIPPED DOZER USE**

Ripping Activity:

Rip the 30.1' wide haul road prior to topsoil placement.

Characterization of Dozer and Ripper Use:

D8R w/ SU blade and 3-shank adjustable parallelogram ripper; ripper has a 43 inch (3.58-foot) pocket spacing.

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

Ripping depth = 2.6' Length = 7,000'
 Ripping effective width = 43"/12" per foot X 3 = 10.75'
 Volume = 7,000' x 30' wide x 2.6' deep ÷ 27 cy/cf = 20,222 cy

Productivity Calculation*:

$$\text{Cycle time} = \left(\frac{7,000 \text{ ft}}{\text{cut length}} \div \frac{88 \text{ ft/min}}{\text{[speed]}} \right) + \frac{0.25 \text{ min}}{\text{fixed turn time**}} = \underline{79.8} \text{ min/pass}$$

$$\text{Passes/hour} = 60 \text{ min/hr} \div \frac{79.8 \text{ min/pass}}{\text{cycle time}} \times \frac{.83}{\text{efficiency factor}} = \underline{.62} \text{ passes/hr}$$

$$\text{Volume cut per pass} = \left(\frac{2.6 \text{ ft}}{\text{tool Penetration}} \times \frac{10.75 \text{ ft}}{\text{cut spacing}} \times \frac{7,000 \text{ ft}}{\text{cut length}} \right) \div 27 \text{ ft}^3/\text{yd}^3 = \underline{7,246} \text{ BCY/pass}$$

$$\text{Hourly Production} = \underline{7,246} \text{ BCY/pass} \times \underline{.62} \text{ passes/hr} = \underline{4,492.7} \text{ BCY/hr}$$

$$\text{Hours Required} = \frac{20,222 \text{ BCY}}{\text{bank volume to be to be ripped}} \div \frac{4,492.7 \text{ BCY/hr}}{\text{hourly production***}} = \underline{4.5} \text{ hrs****}$$

* Remember to use the swell factor to convert from bank cubic yards to loose cubic yards when applying these data to *Worksheet 5*. Calculate separate dozer hauling of ripped material for each lift on *Worksheet 5*.

** Fixed turn time is dependent on dozer used. Normally 0.25 min. per turn is used.

*** This D8R-SU bulldozer is to be for rough grading of the backfill area (see *Worksheets 5A, 7A and 7B*).

**** Use 301 total hours, see *Worksheet 7A*; support equipment, see *Worksheet 13*.

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 7C
 PRODUCTIVITY AND HOURS REQUIRED FOR RIPPER-EQUIPPED DOZER USE**

Ripping Activity:

Rip the office/coal pad area prior to topsoil placement.

Characterization of Dozer and Ripper Use:

D8R w/ SU blade and 3-shank adjustable parallelogram ripper; ripper has a 43 inch (3.58-foot) pocket spacing.

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

Ripping depth = 2.6'

Length = 148'

Ripping effective width = 43"/12" per foot X 3 = 10.75'

Area = 21,780 sf (0.5 ac.)

Volume = 21,780 sf x 2.6' deep ÷ 27 cy/cf = 2,097 cy

Productivity Calculation*:

$$\text{Cycle time} = \left(\frac{148 \text{ ft}}{\text{cut length}} \div \frac{88 \text{ ft/min}}{\text{[speed]}} \right) + \frac{0.25 \text{ min}}{\text{fixed turn time**}} = 1.93 \text{ min/pass}$$

$$\text{Passes/hour} = 60 \text{ min/hr} \div \frac{1.93 \text{ min/pass}}{\text{cycle time}} \times \frac{.83}{\text{efficiency factor}} = 25.80 \text{ passes/hr}$$

$$\text{Volume cut per pass} = \left(\frac{2.6 \text{ ft}}{\text{tool penetration}} \times \frac{10.75 \text{ ft}}{\text{cut spacing}} \times \frac{148 \text{ ft}}{\text{cut length}} \right) \div 27 \text{ ft}^3/\text{yd}^3 = 153.2 \text{ BCY/pass}$$

$$\text{Hourly Production} = 153.2 \text{ BCY/pass} \times 25.80 \text{ passes/hr} = 3,952.6 \text{ BCY/hr}$$

$$\text{Hours Required} = \frac{2,097 \text{ BCY/ yd}^3}{\text{bank volume to be ripped}} \div \frac{3,952.6 \text{ BCY/hr}}{\text{hourly production}} = .53 \text{ hrs***}$$

* Remember to use the swell factor to convert from bank cubic yards to loose cubic yards when applying these data to *Worksheet 5*. Calculate separate dozer hauling of ripped material for each lift on *Worksheet 5*.

** Fixed turn time is dependent on dozer used. Normally 0.25 min. per turn is used.

*** Use 301 total hours, see *Worksheet 7A*; support equipment, see *Worksheet 13*.

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 8A
 PRODUCTIVITY AND HOURS REQUIRED FOR LOADER USE**

Earthmoving Activity:

Load haul truck with spoil from overburden stockpile, west (OSW).

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

988F, Spade-edge 8 cy rock bucket, 11.5' dump height clearance.

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

Loading 35 ton trucks from stockpile with minimum haul.

Productivity Calculations:

$$\text{Cycle time} = \frac{0}{\text{haul time (loaded)}} + \frac{0}{\text{return time (empty)}} + \frac{.575}{\text{basic cycle time}} = \underline{.575} \text{ min}$$

$$\text{Net Bucket Capacity} = \frac{8}{\text{heaped bucket capacity}} \text{ LCY} \times \frac{.8}{\text{bucket fill factor}^*} = \underline{6.4} \text{ LCY}$$

$$\text{Hourly Production} = \frac{6.4}{\text{net bucket capacity}} \text{ LCY} \div \frac{.575}{\text{cycle time}} \text{ min} \times \frac{.75}{\text{efficiency factor}} \times 60 \text{ min/hr} = \underline{501} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{60,315}{\text{volume to be moved}} \text{ LCY} \div \frac{501}{\text{hourly production}} \text{ LCY/hr} = \underline{120} \text{ hr}$$

*See loader section of equipment manual.

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 8B
PRODUCTIVITY AND HOURS REQUIRED FOR LOADER USE**

Earthmoving Activity:

Load haul truck with spoil from overburden stockpile, west (OSE).

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

988F, Spade-edge 8 cy rock bucket, 11.5' dump height clearance.

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

Loading 35 ton trucks from stockpile with minimum haul.

Productivity Calculations:

$$\text{Cycle time} = \frac{0}{\text{haul time (loaded)}} + \frac{0}{\text{return time (empty)}} + \frac{.575}{\text{basic cycle time}} = \underline{.575} \text{ min}$$

$$\text{Net Bucket Capacity} = \frac{8}{\text{heaped bucket capacity}} \text{ LCY} \times \frac{.8}{\text{bucket fill factor}^*} = \underline{6.4} \text{ LCY}$$

$$\text{Hourly Production} = \frac{6.4}{\text{net bucket capacity}} \text{ LCY} \div \frac{.575}{\text{cycle time}} \text{ min} \times \frac{.75}{\text{efficiency factor}} \times 60 \text{ min/hr} = \underline{501} \text{ LCY/h.}$$

$$\text{Hours Required} = \frac{60,315}{\text{volume to be moved}} \text{ LCY} \div \frac{501}{\text{hourly production}} \text{ LCY/hr} = \underline{120} \text{ hr}$$

*See loader section of equipment manual.

Data Source(s): Caterpillar Performance Handbook, Edition 29.

WORKSHEET 8C
PRODUCTIVITY AND HOURS REQUIRED FOR LOADER USE

Earthmoving Activity:

Excavate and load road base material.

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

988F, 8 cy spade-edge rock bucket.

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

Approximately 50' haul at a 4% effective grade.

Productivity Calculations:

$$\text{Cycle time} = \frac{.15}{\text{haul time (loaded)}} + \frac{.135}{\text{return time (empty)}} + \frac{.575}{\text{basic cycle time}} = \underline{.86} \text{ min}$$

$$\text{Net Bucket Capacity} = \frac{8}{\text{heaped bucket capacity}} \text{ LCY} \times \frac{.9}{\text{bucket fill factor}^*} = \underline{7.2} \text{ LCY.}$$

$$\text{Hourly Production} = \frac{7.2}{\text{net bucket capacity}} \text{ LCY} \div \frac{.86}{\text{cycle time}} \text{ min} \times \frac{.75}{\text{efficiency factor}} \times 60 \text{ min/hr} = \underline{376.7} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{22,037}{\text{volume to be moved}} \text{ LCY} \div \frac{376.7}{\text{hourly production}} \text{ LCY/hr} = \underline{59} \text{ hr}$$

*See loader section of equipment manual.

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 8D
PRODUCTIVITY AND HOURS REQUIRED FOR LOADER USE**

Earthmoving Activity:

Office and coal pad area waste cleanup: Remove 10 inches of contaminated material and place in final pit.

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

988F with 8 cy spade-edge rock bucket, 11.5' dump height

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

Approximately 50' haul and loading of 35 ton trucks.

Productivity Calculations:

$$\text{Cycle time} = \frac{0.15}{\text{haul time (loaded)}} + \frac{0.135}{\text{return time (empty)}} + \frac{0.575}{\text{basic cycle time}} = 0.86 \text{ min}$$

$$\text{Net Bucket Capacity} = \frac{8.0}{\text{heaped bucket capacity}} \text{ LCY} \times \frac{0.9}{\text{bucket fill factor}^*} = 7.2 \text{ LCY}$$

$$\text{Hourly Production} = \frac{7.2}{\text{net bucket capacity}} \text{ LCY} \div \frac{0.86}{\text{cycle time}} \text{ min} \times \frac{0.75}{\text{efficiency factor}} \times 60 \text{ min/hr} = 376.7 \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{670}{\text{volume to be moved}} \text{ LCY} \div \frac{376.7}{\text{hourly production}} \text{ LCY/hr} = 2.0 \text{ hr}$$

*See loader section of equipment manual.

NOTE: Total hours for 988F = 120 + 120 + 59 + 2 = 301 hours.

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 9A
 PRODUCTIVITY AND HOURS REQUIRED FOR TRUCK USE**

Earthmoving Activity:

Haul spoil from Overburden Stockpile West (OSW) to open pit.

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

Caterpillar 769D, (21.6 + 31.7) ÷ 2 = 27cy average capacity (ave of struck and heaped).

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

Haul distance and grade from OSW to open pit.

Haul: 1600' @ 3% effective grade plus 200' @ 10% effective grade;

Return: 1600' @ 3% effective grade plus 200' @ (-)7% effective grade

Productivity Calculations:

$$\text{No. Loader Passes/Truck} = \frac{27 \text{ LCY}}{\text{truck capacity}^*} \div \frac{6.4 \text{ LCY}}{\text{loader bucket net capacity}} = \frac{4.22}{\text{(round down to nearest whole number)}} \text{ passes}$$

$$\text{Net Truck Capacity} = \frac{6.4 \text{ LCY}}{\text{loader bucket net capacity}} \times \frac{4}{\text{no. loader passes/truck}} = \frac{25.6}{\text{LCY}}$$

$$\text{Loading Time/Truck} = \frac{.575 \text{ min}}{\text{loader cycle time (from Worksheet 8 or 10)}} \times \frac{4}{\text{no. loader passes/truck}} = \frac{2.3}{\text{min}}$$

$$\text{Truck Cycle Time} = \frac{.6 + .1}{\text{haul time}} + \frac{.45 + .1^{**}}{\text{return time}} + \frac{2.3}{\text{loading time}} + \frac{2.0}{\text{dump and maneuver time}} = \frac{5.55}{\text{min}}$$

$$\text{No. of Trucks Required} = \frac{5.55 \text{ min}}{\text{truck cycle time}} + \frac{2.3 \text{ min}}{\text{loading time}} = \frac{2.41}{\text{trucks}}$$

$$\text{Production Rate} = \frac{27 \text{ LCY}}{\text{truck capacity}^*} \times \frac{3}{\text{no. of trucks}} + \frac{5.55 \text{ min}}{\text{truck cycle time}} = \frac{14.59}{\text{LCY/min}}$$

$$\text{Hourly Production} = \frac{14.59 \text{ LCY/min}}{\text{production rate}} \times 60 \text{ min/hr} \times \frac{.75}{\text{efficiency factor}} = \frac{656.6}{\text{LCY/hr}}$$

$$\text{Hours Required} = \frac{60,315 \text{ LCY}}{\text{volume to be moved}} + \frac{656.6 \text{ LCY/hr}}{\text{hourly production}} = \frac{91.9}{\text{hr}}$$

NOTE: Use 3 trucks for 120 hours each to match loader, see Worksheet 8A.

* Normally the average of the struck and heaped capacities.

** 200' + (25 MPH x 88FPM/1 MPH) = 0.09 min (use 0.1).

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 9B
 PRODUCTIVITY AND HOURS REQUIRED FOR TRUCK USE**

Earthmoving Activity:

Haul spoil from Overburden Stockpile East (OSE) to open pit.

Characterization of Truck Use (type, size, etc.)

Caterpillar 769D, $(21.6 + 31.7) \div 2 = 27$ cy average capacity (ave of struck and heaped).

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

Haul distance and grade from OSE to open pit.

Haul: 800' @ 3% effective grade plus 200' @ 10% grade

Return: 800' @ 3% effective grade plus 200' @ (-)7% grade

Productivity Calculations:

$$\text{No. Loader Passes/Truck} = \frac{27 \text{ LCY}}{\text{truck capacity}^*} \div \frac{6.4 \text{ LCY}}{\text{loader bucket net capacity}} = \frac{4.22}{\text{(round down to nearest whole number)}} \text{ passes}$$

$$\text{Net Truck Capacity} = \frac{6.4 \text{ LCY}}{\text{loader bucket net capacity}} \times \frac{4}{\text{no. loader passes/truck}} = 25.6 \text{ LCY}$$

$$\text{Loading Time/Truck} = \frac{.575 \text{ min}}{\text{loader cycle time (from Worksheet 8 or 10)}} \times \frac{4}{\text{no. loader passes/truck}} = 2.3 \text{ min}$$

$$\text{Truck Cycle Time} = \frac{.4 + .2}{\text{haul time}} + \frac{.3 + .1^{**}}{\text{return time}} + \frac{2.3}{\text{loading time}} + \frac{2.0}{\text{dump and maneuver time}} = 5.3 \text{ min}$$

$$\text{No. of Trucks Required} = \frac{5.3 \text{ min}}{\text{truck cycle time}} \div \frac{2.3 \text{ min}}{\text{loading time}} = 2.3 \text{ trucks.}$$

$$\text{Production Rate} = \frac{27 \text{ LCY}}{\text{truck capacity}^{**}} \times \frac{3}{\text{no. of trucks}} \div \frac{5.3 \text{ min}}{\text{truck cycle time}} = 15.3 \text{ LCY/min}$$

$$\text{Hourly Production} = \frac{15.3 \text{ LCY/min}}{\text{production rate}} \times 60 \text{ min/hr} \times \frac{.75}{\text{efficiency factor}} = 688.5 \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{60,315 \text{ LCY}}{\text{volume to be moved}} \div \frac{688.5 \text{ LCY/hr}}{\text{hourly production}} = 87.6 \text{ hr}$$

NOTE: Use 3 trucks for 120 hours each to match loader, see Worksheet 8B.

* Normally the average of the struck and heaped capacities.

** $200' \div (25 \text{ MPH} \times 88 \text{ FPM} / 1 \text{ MPH}) = 0.09 \text{ min}$ (use 0.1).

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 9C
 PRODUCTIVITY AND HOURS REQUIRED FOR TRUCK USE**

Earthmoving Activity:
 Haul spoil base material to open pit.

Characterization of Truck Use (type, size, etc.)
 Caterpillar 769D, (21.6 + 31.7) ÷ 2 = 27 cy average capacity (ave of struck and heaped).

Description of Truck Use (origin, destination, grade, haul distance, capacity, etc.):
 1800' @ 3% effective grade and 200' haul @ 10% effective grade
 1800' @ 3% effective grade and 200' haul @ (-)7% effective grade

Productivity Calculations:

$$\text{No. Loader Passes/Truck} = \frac{27 \text{ LCY}}{\text{truck capacity}^*} \div \frac{6.4 \text{ LCY}}{\text{loader bucket net capacity}} = \frac{4.22}{\text{(round down to nearest whole number)}} \text{ passes}$$

$$\text{Net Truck Capacity} = \frac{6.4 \text{ LCY}}{\text{loader bucket net capacity}} \times \frac{4}{\text{no. loader passes/truck}} = 25.6 \text{ LCY}$$

$$\text{Loading Time/Truck} = \frac{.575 \text{ min}}{\text{loader cycle time (from Worksheet 8 or 10)}} \times \frac{4}{\text{no. loader passes/truck}} = 2.3 \text{ min}$$

$$\text{Truck Cycle Time} = \frac{.8 + .2}{\text{haul time}} + \frac{0.3 + .1^{**}}{\text{return time}} + \frac{2.3}{\text{loading time}} + \frac{2.0}{\text{dump and maneuver time}} = 5.70 \text{ min}$$

$$\text{No. of Trucks Required} = \frac{5.70 \text{ min}}{\text{truck cycle time}} \div \frac{2.3 \text{ min}}{\text{loading time}} = 2.5 \text{ trucks.}$$

$$\text{Production Rate} = \frac{27 \text{ LCY}}{\text{truck capacity}^*} \times \frac{2}{\text{no. of trucks}} \div \frac{5.7 \text{ min}}{\text{truck cycle time}} = 9.47 \text{ LCY/min}$$

$$\text{Hourly Production} = \frac{9.47 \text{ LCY/min}}{\text{production rate}} \times 60 \text{ min/hr} \times \frac{.75}{\text{efficiency factor}} = 426.3 \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{22,037 \text{ LCY}}{\text{volume to be moved}} \div \frac{426.3 \text{ LCY/hr}}{\text{hourly production}} = 51.7 \text{ hr}$$

NOTE: Use 2 trucks for 59 hours each to match loader, see Worksheet 8C.

* Normally the average of the struck and heaped capacities.

** 200' + (25 MPH x 88FPM/1 MPH) = 0.09 min (use 0.1).

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 9D
 PRODUCTIVITY AND HOURS REQUIRED FOR TRUCK USE**

Earthmoving Activity:

Haul office area/coal pad waste material to open pit for burial.

Characterization of Truck Use (type, size, etc.)

Caterpillar 769C, (21.6 + 31.7) ÷ 2 = 27 cy average capacity (ave of the struck and heaped).

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

Haul: 3200' at 3% effective grade and 200' @ 10% effective grade.

Return: 3200' at 3% effective grade and 200' @ (-)7% effective grade.

Productivity Calculations:

$$\text{No. Loader Passes/Truck} = \frac{27 \text{ LCY}}{\text{truck capacity}^*} \div \frac{6.4 \text{ LCY}}{\text{loader bucket net capacity}} = \frac{4.22}{\text{(round down to nearest whole number)}} \text{ passes}$$

$$\text{Net Truck Capacity} = \frac{6.4 \text{ LCY}}{\text{loader bucket net capacity}} \times \frac{4}{\text{no. loader passes/truck}} = 25.6 \text{ LCY}$$

$$\text{Loading Time/Truck} = \frac{.575 \text{ min}}{\text{loader cycle time (from Worksheet 8 or 10)}} \times \frac{4}{\text{no. loader passes/truck}} = 2.3 \text{ min}$$

$$\text{Truck Cycle Time} = \frac{1.35}{\text{haul time}} + \frac{.2}{\text{return time}} + \frac{.9 + .1^{**}}{\text{return time}} + \frac{2.3}{\text{loading time}} + \frac{2.0}{\text{dump and maneuver time}} = 6.85 \text{ min}$$

$$\text{No. of Trucks Required} = \frac{6.85 \text{ min}}{\text{truck cycle time}} \div \frac{2.3 \text{ min}}{\text{loading time}} = 2.98 \text{ trucks}$$

$$\text{Production Rate} = \frac{27 \text{ LCY}}{\text{truck capacity}^*} \times \frac{3}{\text{no. of trucks}} \div \frac{6.85 \text{ min}}{\text{truck cycle time}} = 11.82 \text{ LCY/min}$$

$$\text{Hourly Production} = \frac{11.82 \text{ LCY/min}}{\text{production rate}} \times 60 \text{ min/hr} \times \frac{.75}{\text{efficiency factor}} = 532.1 \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{670 \text{ LCY}}{\text{volume to be moved}} \div \frac{532.1 \text{ LCY/hr}}{\text{hourly production}} = 1.26 \text{ hr}$$

NOTE: Use 3 trucks for 2 hours each to match loader, see Worksheet 8D.

* Normally the average of the struck and heaped capacities.

** 200' + (25 MPH x 88FPM/1 MPH) = 0.09 min (use 0.1).

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 11B-1
 PRODUCTIVITY OF DOZER PUSH-LOADED SCRAPER USE**

Earthmoving Activity:

Replacing topsoil over Pits #17 - #22.

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

Cat 627F Non-push pull 14cy (struck) + 20 cy (heaped) = (14 cy + 20 cy)/2 = 17 cy ave capacity.

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

750' haul @ 4% effective grade; 750' return @ 4% effective grade.

List Pusher Tractor(s) Used:

D8N dozer will assist the scraper in loading.

Describe Push Tractor Loading Method (see figure):

Back-track loading method with a single push tractor.

Scraper Productivity Calculations:

$$\text{Cycle Time} = \frac{.5}{\text{load time (push-pull is per pair)}} + \frac{.5}{\text{loaded trip time}} + \frac{.6}{\text{maneuver and spread time}} + \frac{.5}{\text{return trip time}} = \frac{2.1}{\text{min (push-pull is per pair)}}$$

$$\text{Hourly Production} = \frac{17}{\text{capacity}^*} \text{ LCY} \times 60 \text{ min/hr} \div \frac{2.1}{\text{cycle time}} \text{ min} \times \frac{.75}{\text{efficiency factor}} = \frac{364.29}{\text{LCY/hr}}$$

$$\text{Hours Required} = \frac{14,626}{\text{volume to be handled}} \text{ LCY} \div \frac{364.29}{\text{net hourly production}} \text{ LCY/hr} = \frac{40}{\text{hr}}$$

* The average of the struck and heaped capacities; use total for two scrapers for push-pull.

Push Tractor Productivity Calculations:

$$\text{Pusher Cycle Time} = \frac{.5}{\text{scraper load time}} \text{ min} \times \frac{1.5}{\text{pusher factor}} = \frac{.75}{\text{min}}$$

$$\text{Scrapers per Pusher} = \frac{2.1}{\text{scraper cycle time}} \text{ min} \div \frac{.75}{\text{pusher cycle time}} \text{ min} = \frac{2.8}{\text{(round down)}}$$

$$\text{Pusher Hours Required} = \frac{40}{\text{scraper hours}} \text{ hrs} \div \frac{2}{\text{scrapers per pusher}} = \frac{20}{\text{(round up)}}$$

Data Source(s): Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 11B-2
 PRODUCTIVITY OF DOZER PUSH-LOADED SCRAPER USE**

Earthmoving Activity:

Replacing topsoil over office area and haul road.

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

Cat 627F Non-push pull 14cy (struck) + 20 cy (heaped) = (14 cy + 20 cy)/2 = 17 cy avg capacity.

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

2,100' haul @ 4% effective grade; 2,100' return @ 4% effective grade.

List Pusher Tractor(s) Used:

D8N dozer will assist the scraper in loading.

Describe Push Tractor Loading Method (see figure on next page):

Back-track loading method with 1 push tractor.

Scraper Productivity Calculations:

$$\begin{array}{l} \text{Cycle Time} = \frac{.5}{\text{load time (push-pull is per pair)}} + \frac{1.1}{\text{loaded trip time}} + \frac{.6}{\text{maneuver and spread time}} + \frac{.8}{\text{return trip time}} = \frac{3.0}{\text{(push-pull is per pair)}} \text{ min} \end{array}$$

$$\begin{array}{l} \text{Hourly Production} = \frac{17}{\text{capacity}^*} \text{ LCY} \times 60 \text{ min/hr} \div \frac{3.0}{\text{cycle time}} \text{ min} \times \frac{.75}{\text{efficiency factor}} = \frac{255}{\text{LCY/hr}} \end{array}$$

$$\begin{array}{l} \text{Hours Required} = \frac{7,149}{\text{volume to be handled}} \text{ LCY} \div \frac{255}{\text{net hourly production}} \text{ LCY/hr} = \frac{28.04}{\text{hr}} \end{array}$$

* The average of the heaped and struck capacities; use total for two scrapers for push-pull.

Push Tractor Productivity Calculations:

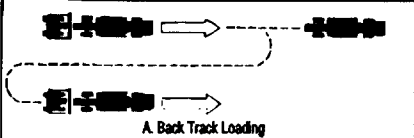
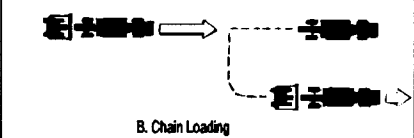
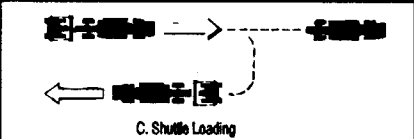
$$\begin{array}{l} \text{Pusher Cycle Time} = \frac{.5}{\text{scraper load time}} \text{ min} \times \frac{1.5}{\text{pusher factor}} = \frac{.75}{\text{min}} \end{array}$$

$$\begin{array}{l} \text{Scrapers per Pusher} = \frac{3.0}{\text{scraper cycle time}} \text{ min} \div \frac{.75}{\text{pusher cycle time}} \text{ min} = \frac{4.0}{\text{(round down)}} \text{ min} \end{array}$$

$$\begin{array}{l} \text{Pusher Hours Required} = \frac{28.04}{\text{scraper hours}} \text{ hrs} \div \frac{2}{\text{scrapers per pusher (match Worksheet 11-B-1)}} = \frac{14.0}{\text{(round up)}} \text{ hr} \end{array}$$

Data Source(s): Caterpillar Performance Handbook, Edition 29.

WORKSHEET 11B (continued)
PRODUCTIVITY OF DOZER PUSH-LOADED SCRAPER USE

PUSHER FACTORS	Single Push	Tandem Push
 A. Back Track Loading	1.5	2.0
 B. Chain Loading	1.3	1.5
 C. Shuttle Loading	1.3	1.5

Modified from Terex, 1981

Data Source(s): Illustration from "Production and Cost Estimating of Material Movement and Earthmoving Equipment," TEREX AMERICAS, Tulsa, OK 74107, (918) 445-5802. See disclaimer in Appendix A, *Worksheet 11B*.

**WORKSHEET 12A
 PRODUCTIVITY AND HOURS REQUIRED FOR MOTORGRADER USE**

Earthmoving Activity:

Final grade ripped area prior to placing topsoil.

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

Caterpillar 140H; 215 horsepower, equipped with EROPS, scarifier/ripper.

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

**Pit area (#17- #22) = 10.9 acres; Haul road area = 10.9 acres; Coal pad/office area = 0.5 acres
 TOTAL: 16.2 acres**

Productivity Calculations:

Grading

Hourly

$$\text{Production} = \frac{2.8}{\text{average speed}} \text{ mi/hr} \times \frac{9}{\text{effective blade width}} \text{ ft} \times 5,280 \text{ ft/mi} \times 1 \text{ ac}/43,560 \text{ ft}^2 \times \frac{.75}{\text{efficiency factor}} = \frac{2.29}{\text{ac/hr}}$$

$$\text{Hours Required} = \frac{16.2}{\text{area to be graded}} \text{ ac} \div \frac{2.29}{\text{hourly production}} \text{ ac/hr} = \frac{7}{\text{hr}}$$

Scarification - N/A

Hourly

$$\text{Production} = \frac{\text{mi/hr}}{\text{average speed}} \times \frac{\text{ft}}{\text{scarifier width}} \times 5,280 \text{ ft/mi} \times 1 \text{ ac}/43,560 \text{ ft}^2 \times \frac{\text{efficiency factor}}{\text{efficiency factor}} = \text{ac/hr}$$

$$\text{Hours Required} = \frac{\text{ac}}{\text{area to be scarified}} + \frac{\text{ac/hr}}{\text{hourly production}} = \text{hr}$$

Total Hours = 301*

***Total support equipment hours is 301 (see *Worksheet 13*).**

Data Source(s): Caterpillar Performance Handbook, Edition 29.

Project: Haul Back Example
 Date: 12/2/99
 Prepared by: K.J. Bond

**WORKSHEET 12B
 PRODUCTIVITY AND HOURS REQUIRED FOR MOTORGRADER USE**

Earthmoving Activity:

Scarify all disturbance prior to re-seeding.

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

Caterpillar 140H; 215 horsepower, equipped with EROPS, scarifier/ripper.

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

Pit area (#11- #22) = 20.8 acres; Haul road area = 4.8 acres; Coal pad/office area = 0.5 acres
 TOTAL: 26.1 acres

Productivity Calculations:

Grading - N/A

Hourly
 Production = $\frac{\text{mi/hr}}{\text{average speed}} \times \frac{\text{ft}}{\text{effective blade width}} \times 5,280 \text{ ft/mi} \times 1 \text{ ac}/43,560 \text{ ft}^2 \times \frac{\text{efficiency factor}}{\text{efficiency factor}} = \text{ac/hr}$

Hours Required = $\frac{\text{ac}}{\text{area to be graded}} \div \frac{\text{ac/hr}}{\text{hourly production}} = \text{hr}$

Scarification

Hourly
 Production = $\frac{2.8 \text{ mi/hr}}{\text{average speed}} \times \frac{7.67 \text{ ft}}{\text{scarifier width}} \times 5,280 \text{ ft/mi} \times 1 \text{ ac}/43,560 \text{ ft}^2 \times \frac{.75 \text{ efficiency factor}}{\text{efficiency factor}} = 1.95 \text{ ac/hr}$

Hours Required = $\frac{26.1 \text{ ac}}{\text{area to be scarified}} + \frac{1.95 \text{ ac/hr}}{\text{hourly production}} = 13.36 \text{ hr}$

Total Hours = 301*

* Motorgrader is assumed to be onsite support equipment during total project (see *Worksheet 13*).

Data Source(s): Caterpillar Performance Handbook, Edition 29.

Project: Haul Back Example
 Date: 12/2/99
 Prepared by: K.J. Bond

**WORKSHEET 13
 SUMMARY CALCULATION OF EARTHMOVING COSTS**

Equipment *	Ownership & Operation Cost (\$/hr)	Labor Cost (\$/hr)	Total Hours Required	Total Cost *** (\$)
627F Scraper	113.47	22.39	34**	4,619
627F Scraper	113.47	22.39	34**	4,619
D8R-SU Push Tractor	84.13	22.39	34**	3,622
988F Loader	100.40	23.47	301*	37,285
D8R-SU Dozer with 3 shank ripper	95.28	22.39	301*	35,419
140 H Grader	37.04	22.39	301*	17,888
6,000 gal. Water Tank	69.96	17.80	301*	26,416
769D Truck	86.09	19.89	360****	38,153
769D Truck	86.09	19.89	360****	38,153
769D Truck	86.09	19.89	118****	12,506
769D Truck	86.09	19.89	6****	636
Grand Total				\$219,316
<p>* Include all necessary attachments and accessories for each item of equipment. Also, add support equipment such as water wagons and graders to match total project time as appropriate. Total Project Time = total truck and loader time = 120 + 120 + 59 + 2 = 301 hours; therefore support equipment time will equal 301 hours.</p> <p>** Account for multiple units in truck and/or scraper teams.</p> <p>*** To compute Total Cost: Add Ownership & Operation Cost and Labor Cost columns then multiply by Total Hours Required column.</p> <p>**** See Worksheets 9A, B, C and D.</p>				

Data Source(s): D8R-SU hourly rate estimate quoted by PRIMEDIA (PRIMEDIA Information, Inc., Cost Reference Guide for Construction Equipment.) Labor cost for last five items from AZ 990017 (08/06/99); assume wages for highway use truck drivers, Navajo County.

**WORKSHEET 14
 REVEGETATION COSTS**

Name and Description of Area to be Revegetated:

Pits #11 - #22 = 20.8 acres; Haul road = 4.8 acres; Coal pad/office area = 0.5 acres;
 TOTAL = 26.1 acres

Description of Revegetation Activities:

No special revegetation activities required. Seedbed preparation has already taken place. The local NRCS office provided an average revegetation cost of \$450/acre.

Cost Calculation for Individual Revegetation Activities:

Initial Seeding

$$\frac{26.1}{\text{area to be seeded}} \text{ ac} \times \left(\$ \frac{\quad}{\text{seedbed preparation}} / \text{ac} + \$ \frac{450}{\text{seeding, fertilizing \& mulching}} / \text{ac} \right) = \$ \underline{11,745}$$

Planting Trees and Shrubs

$$\frac{\quad}{\text{area to be planted}} \text{ ac} \times \left(\$ \frac{\quad}{\text{planting}} / \text{ac} + \$ \frac{\quad}{\text{herbicide treatment}} / \text{ac} \right) = \$ \underline{0}$$

Reseeding

$$\frac{31.7}{\text{area to be seeded \& unreleased disturbed areas}} \text{ ac} \times \frac{.25}{\text{failure rate}^*} \times \left(\$ \frac{\quad}{\text{seedbed preparation}} / \text{ac} + \$ \frac{450}{\text{seeding, fertilizing \& mulching}} / \text{ac} \right) = \$ \underline{3,566}$$

Replanting Trees and Shrubs

$$\frac{\quad}{\text{area to be planted \& unreleased disturbed areas}} \text{ ac} \times \frac{\quad}{\text{failure rate}^*} \times \left(\$ \frac{\quad}{\text{planting}} / \text{ac} + \$ \frac{\quad}{\text{herbicide treatment}} / \text{ac} \right) = \$ \underline{0}$$

Other Revegetation Activity for this Area:

(Examples of other activities that may be necessary include soil sampling, irrigation, and rill and gully repair. Describe each activity and provide a cost estimate with documentation. Use additional worksheets if necessary.)

Other Costs: \$ _____

TOTAL REVEGETATION COST FOR THIS AREA = \$ 15,311

* The 25% failure rate is applied to all initial seeding disturbance (26.1 acres) plus reclaimed but unreleased areas within the permit boundary (5.6 acres).

Data Source(s): Mine plan and local NRCS.

**WORKSHEET 16
 RECLAMATION BOND SUMMARY SHEET**

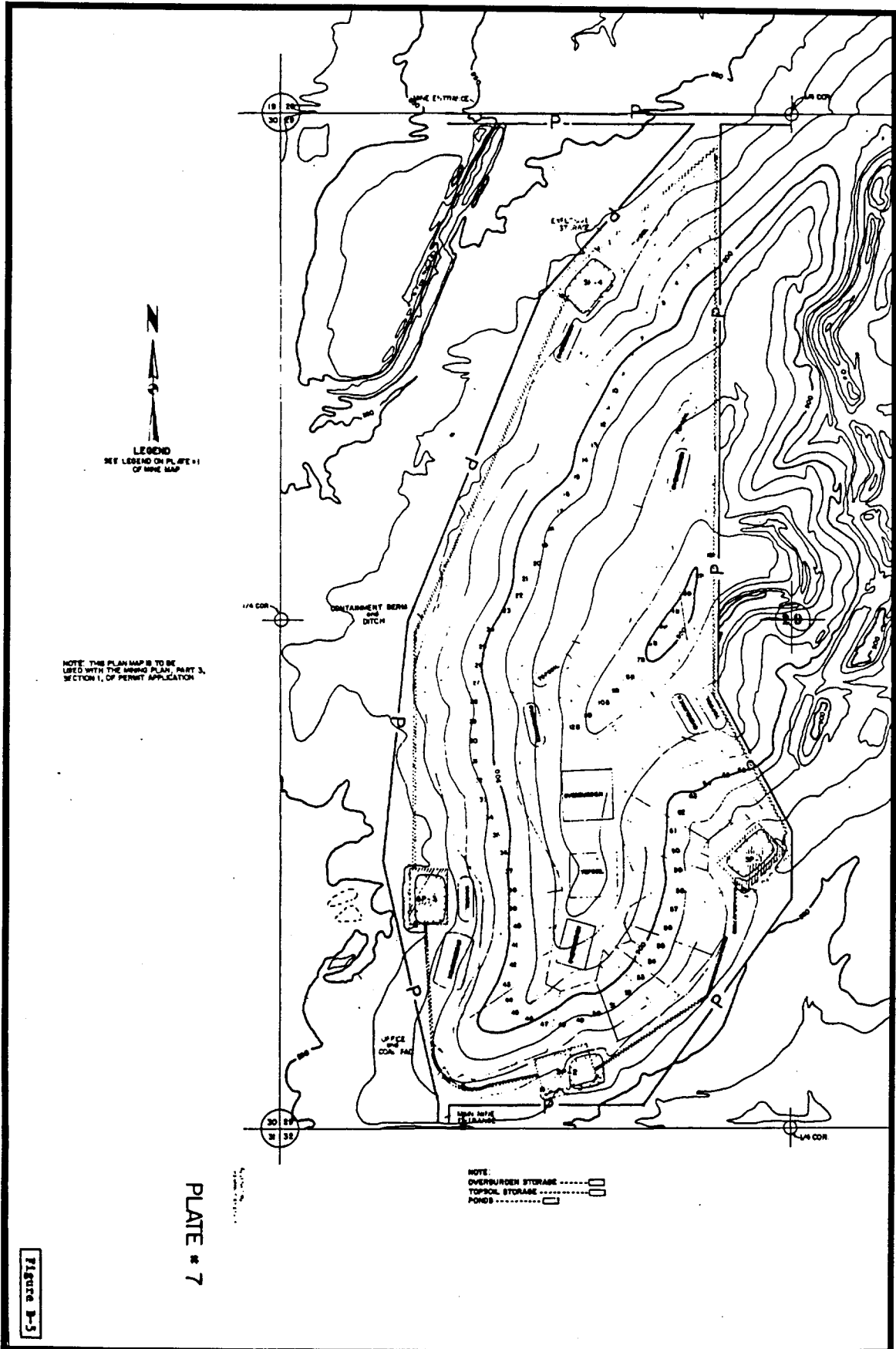
1.	Total Facility and Structure Removal Costs	\$	<u>545</u>	
2.	Total Earthmoving Costs	\$	<u>219,317</u>	
3.	Total Revegetation Costs	\$	<u>15,311</u>	
4.	Total Other Reclamation Activities Costs	\$	<u>0</u>	
5.	Total Direct Costs (sum of Lines 1 through 4)	\$	<u>235,173</u>	
6.	<u>Inflated Total Direct Costs</u> (Line 5 x inflation factor *)	\$		<u>265,745</u>
7.	Mobilization/Demobilization (<u>5</u> % of Line 6) (1% to 10% of Line 6)	\$	<u>13,287</u>	
8.	Contingencies (<u>4</u> % of Line 6) (3% to 5% of Line 6)	\$	<u>10,630</u>	
9.	Engineering Redesign Fee (<u>4.25</u> % of Line 6) (2.5% to 6% of Line 6)	\$	<u>11,294</u>	
10.	Contractor Profit/ Overhead (<u>27</u> % of Line 6) (see Graph 1)	\$	<u>71,751</u>	
11.	Project Management Fee (<u>5.25</u> % of Line 6) (see Graph 2)	\$	<u>13,952</u>	
12.	<u>Total Indirect Costs</u> (sum of Lines 7 through 11)	\$		<u>120,914</u>
13.	GRAND TOTAL BOND AMOUNT (sum of Lines 6 and 12)	\$		<u>386,659</u> (round to \$387,000)

* Inflation factor = $\frac{\text{ENR Construction Cost Index (CCI) for current mo/yr}}{\text{ENR CCI for mo/yr 5 years prior to current mo/yr}} = \frac{6127}{5439} = 1.13$

Identify current month/year used in formula above: 12/99
 Identify prior month/year used in formula above: 12/94

ENR = *Engineering News Record*, McGraw-Hill Construction Information Group, New York, NY; <http://www.enr.com>.

Formula assumes permit term or time until next bond adequacy evaluation is 5 years. Adjust timeframe as necessary.



BOND AMOUNT COMPUTATION

Applicant: Mountain Top Removal Example

Permit Number: Example No. 4 **Permitted Acreage:** 175

Bonding Scheme (permit area, incremental, cumulative): Permit Area

If Incremental:

Increment Number: _____

Increment Acreage: _____

If Cumulative:

Acres previously authorized for disturbance: _____

New acres proposed for disturbance: _____

Type of Operation: Mountain Top Removal

Location: USA

Prepared by: R. R. Bond

Date: December 2, 1999

Total Bond Amount: \$ 653,000

WORKSHEET 1
DESCRIPTION OF THE WORST-CASE RECLAMATION SCENARIO

This is a 175-acre mountain-top-removal site from which six seams of coal will be removed (see Figures B-6 through B-9 at end of worksheets). The spoil will be stored both in temporary and permanent storage. Spoil material is composed of 90% sandstone and 10% shale. The permanent storage will be in two durable rock valley fills neither of which encroaches on streams. The temporary spoil storage will be adjacent to the working face of the highwall. The spoil above the 2,975-foot elevation will be stored in the valley fills while the spoil below elevation 2,975 will be temporarily stored, as shown on attached drawings, and graded over the disturbed mine area for positive drainage.

The worst-case reclamation scenario occurs when the mining of the lower seams (A & B) just begins. At this point, approximately 1,400 feet of highwall is exposed above the B through E seams. It is assumed that all work activities on both hollow fills are current except for spreading topsoil and revegetation. Hollow fills are approximately one-half their designed capacity at this point.

The following sections discuss the reclamation plan for the worst-case scenario.

1. Structure Removal

No buildings are planned for the site; however, three 40-foot storage trailers will need to be removed.

2. Earth Moving Activities

The first step of the earthmoving activities is backfilling of the open highwall. Approximately 1,400 feet of highwall length is exposed at the D-seam level. This highwall will be eliminated by blasting a portion of it to an acceptable grade and pushing the blast material and the stored spoil to reclaim the highwall. Spoil is stored adjacent to the base of the exposed highwall. Prior to topsoil redistribution, the spoil storage areas adjacent to the highwall must be graded to final contours.

For the road areas, the main road will be permanent. The access road to the ponds will be removed when the ponds are removed.

Ponds are to be removed by grading the pond berms to original drainage contours.

3. Revegetation and Topsoil Redistribution

Topsoil will be redistributed by loaders and trucks and will be graded by dozers. It is assumed that 140 acres will require topsoil distribution. This includes the mined area and hollow fills. A 6-inch depth amounts to 112,933 cubic yards of topsoil requiring replacement. It is assumed that the topsoil will need to be hauled 650 feet up a 5 percent

WORKSHEET 1 (continued)
DESCRIPTION OF THE WORST-CASE RECLAMATION SCENARIO

grade to the mined area and 600 feet down a 5 percent grade to the hollow-fills. Assume that the trucks will spread 50 percent of the topsoil in dumping and the remaining 50 percent is spread by dozers.

The areas that require re-vegetation and topsoil redistribution are listed below.

<u>Area</u>	<u>Re-vegetation</u>	<u>Topsoil Redistribution</u>
Mining	58.2 Ac	58.2 Ac
Hollow-fill A	37.8 Ac	37.8 Ac
Hollow-fill B	35.6 Ac	35.6 Ac
Basins	4.6 Ac	4.6 Ac
Basin Access Road	1.3 Ac	1.3 Ac
Explosive Area	<u>2.5 Ac</u>	<u>2.5 Ac</u>
	140 Ac	140 Ac

It is assumed that all areas will be re-vegetated using the same type of seed mix recommended in the mining plan and no tree planting will be conducted.

4. Other Reclamation Activities

- a. Ponds will need to be maintained and pumped prior to removal.
- b. The haul-road is permanent and will need to be maintained until reclamation is complete.
- c. Drilling and blasting the high-wall to an acceptable grade is required.

Assumptions: Mining, reclamation and hollowfill construction has progressed as planned.

NOTE: Worksheets 4A, 7, 11A, 11B, 12, 17 and 18 are not applicable to this example.

Data Source(s): Permit Application.

Project: Mountain Top Example
 Date: 12/02/99
 Prepared By: R.R. Bond

**WORKSHEET 2
 STRUCTURE DEMOLITION AND DISPOSAL COSTS**

Structures to be demolished:

Item	Construction Material	Volume (cubic feet)	Unit Cost Basis (\$)	Demolition Cost (\$)
Subtotal				\$0

Other items to be demolished (paved roads, conveyors, utility poles, rail spurs, etc.):

Remove 40-foot storage trailers - 3 each @ \$500 each = \$1,500.

Subtotal = \$ 1,500

Debris Handling and Disposal Costs:

Subtotal = \$ 0

TOTAL DEMOLITION AND DISPOSAL = \$ 1,500

Data Source(s): Permit Application.

Project: Mountain Top Example
 Date: 12/02/99
 Prepared By: R.R. Bond

**WORKSHEET 3
 MATERIAL HANDLING PLAN SUMMARY**

Earthmoving Activity	Volume (LCY)	Origin	Destination	Haul Distance (ft)	Grade * (%)	Equipment To Be Used
1. Grade spoil, ½ blasted rock, into pit	39,638	Highwall	Highwall	140	(-)30	D9R with SU-Blade
2. Grade spoil from temporary storage highwall	63,519	Storage	Highwall	100	30	D9R with SU-Blade
3. Grade temporary spoil storage area	18,563	Storage	Storage Area	100	0	D9R with SU-Blade
4. Load topsoil	53,724	Storage	Trucks			992G Loader
5. Haul topsoil	53,724	Storage	Mined Area	650	5	773D Truck
6. Load topsoil	59,209	Storage	Trucks			992G Loader
7. Haul topsoil	59,209	Storage	A, B Hollow-fill	600	(-)5	773D Truck
8. Spread topsoil	56,467	Site	Disturbed Area	100	15	D9R with SU-Blade
9. Remove ponds	11,500	Berm	Pond	100	0	D9R with SU-Blade
10. Remove pond access roads	1,407	Fill Areas	Cut Areas	100	(-)5	D9R with SU-Blade
11. Final grading	140 ac**				30**	D6R with S-Blade

* Record grade resistance (% grade) here.

** 98.9 ac (58.2 ac + [(37.8 ac + 35.6 ac)/2]) are steep slopes of hollow fills and the regraded, reduced highwall area (30% grade); the remaining 45.1 acres are contour graded (0% grade).

**WORKSHEET 4B
 EARTHWORK QUANTITY**

1. **Grade blasted material. Assume 1/2 of the material is casted in blasting.**
 Material Volume = 1/2 (1/2 x 58' x 32.95' x 1400' ÷ 27 ft³/yd³) = 24,774 yd³ x 1.60 swell
 = 39,638 yd³

2. **Grade spoil peaks in temporary storage to highwall at lower seams. (See Figure B-8 at end of worksheets.)**

Material Volume = 2 levels x 1/2 (35' x 35') x 1400' ÷ 27 ft³/yd³ = 63,519 yd³

3. **Grade temporary spoil pile left after high-wall back-filled.**

Material Volume = 1.0' (Depth) x 358' (Area) x 1400 ÷ 27 ft³/yd³ = 18,563 yd³

4. **Load and haul topsoil.**

Material Volume/hollow fill A & B = 73.4 ac x 43,560 ft²/ac x 0.5 ft ÷ 27 ft³/yd³
 = 59,209 yd³

Material Volume/Mining, Basins,
 Ponds, etc. = 66.6 ac x 43,560 ft² /ac x 0.5 ft ÷ 27 ft³/yd³ = 53,724 yd³

5. **Spread topsoil. Assume 1/2 of topsoil is spread by trucks; 1/2 by dozers.**

Material Volume = 112,933 yd³ ÷ 2 = 56,467 yd³

6. **Pond removal. Remove ponds by grading to original contours.**

<u>Pond</u>	<u>Volume</u>	<u>Area</u>
021	6.8 ac-ft	35,625 ft ²
022	11.9	63,000
023	6.8	35,625
024	3.3	21,000
Totals	28.8 ac-ft	155,250 ft²

Estimate Volume as a 2-ft depth over pond area.
 Material Volume = 155,250 ft² x 2 ft ÷ 27 ft³/yd³ = 11,500 yd³

7. **Pond access road removal.**
 Material Volume = 3,800 ft x 10 ft x 1 ft ÷ 27 ft³/yd³ = 1,407 yd³

Data Source(s): Permit Application.

Project: Mountain Top Example
 Date: 12/02/99
 Prepared By: R.R. Bond

**WORKSHEET 5A
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE**

Earthmoving Activity:

Grade spoil, ½-blasted rock, into open pit.

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

D9R with SU-blade.

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

The dozer is used to push ½ of blasted rock into the open pit. The material will be pushed 140 feet down (-) 30% effective grade.

Productivity Calculations:

$$\begin{aligned} \text{Operating Adjustment Factor} = & \frac{.75}{\text{operator factor}} \times \frac{.70}{\text{material factor}} \times \frac{.83}{\text{efficiency factor}} \times \frac{1.25}{\text{grade factor}} \\ & \times \frac{.90}{\text{weight correction factor}^*} \times \frac{1.00}{\text{production method/blade factor}^{**}} \times \frac{1.00}{\text{visibility factor}} \times \frac{1.00}{\text{elevation factor}^{**}} = .49 \end{aligned}$$

$$\text{Net Hourly Production} = \frac{950}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{.49}{\text{operating adjustment factor}} = \frac{466}{\text{LCY/hr}}$$

$$\text{Hours Required} = \frac{39,638}{\text{volume to be moved}} \text{ LCY} \div \frac{466}{\text{net hourly production}} \text{ LCY/hr} = \frac{85}{\text{hr}}$$

* Weight Factor = $2,300 \text{ lb/yd}^3 \div 2,550 \text{ lb/yd}^3 = 0.90$

** Normal dozing with straight and U-blades use 1.00.

Data Source(s): Permit Application; Caterpillar Performance Handbook, Edition 29.

Project: Mountain Top Example
 Date: 12/02/99
 Prepared By: R.R. Bond

**WORKSHEET 5B
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE**

Earthmoving Activity:

Grade spoil from temporary storage to open pit.

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

D9R with SU-blade

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

The dozer is used to push spoil 100 feet up a + 30% effective grade.

Productivity Calculations:

$$\begin{aligned} \text{Operating Adjustment Factor} = & \frac{.75}{\text{operator factor}} \times \frac{.70}{\text{material factor}} \times \frac{.83}{\text{efficiency factor}} \times \frac{1.25}{\text{grade factor}} \\ & \times \frac{.90}{\text{weight correction factor}^*} \times \frac{1.00}{\text{production method/blade factor}^{**}} \times \frac{1.00}{\text{visibility factor}} \times \frac{1.00}{\text{elevation factor}^{**}} = .49 \end{aligned}$$

$$\text{Net Hourly Production} = \frac{1,250}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{.49}{\text{operating adjustment factor}} = \frac{613}{\text{LCY/hr}}$$

$$\text{Hours Required} = \frac{63,519}{\text{volume to be moved}} \text{ LCY} \div \frac{613}{\text{net hourly production}} \text{ LCY/hr} = \frac{104}{\text{hr}}$$

* Weight Factor = $2,300 \text{ lb/yd}^3 \div 2,550 \text{ lb/yd}^3 = 0.90$

** Normal dozing with straight and U-blades use 1.00.

Data Source(s): Permit Application; Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 5C
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE**

Earthmoving Activity:

Grade temporary spoil storage area to final reclaimed contours.

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

D9R with SU-blade

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

The dozer is used to grade spoil by pushing 100 feet at a 0% effective grade.

Productivity Calculations:

$$\begin{aligned} \text{Operating Adjustment Factor} = & \frac{.75}{\text{operator factor}} \times \frac{.70}{\text{material factor}} \times \frac{.83}{\text{efficiency factor}} \times \frac{1.00}{\text{grade factor}} \\ & \times \frac{.90}{\text{weight correction factor}^*} \times \frac{1.00}{\text{production method/blade factor}^{**}} \times \frac{1.00}{\text{visibility factor}} \times \frac{1.00}{\text{elevation factor}^{**}} = .39 \end{aligned}$$

$$\text{Net Hourly Production} = \frac{1,250}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{.39}{\text{operating adjustment factor}} = \frac{488}{\text{LCY/hr}}$$

$$\text{Hours Required} = \frac{18,563}{\text{volume to be moved}} \text{ LCY} \div \frac{488}{\text{net hourly production}} \text{ LCY/hr} = \frac{38}{\text{hr}}$$

* Weight Factor = $2,300 \text{ lb/yd}^3 \div 2,550 \text{ lb/yd}^3 = 0.90$

** Normal dozing with straight and U-blades use 1.00.

Data Source(s): Permit Application; Caterpillar Performance Handbook, Edition 29.

Project: Mountain Top Example
 Date: 12/02/99
 Prepared By: R.R. Bond

**WORKSHEET 5D
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE**

Earthmoving Activity:
Spread topsoil.

Characterization of Dozer Used (type, size, etc.):
D9R with SU-blade

Description of Dozer Use (origin, destination, grade, haul distance, material, etc.):
The dozer is used to spread topsoil 100 feet up a + 15% effective grade.

Productivity Calculations:

$$\begin{aligned} \text{Operating Adjustment Factor} = & \frac{.75}{\text{operator factor}} \times \frac{1.20}{\text{material factor}} \times \frac{.83}{\text{efficiency factor}} \times \frac{.75}{\text{grade factor}} \\ & \times \frac{.90}{\text{weight correction factor}^*} \times \frac{1.00}{\text{production method/blade factor}^{**}} \times \frac{1.00}{\text{visibility factor}} \times \frac{1.00}{\text{elevation factor}^{**}} = .50 \end{aligned}$$

$$\text{Net Hourly Production} = \frac{1,250}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{.50}{\text{operating adjustment factor}} = \frac{625}{\text{LCY/hr}}$$

$$\text{Hours Required} = \frac{56,467}{\text{volume to be moved}} \text{ LCY} \div \frac{625}{\text{net hourly production}} \text{ LCY/hr} = \frac{90}{\text{hr}}$$

* Weight Factor = $2,300 \text{ lb/yd}^3 \div 2,550 \text{ lb/yd}^3 = 0.90$

** Normal dozing with straight and U-blades use 1.00.

Data Source(s): Permit Application; Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 5E
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE**

Earthmoving Activity:

Remove ponds by grading each berm to original contours.

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

D9R with SU-blade.

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

Dozer will push pond berm 100 feet to original drainage contours over mostly flat (0%) grades.

Productivity Calculations:

$$\begin{aligned} \text{Operating Adjustment Factor} &= \frac{.75}{\text{operator factor}} \times \frac{1.20}{\text{material factor}} \times \frac{.83}{\text{efficiency factor}} \times \frac{1.00}{\text{grade factor}} \\ &\times \frac{.90}{\text{weight correction factor}^*} \times \frac{1.00}{\text{production method/blade factor}^{**}} \times \frac{1.00}{\text{visibility factor}} \times \frac{1.00}{\text{elevation factor}^{**}} = \underline{.67} \end{aligned}$$

$$\text{Net Hourly Production} = \frac{1,250}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{.67}{\text{operating adjustment factor}} = \underline{838} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{11,500}{\text{volume to be moved}} \text{ LCY} \div \frac{838}{\text{net hourly production}} \text{ LCY/hr} = \underline{14} \text{ hr}$$

* Weight Factor = $2,300 \text{ lb/yd}^3 \div 2,550 \text{ lb/yd}^3 = 0.90$

** Normal dozing with straight and U-blades use 1.00.

Data Source(s): Permit Application; Caterpillar Performance Handbook, Edition 29.

Project: Mountain Top Example
 Date: 12/02/99
 Prepared By: R.R. Bond

**WORKSHEET 5F
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE**

Earthmoving Activity:
 Remove access road to ponds.

Characterization of Dozer Used (type, size, etc.):
 D9R with SU-blade.

Description of Dozer Use (origin, destination, grade, haul distance, material, etc.):
 Dozer used to grade road and ditches to original contours. Push distance, 100 feet, (-)5% effective grade.

Productivity Calculations:

$$\begin{aligned} \text{Operating Adjustment Factor} &= \frac{.75}{\text{operator factor}} \times \frac{1.10}{\text{material factor}} \times \frac{.83}{\text{efficiency factor}} \times \frac{1.1}{\text{grade factor}} \\ &\times \frac{.90}{\text{weight correction factor}^*} \times \frac{1.00}{\text{production method/blade factor}^{**}} \times \frac{1.00}{\text{visibility factor}} \times \frac{1.00}{\text{elevation factor}^{**}} = .68 \end{aligned}$$

$$\text{Net Hourly Production} = \frac{1,250}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{.68}{\text{operating adjustment factor}} = \underline{850} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{1,407}{\text{volume to be moved}} \text{ LCY} \div \frac{850}{\text{net hourly production}} \text{ LCY/hr} = \underline{2.0} \text{ hr}$$

* Weight Factor = $2,300 \text{ lb/yd}^3 \div 2,550 \text{ lb/yd}^3 = 0.90$.

** Normal dozing with straight and U-blades use 1.00.

Total Dozer Hours from all Worksheets 5A - F: $85 + 104 + 38 + 90 + 14 + 2 = 333$.

Data Source(s): Permit Application; Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 6
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE--GRADING**

Earthmoving Activity:
Final grading

Characterization of Dozer Used (type, size, etc.):
D6R - 11 ft. wide straight (S) blade (effective width with blade overlap = 10 ft.)

Description of Dozer Use (% grade, effective blade width, operating speed, etc.):
1. Grading backfilled spoil on 98.9 acres of steeper slopes at 30% grade but backtracking up-slope for net 0%; 2. Contour grading of backfill and disturbed areas on 45.1 acres at 0% grade.

Productivity Calculations:

$$\begin{aligned} \text{Operating Adjustment Factor} &= \frac{.75}{\text{operator factor}} \times \frac{1.0}{\text{material factor}} \times \frac{.83}{\text{efficiency factor}} \times \frac{1.00}{\text{grade factor}} \\ &\times \frac{1.00}{\text{weight correction factor}} \times \frac{1.00}{\text{production method/blade factor}} \times \frac{1.00}{\text{visibility factor}} \times \frac{1.00}{\text{elevation factor}} = \underline{.62} \end{aligned}$$

$$\begin{aligned} \text{Hourly Production} &= \frac{3.0}{\text{average speed}} \text{ mi/hr} \times \frac{10}{\text{effective blade width}} \text{ ft} \times 5,280 \text{ ft/mi} \times 1 \text{ ac/43,560 ft}^2 \\ &= \underline{3.6} \text{ ac/hr} \end{aligned}$$

$$\text{Net Hourly Production} = \frac{3.6}{\text{hourly production}} \text{ ac/hr} \times \frac{.62}{\text{operating adjustment factor}} = \underline{2.23} \text{ ac/hr}$$

$$\text{Hours Required} = \frac{144}{\text{area to be graded}} \text{ ac} \div \frac{2.23}{\text{net hourly production}} \text{ ac/hr} = \underline{65} \text{ hr}$$

Data Source(s): Permit Application; Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 8A
 PRODUCTIVITY AND HOURS REQUIRED FOR LOADER USE**

Earthmoving Activity:

Load topsoil on trucks to be hauled to mined area.

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

992G with Large Standard Spade-edge, 16 CY rock bucket, 15.3 ft. dump clearance

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

Load topsoil in storage area.

Productivity Calculations:

$$\text{Cycle time} = \frac{\text{haul time (loaded)}}{\text{min}} + \frac{\text{return time (empty)}}{\text{min}} + \frac{.7}{\text{basic cycle time}} \text{ min} = .7 \text{ min}$$

$$\text{Net Bucket Capacity} = \frac{16.0}{\text{heaped bucket capacity}} \text{ LCY} \times \frac{1.0}{\text{bucket fill factor}^*} = 16.0 \text{ LCY}$$

$$\text{Hourly Production} = \frac{16.0}{\text{net bucket capacity}} \text{ LCY} \div \frac{.7}{\text{cycle time}} \text{ min} \times \frac{.75}{\text{efficiency factor}} \times 60 \text{ min/hr} = 1,029 \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{53,724}{\text{volume to be moved}} \text{ LCY} \div \frac{1,029}{\text{hourly production}} \text{ LCY/hr} = 52 \text{ hr}^{**}$$

* See loader section of equipment manual.

** NOTE: Use 57 hours to match trucks (see *Worksheet 9A*).

Data Source(s): Permit Application; Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 8B
 PRODUCTIVITY AND HOURS REQUIRED FOR LOADER USE**

Earthmoving Activity:

Load topsoil on trucks to be hauled to mined area.

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

992G with Large Standard Spade-edge, 16 CY rock bucket, 15.3 ft. dump clearance

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

Load topsoil in storage area.

Productivity Calculations:

$$\text{Cycle time} = \frac{\text{haul time (loaded)}}{\text{min}} + \frac{\text{return time (empty)}}{\text{min}} + \frac{.7}{\text{basic cycle time}} \text{ min} = \underline{.7} \text{ min}$$

$$\text{Net Bucket Capacity} = \frac{16.0}{\text{heaped bucket capacity}} \text{ LCY} \times \frac{1.0}{\text{bucket fill factor}^*} = \underline{16.0} \text{ LCY}$$

$$\text{Hourly Production} = \frac{16.0}{\text{net bucket capacity}} \text{ LCY} \div \frac{.7}{\text{cycle time}} \text{ min} \times \frac{.75}{\text{efficiency factor}} \times 60 \text{ min/hr} = \underline{1,029} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{59,209}{\text{volume to be moved}} \text{ LCY} \div \frac{1,029}{\text{hourly production}} \text{ LCY/hr} = \underline{58} \text{ hr}$$

* See loader section of equipment manual.

NOTE: Total Loader Hours from Worksheets 8A and B = 57 + 58 = 115

Data Source(s): Permit Application; Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 9A
 PRODUCTIVITY AND HOURS REQUIRED FOR TRUCK USE**

Earthmoving Activity:
 Haul topsoil from temporary storage to mined area.

Characterization of Truck Use (type, size, etc.):
 777D Truck struck capacity = 60.1 CY, heaped capacity = 78.6 CY, 69.35 CY average capacity

Description of Truck Use (origin, destination, grade, haul distance, capacity, etc.):
 Haul topsoil from storage to disturbed area. Haul and return distance are both 650 feet over + 5% effective grade.

Productivity Calculations:

$$\text{No. Loader Passes/Truck} = \frac{69.35 \text{ LCY}}{\text{truck capacity}^*} \div \frac{16.0 \text{ LCY}}{\text{loader bucket net capacity}} = \frac{4}{\text{(round down to nearest whole number)}} \text{ passes}$$

$$\text{Net Truck Capacity} = \frac{16.0 \text{ LCY}}{\text{loader bucket net capacity}} \times \frac{4}{\text{no. loader passes/truck}} = 64 \text{ LCY}$$

$$\text{Loading Time/Truck} = \frac{.7 \text{ min}}{\text{loader cycle time (from Worksheet 8 or 10)}} \times \frac{4}{\text{no. loader passes/truck}} = 2.8 \text{ min}$$

$$\text{Truck Cycle Time} = \frac{.9 \text{ min}}{\text{haul time}} + \frac{.45 \text{ min}}{\text{return time}} + \frac{2.8 \text{ min}}{\text{loading time}} + \frac{2.0 \text{ min}}{\text{dump and maneuver time}} = 6.15 \text{ min}$$

$$\text{No. Trucks Required} = \frac{6.15 \text{ min}}{\text{truck cycle time}} \div \frac{2.8 \text{ min}}{\text{total loading time}} = 2.20 \text{ (use 2)} \text{ trucks}$$

$$\text{Production Rate} = \frac{64 \text{ LCY}}{\text{net truck capacity}} \times \frac{2}{\text{no. trucks}} \div \frac{6.15 \text{ min}}{\text{truck cycle time}} = 20.8 \text{ LCY/min}$$

$$\text{Hourly Production} = \frac{20.8 \text{ LCY/min}}{\text{production rate}} \times 60 \text{ min/hr} \times \frac{.75}{\text{efficiency factor}} = 936 \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{53,724 \text{ LCY}}{\text{volume to be moved}} \div \frac{936 \text{ LCY/hr}}{\text{hourly production}} = 57 \text{ hr}$$

* Use the average of the struck and heaped capacities.

Data Source(s): Permit Application; Caterpillar Performance Handbook, Edition 29.

**WORKSHEET 9B
 PRODUCTIVITY AND HOURS REQUIRED FOR TRUCK USE**

Earthmoving Activity:
 Haul topsoil from temporary storage to Hollowfills A and B.

Characterization of Truck Use (type, size, etc.):
 777D Truck struck capacity = 60.1 CY, heaped capacity = 78.6 CY, 69.35 CY average capacity.

Description of Truck Use (origin, destination, grade, haul distance, capacity, etc.):
 Haul topsoil from storage to disturbed area. Haul distance is 600 ft. over (-) 5% effective grade; return is 600 ft. at 0% effective grade.

Productivity Calculations:

$$\text{No. Loader Passes/Truck} = \frac{69.35 \text{ LCY}}{\text{truck capacity}^*} \div \frac{16.0 \text{ LCY}}{\text{loader bucket net capacity}} = \frac{4}{\text{(round down to nearest whole number)}} \text{ passes}$$

$$\text{Net Truck Capacity} = \frac{16.0 \text{ LCY}}{\text{loader bucket net capacity}} \times \frac{4}{\text{no. loader passes/truck}} = 64 \text{ LCY}$$

$$\text{Loading Time/Truck} = \frac{.7 \text{ min}}{\text{loader cycle time (from Worksheet 8 or 10)}} \times \frac{4}{\text{no. loader passes/truck}} = 2.8 \text{ min}$$

$$\text{Truck Cycle Time} = \frac{.27^{**}}{\text{haul time}} \text{ min} + \frac{.45}{\text{return time}} \text{ min} + \frac{2.8}{\text{loading time}} \text{ min} + \frac{2.0}{\text{dump and maneuver time}} \text{ min} = 5.52 \text{ min}$$

$$\text{No. Trucks Required} = \frac{5.52 \text{ min}}{\text{truck cycle time}} \div \frac{2.8 \text{ min}}{\text{total loading time}} = 1.97 \text{ (use 2)} \text{ trucks}$$

$$\text{Production Rate} = \frac{64 \text{ LCY}}{\text{net truck capacity}} \times \frac{2}{\text{no. trucks}} \div \frac{5.52 \text{ min}}{\text{truck cycle time}} = 23.2 \text{ LCY/min}$$

$$\text{Hourly Production} = \frac{23.2 \text{ LCY/min}}{\text{production rate}} \times 60 \text{ min/hr} \times \frac{.75}{\text{efficiency factor}} = 1,044 \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{59,209 \text{ LCY}}{\text{volume to be moved}} \div \frac{1,044 \text{ LCY/hr}}{\text{hourly production}} = 57 \text{ (use 58 hr to match loader)}$$

* Use the average of the struck and heaped capacities.

** 600 ft / (25 MPH X 88 FPM/MPH) = .27 min.

NOTE: Total Truck Hours from Worksheets 9A and B = 57 + 58 = 115

Data Source(s): Permit Application; Caterpillar Performance Handbook, Edition 29.

Project: Mountain Top Example
 Date: 12/02/99
 Prepared By: R.R. Bond

**WORKSHEET 13
 SUMMARY CALCULATION OF EARTHMOVING COSTS**

Equipment *	Ownership & Operation Cost (\$/hr)	Labor Cost (\$/hr)	Total Hours Required **	Total Cost *** (\$)
D9R-SU Dozer	113.22	14.56	333	42,551
D6R-S Dozer	45.79	14.56	333	20,097
992G Loader	216.78	15.56	115	26,719
777D Truck	170.07	12.90	115	21,042
777D Truck	170.07	12.90	115	21,042
Grand Total				\$131,451
<p>* Include all necessary attachments and accessories for each item of equipment. Also, add support equipment such as water wagons and graders to match total project time as appropriate.</p> <p>** Account for multiple units in truck and/or scraper teams.</p> <p>*** To compute Total Cost: Add Ownership & Operation Cost and Labor Cost columns then multiply by Total Hours Required column.</p>				

Data Source(s): PRIMEDIA Information, Inc., Cost Reference Guide for Construction Equipment, 1999.

**WORKSHEET 14
 REVEGETATION COSTS**

Name and Description of Area To Be Revegetated:
All disturbed acreage requires seeding; no tree planting.

Description of Revegetation Activities:
Hydroseeding will be used because of the steep slope conditions.

Cost Calculation for Individual Revegetation Activities:

Initial Seeding

$$\frac{140}{\text{area to be seeded}} \text{ ac} \times \left(\$ \frac{180}{\text{seedbed preparation}} / \text{ac} + \$ \frac{720}{\text{seeding, fertilizing \& mulching}} / \text{ac} \right) = \$ \underline{126,000}$$

Planting Trees and Shrubs

$$\text{_____} \text{ ac} \times \left(\$ \text{_____} / \text{ac} + \$ \text{_____} / \text{ac} \right) = \$ \text{_____}$$

planting
herbicide treatment

Reseeding

$$\frac{140}{\text{area to be seeded \& unreleased disturbed areas}} \text{ ac} \times \frac{.50}{\text{failure rate}^*} \times \left(\$ \frac{180}{\text{seedbed preparation}} / \text{ac} + \$ \frac{720}{\text{seeding, fertilizing \& mulching}} / \text{ac} \right) = \$ \underline{63,000}$$

Replanting Trees and Shrubs

$$\text{_____} \text{ ac} \times \frac{\text{_____}}{\text{failure rate}^*} \times \left(\$ \text{_____} / \text{ac} + \$ \text{_____} / \text{ac} \right) = \$ \text{_____}$$

planting
herbicide treatment

Other Necessary Revegetation Activities

(Examples of other activities that may be necessary include soil sampling, irrigation, and rill and gully repair. Describe each activity and provide a cost estimate with documentation. Use additional worksheets if necessary.)

Other Costs: \$ _____

TOTAL REVEGETATION COST = \$ 189,000

* Assumes a 50% failure rate for reseeded based on historic AML costs.

Data Source(s): Permit Application; Historic AML Costs.

Project: Mountain Top Example
Date: 12/02/99
Prepared By: R.R. Bond

**WORKSHEET 15A
OTHER RECLAMATION ACTIVITY COSTS**

(Subsidence damage repair costs, water supply replacement costs, funds required to support long-term treatment of unanticipated acid or ferruginous mine drainage, etc.)

Description of Reclamation, Repair or Pollution Abatement Activity:

Maintenance, pumping, and treatment of ponds.

Assumptions:

Volume = 28.8 ac-ft.

Cost Estimate Calculations:

28.8 ac-ft x 43,560 ft² /ac. x \$0.15/10 ft³ = \$18,818

TOTAL COSTS = \$ 18,818 _____

Other Documentation or Notes:

(Include additional sheets, maps, calculations, etc., as necessary to document estimate.)

Data Source(s): Permit Application; Historic AML Costs.

Project: Mountain Top Example
Date: 12/02/99
Prepared By: R.R. Bond

**WORKSHEET 15B
OTHER RECLAMATION ACTIVITY COSTS**

(Subsidence damage repair costs, water supply replacement costs, funds required to support long-term treatment of unanticipated acid or ferruginous mine drainage, etc.)

Description of Reclamation, Repair or Pollution Abatement Activity:

Haul road maintenance during reclamation.

Assumptions:

Haul road = 3.5 ac.

Cost Estimate Calculations:

3.5 ac x \$600 per ac = \$2,100

TOTAL COSTS = \$2,100 _____

Other Documentation or Notes:

(Include additional sheets, maps, calculations, etc., as necessary to document estimate.)

Data Source(s): Permit Application; Historic AML Costs.

Project: Mountain Top Example
Date: 12/02/99
Prepared By: R.R. Bond

**WORKSHEET 15C
OTHER RECLAMATION ACTIVITY COSTS**

(Subsidence damage repair costs, water supply replacement costs, funds required to support long-term treatment of unanticipated acid or ferruginous mine drainage, etc.)

Descriptions of Reclamation, Repair or Pollution Abatement Activity*:

Drilling and blasting

Assumptions:

Quantities - See Worksheet 15D

**Drill - (D75KS) = \$ 197.28/hr
Driller Cost = \$20.65/hr
Blaster Cost = \$22.65/hr
Drilling Hours Required = 185.5 hrs**

Cost Estimate Calculations:

	(Ownership Cost)	(Driller Cost)	(Blaster Cost)	
Drilling Cost =	(185.5 hr x \$197.28/hr)	(185.5 hr x \$20.65/hr)	(185.5 hr x \$22.65/hr)	=
	\$36,595	+\$3,831	+ \$4,202	= <u>\$44,628</u>

3 Drill bits - \$2,094/ea = \$6,282
Explosives - \$0.2024/lb** x 33,540 lb = \$6,788
Blasting caps - \$3.30ea X 936 holes = \$3,088**

**** 1986 costs adjusted for inflation: Drill bits cost = \$1,500 X (5997/4294.75) = \$2,094; Explosives cost = \$0.145 X 1.396 = \$0.2024/lb.**

TOTAL = \$ \$60,786

Other Documentation or Notes:

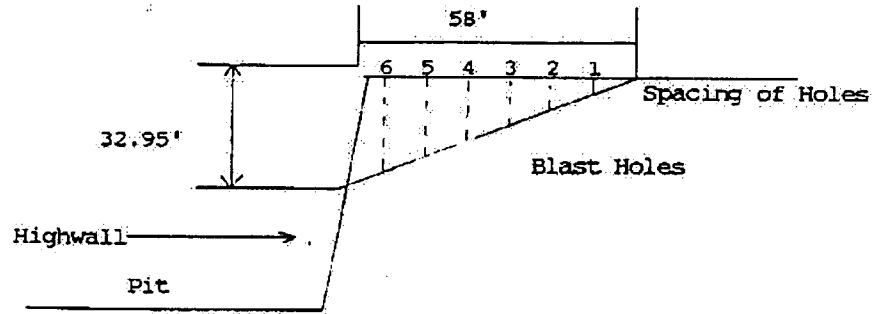
(Include additional sheets, maps, calculations, etc., as necessary to document estimate.)

See next page.

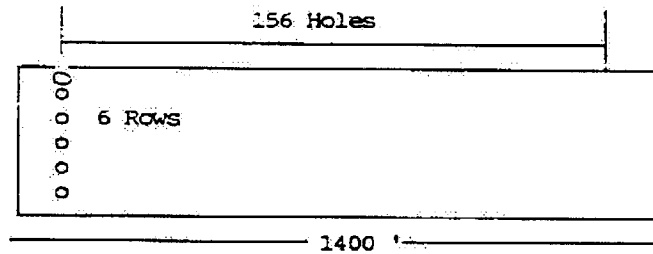
GRAND TOTAL FROM WORKSHEETS 15A, B and C = \$18,818 + \$2,100 + \$60,786 = \$81,704

Data Source(s): Dodge, Construction Cost Guide, 1986; PRIMEDIA Information, Inc., Cost Reference Guide for Construction Equipment, 1999; R.S. Means, Building Construction Cost Data, 1998; E. I. duPont deMemours & Co., Blaster's Handbook the Engineering News Record website (www.enr.com).

WORKSHEET 15C (continued)
OTHER RECLAMATION ACTIVITY COSTS



Drill Hole	1	2	3	4	5	6	Total
Distance to Highwall Face (in feet)	54	45	36	27	18	9	
Drill Hole Depth (feet)	5	10.2	15.3	20.5	25.6	30.7	107
Explosive in Column (lbs.)	10	21	31	42	52	63	219



Total No./Holes = 1,400 ft ÷ 9 ft = 156 Holes x 6 Rows = 936 Holes

Total Feet of Drilling Required:

107 ft/6 holes x 156 = 1 6,692 ft
 Avg. Drilling Rate = 1.5 ft/min
 Time = 16,692 ft ÷ 1.5 ft/min ÷ 60 min/hr
 = 185.5 hr

Total Amount of Explosives Required:

215 lb /6 holes x 156 = 33,540 lbs

Project: Mountain Top Example
 Date: 12/02/99
 Prepared By: R.R. Bond

**WORKSHEET 16
 RECLAMATION BOND SUMMARY SHEET**

1.	Total Facility and Structure Removal Costs	\$	<u>1,500</u>	
2.	Total Earthmoving Costs	\$	<u>131,451</u>	
3.	Total Revegetation Costs	\$	<u>189,000</u>	
4.	Total Other Reclamation Activities Costs	\$	<u>81,704</u>	
5.	Total Direct Costs (sum of Lines 1 through 4)	\$	<u>403,655</u>	
6.	<u>Inflated Total Direct Costs</u> (Line 5 x inflation factor *)	\$		<u>448,703</u>
7.	Mobilization/Demobilization (<u>5</u> % of Line 6) (1% to 10% of Line 6)	\$	<u>22,435</u>	
8.	Contingencies (<u>5</u> % of Line 6) (3% to 5% of Line 6)	\$	<u>22,435</u>	
9.	Engineering Redesign Fee (<u>6</u> % of Line 6) (2.5% to 6% of Line 6)	\$	<u>26,922</u>	
10.	Contractor Profit/ Overhead (<u>26</u> % of Line 6) (see Graph 1)	\$	<u>116,663</u>	
11.	Project Management Fee (<u>3.6</u> % of Line 6) (see Graph 2)	\$	<u>16,153</u>	
12.	<u>Total Indirect Costs</u> (sum of Lines 7 through 11)	\$		<u>204,608</u>
13.	GRAND TOTAL BOND AMOUNT (sum of Lines 6 and 12)	\$		<u>653,310</u> (round to \$ 653,000)

* Inflation factor = $\frac{\text{ENR Construction Cost Index (CCI) for current mo/yr}}{\text{ENR CCI for mo/yr 5 years prior to current mo/yr}} = \frac{6008}{5405} = 1.1116$

Identify current month/year used in formula above: 4/99
 Identify prior month/year used in formula above: 4/94

ENR = *Engineering News Record*, McGraw-Hill Construction Information Group, New York, NY; <http://www.enr.com>.

Formula assumes permit term or time until next bond adequacy evaluation is 5 years. Adjust timeframe as necessary.

LEGEND

	PERMIT AREA
	PROPERTY LINE
	MAILED
	CONTINUOUS FLOW STREAM
	INTERMITTENT STREAM
	SURFACE RUNOFF
	SEWAGE BASIN
	DESIGNATE MONITORING POINT AND ELEVATION
	INVERSION CHANNEL (CONTIGUOUS PERMIT AREA)
	WELL
	WITNESS BREAK LINE
	OFF-ROAD
	REFERENCE AREA
	SLOPE ANGLE
	SPILL STORAGE AREA
	TOPSOIL STORAGE AREA
	COAL STOCKPILE
	OPHAR AREA
	SURFACE WATER MONITORING POINT
	DEEP WIRE ENTRY
	BASE ACCESS ROAD (CLASS III)
	REGULATED SAMPLING POINT AND ELEVATION
	DIVERSION CHANNEL (PERMIT AREA)

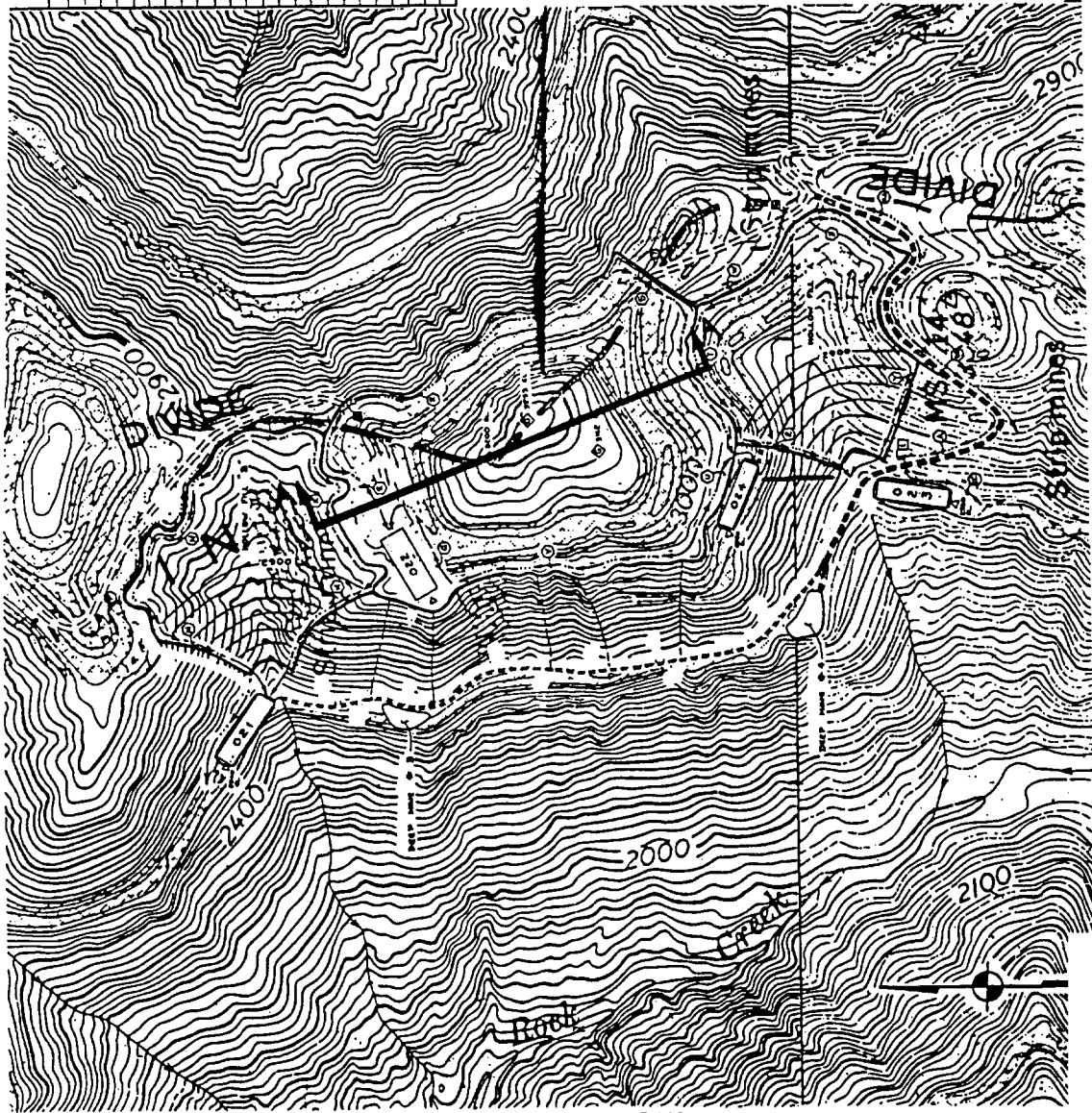


Figure 3-4

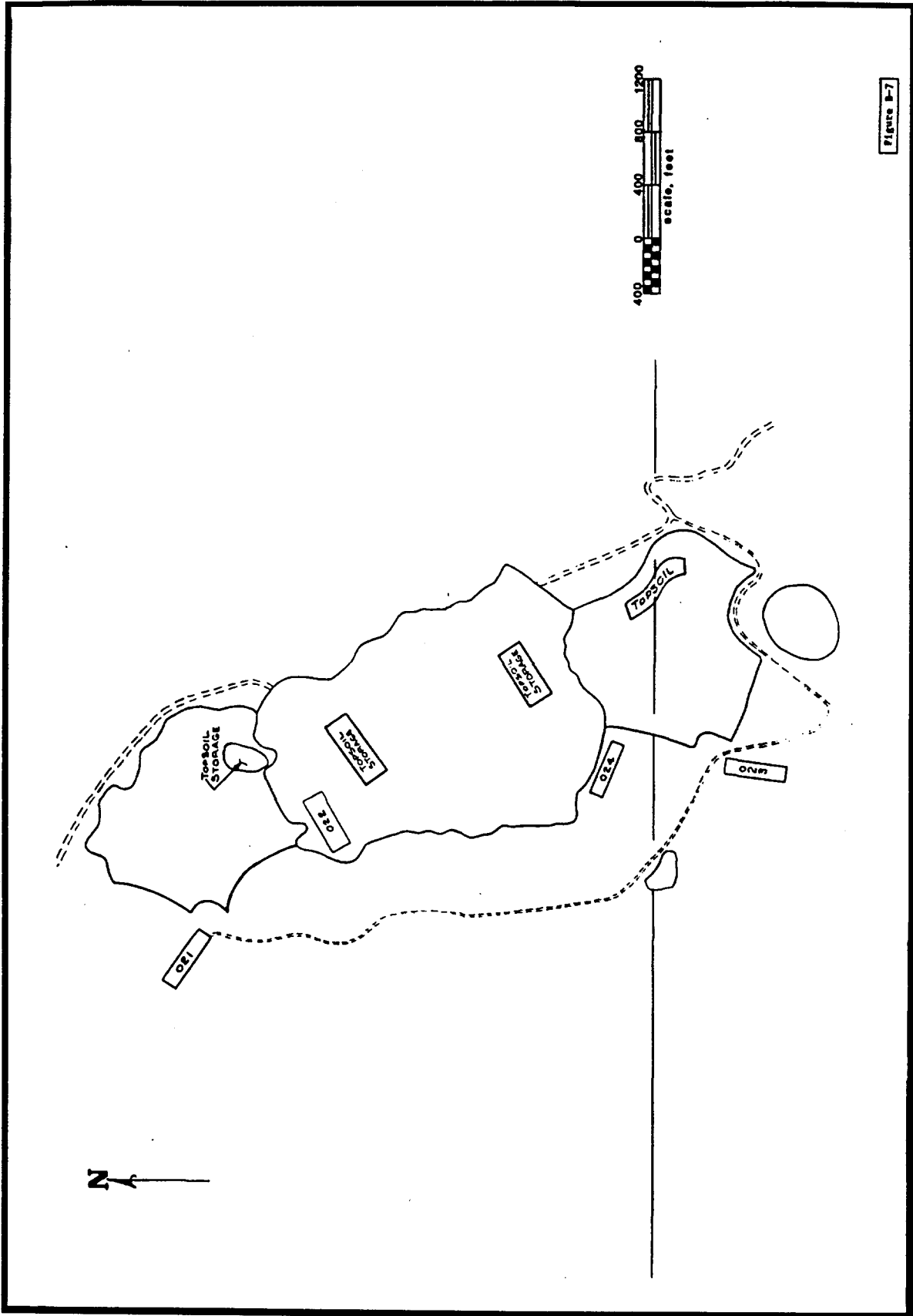
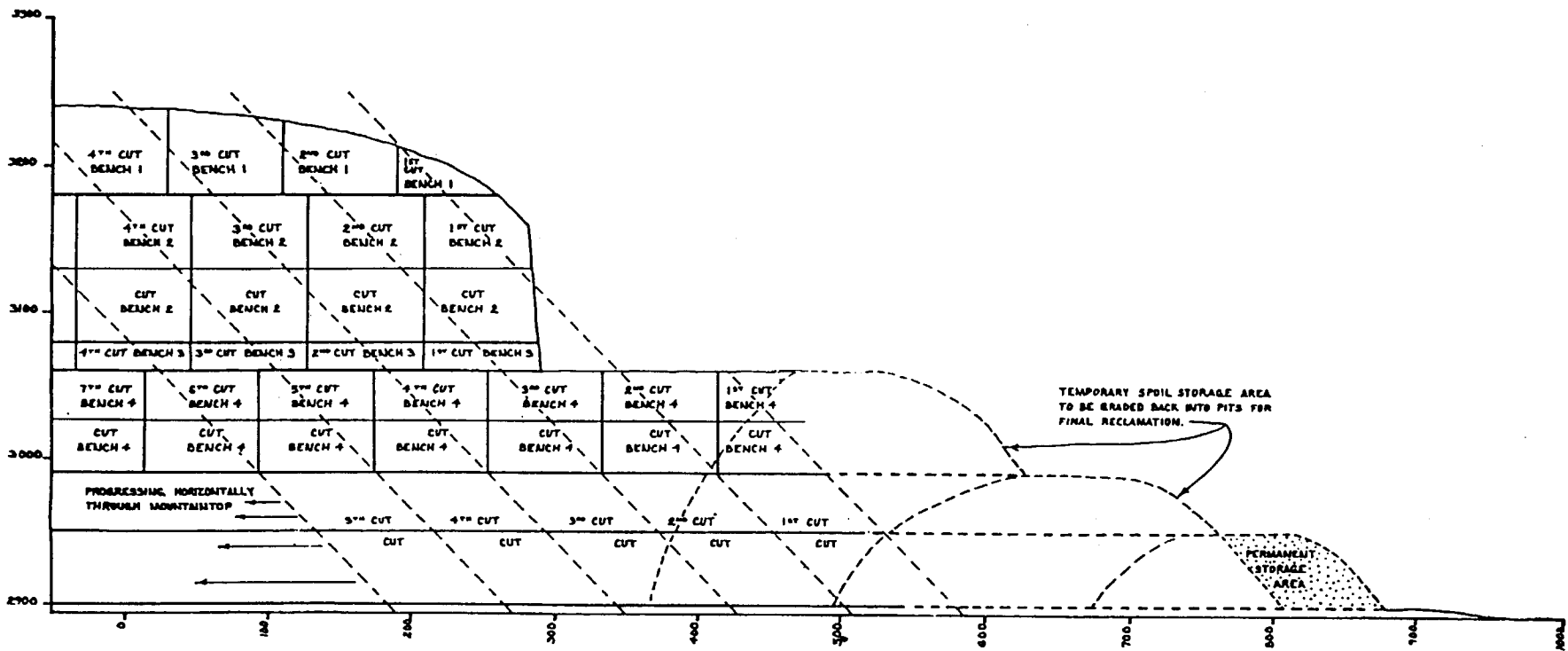
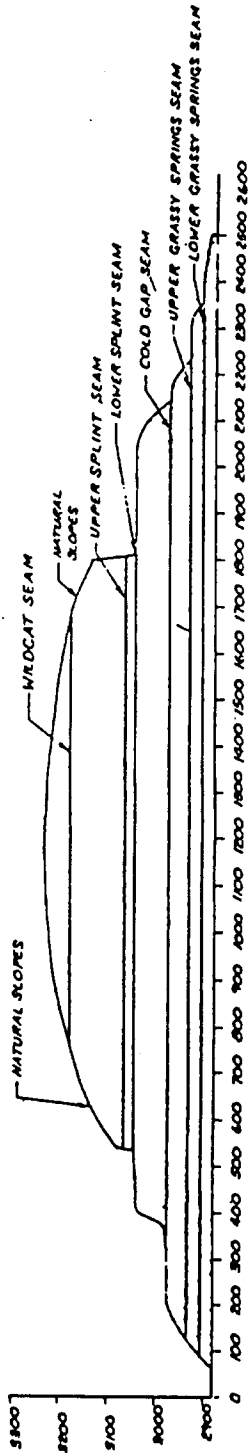


Figure B-7



LOCATION & SEQUENCE OF CUTS

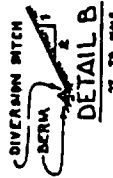
Figure B-8



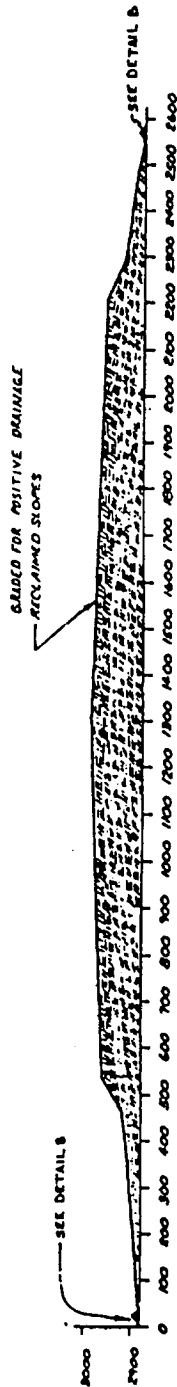
PRE-MINING AREA SECTION "A-A"



DETAIL A
1" = 20' HORIZ.
1" = 20' VERT.



DETAIL B
1" = 10' HORIZ.
1" = 10' VERT.



POST MINING AREA SECTION "A-A"

Figure B-2

BOND AMOUNT COMPUTATION

Applicant: Processing Plant Example

Permit Number: Example No. 5 **Permitted Acreage:** 31.0

Bonding Scheme (permit area, incremental, cumulative): permit area

If Incremental:

Increment Number: _____

Increment Acreage: _____

If Cumulative:

Acres previously authorized for disturbance: _____

New acres proposed for disturbance: _____

Type of Operation: Coal Processing

Location: USA

Prepared by: P. T. Bond

Date: 12/02/99

Total Bond Amount: \$ 226,000

WORKSHEET 1
DESCRIPTION OF THE WORST-CASE RECLAMATION SCENARIO

The coal-processing operation consists of a processing plant, a rail loading facility, and a refuse disposal area. The processing/loading site covers a disturbed area of approximately 9 acres, and the refuse disposal site covers approximately 22 acres. (Figures B-10 through B-13 pertain to this example and can be found at the end of the worksheets.)

The processing/loading operation consists of: a raw coal stockpile, an underground conveyor to the plant, the processing plant, and conveyors from the plant to the refuse stockpile and the clean coal silo/stockpile. Support structures for the operation include: scale house/office, scale, and shop building. Surface drainage control structures include diversion ditches, two storage basins that supply water to the plant, and sedimentation pond No. 001.

Refuse from the processing operation is transported via a public road a distance of approximately 1.4 miles to the refuse disposal area. The refuse disposal site is an abandoned surface coal mine. The spoil from the abandoned mine is salvaged, segregated, stored along the perimeter of the refuse area, and used as a topsoil substitute to cover the refuse. Refuse is compacted in lifts, and topsoil substitute is graded to cover the completed lifts with 4 feet of material. Sedimentation pond No. 002 provides surface drainage control for the refuse disposal site.

Reclamation of the area includes removal of all structures from the processing/loading site. Waste coal and contaminated soil will be excavated and transported to the refuse disposal area. The surface of the site will be ripped to loosen and mix the compacted soil prior to seed-bed preparation. The site will be returned to its approximate original contour and vegetated with herbaceous species, achieving a condition capable of supporting an industrial post-mining land use. The refuse disposal area will be covered with the topsoil substitute and vegetated with species that will stabilize the site and provide wild life enhancement, achieving an undeveloped post-mining land use.

When it has been determined that vegetation has been successfully established and the surface drainage control structures are no longer required, the storage basins and sedimentation pond No. 001 will be back-filled and eliminated, and the sites vegetated. Sedimentation pond No. 002 will be eliminated, a rock-lined channel will be constructed on the pond site, and the adjacent terrain will be vegetated.

Data Source(s): Permit Application.

WORKSHEET 1 (continued)
DESCRIPTION OF THE WORST-CASE RECLAMATION SCENARIO

1. Earthmoving

Waste coal and contaminated soil: Soil will be removed to a depth of 6 inches from the three stockpile areas that total 1.4 acres. With 15 percent final swell volume, total volume is 1,300 cubic yards.

Topsoil substitute material: Material salvaged for final lift area at refuse disposal site; 0.86-acre surface area with depth of 4 feet, plus 15 percent final swell volume, yields total volume of 6,400 cubic yards.

Storage basins and sediment pond No. 001: Pond No. 001 embankment contains 5,000 cubic yards; the material excavated from the basins and comprising the berms will be used to fill the basins; basin No. 1 volume is 313 cubic yards; basin No. 2 volume is 333 cubic yards; with 15 percent final swell volume, total volume is 6,500 cubic yards.

Area to be ripped: Two acres of a 9-acre processing/loading site is vegetated and will not be re-disturbed; remaining 7 acres will be ripped.

2. Re-vegetation

Processing/loading site: Seven acres will require re-vegetation.

Refuse disposal site: Maximum resistance will occur with final lift; concurrent reclamation will have resulted in 17 acres of a 22-acre site with vegetation; remaining 5 acres will require revegetation.

3. Other Reclamation Activity

Sediment pond No. 002: Embankment will be graded and eliminated during construction of rock-lined drainage channel.

Treating and Dewatering ponds' basins/ponds: Volume of water to be removed is total of basins' and volumes at normal pool level.

Basin No. 1	8,450 ft ³
Basin No. 2	9,000 ft ³
Pond No. 001	214,751 ft ³
Pond No. 002	463,914 ft ³
	696,115 ft ³

NOTE: Worksheets 4B, 10, 11A, 11B, 12, 17 and 18 are not applicable to this example.

Data Source(s): Permit Application.

**WORKSHEET 2
 STRUCTURE DEMOLITION AND DISPOSAL COSTS**

Structures to be demolished:

Item	Construction Material	Volume (cubic feet)	Unit Cost Basis (\$/ft)	Demolition Cost (\$)
1. Plant	Steel beams; metal siding and roofing	200,000	0.17	34,000
2. Scale house/office	Wood frame; asphalt siding and roofing	5,600	0.17	952
3. Scale	Wood frame; asphalt siding and roofing	750	0.17	128
4. Shop building	Wood frame; metal siding; asphalt roofing	8,100	0.17	1,377
Subtotal				\$36,457

Other items to be demolished (paved roads, conveyors, utility poles, rail spurs, etc.):

Conveyor Systems: Structural steel supports for elevated units; underground units enclosed in metal pipes; total length of conveyor system is 790 linear feet.

$$790 \text{ LF} \times \$16 / 1 \text{ LF} = \$12,640$$

Subtotal = \$ 12,640

Debris Handling and Disposal Costs:

Lump-sum cost includes demolition of concrete block foundation of plant and concrete silo, grading of rubble into the underground conveyor excavations, and removal/disposal of culvert.

Lump sum = \$6,000

Subtotal = \$ 6,000

TOTAL DEMOLITION AND DISPOSAL = \$ 55,097

Data Source(s): Means *Site Work and Landscape Cost Data*, 1998; AML data; conveyor demolition cost developed from crew and equipment composition and cost data from Means *Building Construction Cost Data*.

Project: Processing Plant Example
 Date: 12/2/99
 Prepared by: P.T. Bond

**WORKSHEET 3
 MATERIAL HANDLING PLAN SUMMARY**

Earthmoving Activity	Volume (LCY)	Origin	Destination	Haul Distance (ft)	Grade * (%)	Equipment To Be Used
1. Excavate coal waste	1,300	Coal stockpile pad	Coal stockpile pad	50	0	D7R-SU w/ 3-shank ripper
2. Load coal waste	1,300	Site	Site	50	0	988 F
3. Haul coal waste	1,300	Site	Site	50	0	769D
4. Grade coal waste	1,300	Site	Site	50	0	D6R-S
5. Rip surface of site; 7 acres					0	D7R-SU W/3-shank ripper
6. Final grading of site; 7 acres					0	D6R-S
7. Grade topsoil substitute	6,400	Site	Site	150	0	D7R-SU W/3-shank ripper
8. Grade and remove pond No. 001 and storage basins	6,500	Embankments	Basins and Pond	100	0	D7R-SU W/3-shank ripper
9. Grade and remove pond No. 002 and construct channel						See Worksheet 15A
*Record grade resistance (% grade) here.						

**WORKSHEET 5A
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE**

Earthmoving Activity:

Excavate 6-inch layer of coal waste and contaminated soil from the 1.4-acre stockpile area.
 Volume of material is 1,300 LCY.

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

D7R with SU-blade dozer and 3-shank ripper

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

Dozer will excavate and pile material for loading; the average push distance is 50 feet and the effective grade is 0 percent. The material weight is 2,300 lb/CY.

Productivity Calculations:

$$\text{Operating Adjustment Factor} = \frac{.75}{\text{operator factor}} \times \frac{.80}{\text{material factor}} \times \frac{.83}{\text{efficiency factor}} \times \frac{1.0}{\text{grade factor}} \times \frac{1.0^*}{\text{weight correction factor}} \times \frac{1.0^{**}}{\text{production method/blade factor}} \times \frac{1.0}{\text{visibility factor}} \times \frac{1.0}{\text{elevation factor}} = \underline{.50}$$

$$\text{Net Hourly Production} = \frac{1,050}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{.50}{\text{operating adjustment factor}} = \underline{525} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{1,300}{\text{volume to be moved}} \text{ LCY} \div \frac{525}{\text{net hourly production}} \text{ LCY/hr} = \underline{3} \text{ hr}$$

* Weight Factor = $\frac{2,300 \text{ lb/CY}}{2,300 \text{ lb/CY}} = 1.00$

** Normal dozing with SU-blade use 1.00

Data Source(s): Permit Application; Caterpillar Performance Handbook, Edition 28.

**WORKSHEET 5B
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE**

Earthmoving Activity:

Grade waste/soil at refuse site to blend with contour of fill. Volume of material is 1,300 LCY.

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

D6R with S-blade.

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

Dozer will grade material to blend with refuse and achieve final contour of fill; the average push distance is 50 feet and the effective grade is 0 percent. The material weight is 2,300 lb/CY.

Productivity Calculations:

$$\begin{aligned} \text{Operating Adjustment Factor} &= \frac{.75}{\text{operator factor}} \times \frac{1.20}{\text{material factor}} \times \frac{.83}{\text{efficiency factor}} \times \frac{1.0}{\text{grade factor}} \times \\ &\frac{1.0^*}{\text{weight correction factor}} \times \frac{1.0^{**}}{\text{production method/blade factor}} \times \frac{1.0}{\text{visibility factor}} \times \frac{1.0}{\text{elevation factor}} = \underline{.75} \end{aligned}$$

$$\text{Net Hourly Production} = \frac{450}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{.75}{\text{operating adjustment factor}} = \underline{337.5} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{1,300}{\text{volume to be moved}} \text{ LCY} \div \frac{337.5}{\text{net hourly production}} \text{ LCY/hr} = \underline{4} \text{ hr}$$

* Weight Factor = $\frac{2,300 \text{ lb/CY}}{2,300 \text{ lb/CY}} = 1.00$

** Normal dozing with S-blade use 1.00

Data Source(s): Permit Application; Caterpillar Performance Handbook, Edition 28.

**WORKSHEET 5C
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE**

Earthmoving Activity:

Grade topsoil substitute to distribute over refuse and achieve final contour. Volume of material is 6,400 LCY.

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

D6R with S-blade.

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

Dozer will grade material to achieve 4-foot depth over 0.86-acre surface of the refuse fill; the average push distance is 150 feet and the effective grade is 0 percent. The material weight is 2,550 lb/CY.

Productivity Calculations:

$$\text{Operating Adjustment Factor} = \frac{.75}{\text{operator factor}} \times \frac{1.20}{\text{material factor}} \times \frac{.83}{\text{efficiency factor}} \times \frac{1.0}{\text{grade factor}} \times \frac{0.9^*}{\text{weight correction factor}} \times \frac{1.0^{**}}{\text{production method/blade factor}} \times \frac{1.0}{\text{visibility factor}} \times \frac{1.0}{\text{elevation factor}} = .67$$

$$\text{Net Hourly Production} = \frac{525}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{.67}{\text{operating adjustment factor}} = \frac{352}{\text{LCY/hr}}$$

$$\text{Hours Required} = \frac{6,400}{\text{volume to be moved}} \text{ LCY} + \frac{352}{\text{net hourly production}} \text{ LCY/hr} = \frac{18}{\text{hrs}}$$

* Weight Factor = $\frac{2,300 \text{ lb/CY}}{2,550 \text{ lb/CY}} = 0.90$

** Normal dozing with S-blade use 1.00

Data Source(s): Permit Application; Caterpillar Performance Handbook, Edition 28.

**WORKSHEET 5D
 PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE**

Earthmoving Activity:

Grade embankment material to backfill storage basins and pond 001. Volume of material is 6,500 LCY.

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

D7R with SU-blade and 3-shank ripper.

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

Dozer will grade embankment material to fill excavations; the average push distance is 100 feet and the effective grade is 0 percent. The material weight is 2,550 lb/CY.

Productivity Calculations:

$$\text{Operating Adjustment Factor} = \frac{.75}{\text{operator factor}} \times \frac{1.00}{\text{material factor}} \times \frac{.83}{\text{efficiency factor}} \times \frac{1.00}{\text{grade factor}} \times \frac{0.90^*}{\text{weight correction factor}} \times \frac{1.00^{**}}{\text{production method/blade factor}} \times \frac{1.00}{\text{visibility factor}} \times \frac{1.00}{\text{elevation factor}} = .56$$

$$\text{Net Hourly Production} = \frac{750}{\text{normal hourly production}} \text{ LCY/hr} \times \frac{.56}{\text{operating adjustment factor}} = 420 \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{6,500}{\text{volume to be moved}} \text{ LCY} \div \frac{420}{\text{net hourly production}} \text{ LCY/hr} = 16 \text{ hr}$$

* Weight Factor = $\frac{2,300 \text{ lb/CY}}{2,550 \text{ lb/CY}} = 0.90$

** Normal dozing with SU-blade use 1.00

Data Source(s): Permit Application; Caterpillar Performance Handbook, Edition 28.

WORKSHEET 6
PRODUCTIVITY AND HOURS REQUIRED FOR DOZER USE--GRADING

Earthmoving Activity:
Final grading.

Characterization of Dozer Used (type, size, etc.):
D6R with 11-foot wide S-blade

Description of Dozer Use (% grade, effective blade width, operating speed, etc.):
Grading along contour (0% grade) to smooth coal refuse moved by truck and loader team and to eliminate rills and gullies prior to topsoil replacement.

Productivity Calculations:

$$\text{Operating Adjustment Factor} = \frac{.75}{\text{operator factor}} \times \frac{1.00}{\text{material factor}} \times \frac{.83}{\text{efficiency factor}} \times \frac{1.00}{\text{grade factor}} \times$$

$$\frac{1.00}{\text{weight correction factor}} \times \frac{1.00}{\text{production method/blade factor}} \times \frac{1.00}{\text{visibility factor}} \times \frac{1.00}{\text{elevation factor}} = \underline{.623}$$

$$\text{Hourly Production} = \frac{3.0}{\text{average speed}} \text{ mi/hr} \times \frac{11.0}{\text{effective blade width}} \text{ ft} \times 5,280 \text{ ft/mi} \times 1 \text{ ac}/43,560 \text{ ft}^2 = \underline{4} \text{ ac/hr}$$

$$\text{Net Hourly Production} = \frac{4}{\text{hourly production}} \text{ ac/hr} \times \frac{.623}{\text{operating adjustment factor}} = \underline{2.49} \text{ ac/hr}$$

$$\text{Hours Required} = \frac{12.0}{\text{area to be graded}} \text{ ac} \div \frac{2.49}{\text{net hourly production}} \text{ ac/hr} = \underline{8} \text{ hr}$$

* Effective blade width = 11.0 ft. - 1.0 ft. (blade overlap) = 10.0 ft.

Data Source(s): Permit Application.

WORKSHEET 7
PRODUCTIVITY AND HOURS REQUIRED FOR RIPPER-EQUIPPED DOZER USE

Ripping Activity:

Characterization of Dozer and Ripper Use:

D7R with SU-blade and 3-shank, parallelogram ripper

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

Dozer will rip surface area of 304,920 square feet. The average cut length is 200 feet, ripping depth is 2 feet, and ripping width is 9.75 feet. (3 ripper shanks with a 39" spacing and 39" gap between passes. Pass width = $3 \times 39" / 12" / 1 \text{ ft.} = 9.75 \text{ feet.}$)

Productivity Calculation:

$$\text{Cycle time} = \left(\frac{200 \text{ ft}}{\text{cut length}} \div \frac{88 \text{ ft/min}}{\text{(speed)}} \right) + \frac{.3 \text{ min}}{\text{fixed turn time}^*} = 2.6 \text{ min/pass}$$

$$\text{Passes/hour} = 60 \text{ min/hr} \div \frac{2.6 \text{ min/pass}}{\text{cycle time}} \times \frac{.83}{\text{efficiency factor}} = 19.2 \text{ passes/hr}$$

$$\text{Volume cut per pass} = \left(\frac{2.0 \text{ ft}}{\text{tool penetration}} \times \frac{9.75 \text{ ft}}{\text{cut spacing}} \times \frac{200 \text{ ft}}{\text{cut length}} \right) \div 27 \text{ ft}^3/\text{yd}^3 = 144.4 \text{ BCY/pass}$$

$$\text{Hourly Production} = 144.4 \text{ BCY/pass} \times 19.2 \text{ passes/hr} = 2,772.5 \text{ BCY/hr}$$

$$\text{Hours Required} = \frac{22,587 \text{ BCY}}{\text{bank volume to be to be ripped}^{**}} \div \frac{2,772.5 \text{ BCY/hr}}{\text{hourly production}} = 8.0 \text{ hr}$$

* Fixed turn time depends on dozer. 0.25 min/turn is used.

** Calculate separate dozer hauling of ripped material in each lift on *Worksheet 5*. Use swell factor to convert from bank to loose cubic yards.

Data Source(s): Permit Application.

**WORKSHEET 8
 PRODUCTIVITY AND HOURS REQUIRED FOR LOADER USE**

Earthmoving Activity:

Load excavated waste coal and contaminated soil for haul to refuse area. Volume of material is 1,300 cubic yards.

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

988F loader with an 8 CY rock bucket

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

Loader will load material for haul.

Productivity Calculations:

$$\text{Cycle time} = \frac{0}{\text{haul time (loaded)}} + \frac{0}{\text{return time (empty)}} + \frac{.65}{\text{basic cycle time}} = \underline{.65} \text{ min}$$

$$\text{Net Bucket Capacity} = \frac{8.0}{\text{heaped bucket capacity}} \text{ LCY} \times \frac{.85}{\text{bucket fill factor}^*} = \underline{6.8} \text{ LCY}$$

$$\text{Hourly Production} = \frac{6.8}{\text{net bucket capacity}} \text{ LCY} \div \frac{.65}{\text{cycle time}} \text{ min} \times \frac{.75}{\text{efficiency factor}} \times 60 \text{ min/hr} = \underline{470.8} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{1,300}{\text{volume to be moved}} \text{ LCY} \div \frac{470.8}{\text{hourly production}} \text{ LCY/hr} = \underline{3} \text{ hrs}$$

* See loader section of equipment manual.

Data Source(s): Permit Application.

**WORKSHEET 9
 PRODUCTIVITY AND HOURS REQUIRED FOR TRUCK USE**

Earthmoving Activity:

Haul waste coal and contaminated soil to refuse disposal site. Volume of material is 1,300 cubic yards.

Characterization of Truck Use (type, size, etc.)

769D truck with a 21.2 CY struck and 30.7 CY heaped capacity = 26 CY average capacity.

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

Trucks will haul material from processing/loading site to disposal site, a haul distance of 1.4 miles (7,400 ft). The effective grade for the haul is 4%; the effective grade for the return is 4%.

Productivity Calculations:

$$\text{No. Loader Passes/Truck} = \frac{26 \text{ LCY}}{\text{truck capacity}^*} \div \frac{6.8 \text{ LCY}}{\text{loader bucket net capacity}} = \underline{3.8 \text{ (use 4)}} \text{ passes}$$

$$\text{Net Truck Capacity} = \frac{6.8 \text{ LCY}}{\text{loader bucket net capacity}} \times \frac{4}{\text{no. loader passes/truck}} = \underline{27.2} \text{ LCY}$$

$$\text{Loading Time/Truck} = \frac{.65 \text{ min}}{\text{loader cycle time (from Worksheet 8)}} \times \frac{4}{\text{no. loader passes/truck}} = \underline{2.6} \text{ min}$$

$$\text{Truck Cycle Time} = \frac{3.36}{\text{haul time}} + \frac{2.4}{\text{return time}} + \frac{2.6}{\text{total loading time}} + \frac{2.0}{\text{dump and maneuver time}} = \underline{10.36} \text{ min}$$

$$\text{Number of Trucks Required} = \frac{10.36 \text{ min}}{\text{truck cycle time}} \div \frac{2.6}{\text{total loading time}} \text{ min} = \underline{4} \text{ trucks}$$

$$\text{Production Rate} = \frac{27.2 \text{ LCY}}{\text{net truck capacity}} \times \frac{4}{\text{no. of trucks}} \div \frac{10.36 \text{ min}}{\text{truck cycle time}} = \underline{10.5} \text{ LCY/min}$$

$$\text{Hourly Production} = \frac{10.5 \text{ LCY/min}}{\text{production rate}} \times 60 \text{ min/hr} \times \frac{.75}{\text{efficiency factor}} = \underline{472.6} \text{ LCY/hr}$$

$$\text{Hours Required} = \frac{1,300 \text{ LCY}}{\text{volume to be moved}} \div \frac{472.6 \text{ LCY/hr}}{\text{hourly production}} = \underline{3} \text{ hr}$$

* Normally the average of the struck and heaped capacities.

Haul Time: 7400 ft/ (25 MPH x 88 fpm/MPH) = 3.36 minutes
 Return Time: 7400 ft/ (35 MPH x 88 fpm /MPH) = 2.4 minutes

Data Source(s): Permit Application.

**WORKSHEET 13
 SUMMARY CALCULATION OF EARTHMOVING COSTS**

Equipment *	Ownership & Operation Cost (\$/hr)	Labor Cost (\$/hr)	Total Hours Required **	Total Cost *** (\$)
D7R-SU with ripper	76.62	14.56	29	44,446
D6R-S	45.79	14.56	30	1,811
988F	100.90	15.56	3	349
769D	86.09	12.90	3	297
769D	86.09	12.90	3	297
769D	86.09	12.90	3	297
769D	86.09	12.90	3	297
Grand Total				\$47,794
<p>* Include all necessary attachments and accessories for each item of equipment. Also, add support equipment such as water wagons and graders to match total project time as appropriate.</p> <p>** Account for multiple units in truck and/or scraper teams.</p> <p>*** To compute Total Cost: Add Ownership & Operation Cost and Labor Cost columns then multiply by Total Hours Required column.</p>				

Data Source(s): PRIMEDIA Information, Inc., Cost Reference Guide, 1999.

**WORKSHEET 14
 REVEGETATION COSTS**

Name and Description of Area To Be Revegetated:
 Seven acres of processing/loading site and 5 acres of refuse site.

Description of Revegetation Activities:
 Seedbed preparation; liming; seeding and mulching; shrub-planting pattern will cover total area at one acre; 50% reseeding failure rate assumed and 20% plant failure assumed.

Cost Calculation for Individual Revegetation Activities:

Initial Seeding

$$\frac{12}{\text{area to be seeded}} \text{ ac} \times \left(\$ \frac{180}{\text{seedbed preparation}} / \text{ac} + \$ \frac{720}{\text{seeding, fertilizing \& mulching}} / \text{ac} \right) = \$ \underline{10,800}$$

Planting Trees and Shrubs

$$\frac{1}{\text{area to be planted}} \text{ ac} \times \left(\$ \frac{270}{\text{planting}} / \text{ac} + \$ \frac{100}{\text{herbicide treatment}} / \text{ac} \right) = \$ \underline{370}$$

Reseeding

$$\frac{12}{\text{area to be seeded \& unreleased disturbed areas}} \text{ ac} \times \frac{.50}{\text{failure rate}^*} \times \left(\$ \frac{180}{\text{seedbed preparation}} / \text{ac} + \$ \frac{720}{\text{seeding, fertilizing \& mulching}} / \text{ac} \right) = \$ \underline{5,400}$$

Replanting Trees and Shrubs

$$\frac{1}{\text{area to be planted \& unreleased disturbed areas}} \text{ ac} \times \frac{.20}{\text{failure rate}^*} \times \left(\$ \frac{270}{\text{planting}} / \text{ac} + \$ \frac{100}{\text{herbicide treatment}} / \text{ac} \right) = \$ \underline{74}$$

Other Necessary Revegetation Activities

(Examples of other activities that may be necessary include soil sampling, irrigation, and rill and gully repair. Describe each activity and provide a cost estimate with documentation. Use additional worksheets if necessary.)

Other Costs: \$ _____

TOTAL REVEGETATION COST = \$ 16,644

* See description of revegetation above. Based on AML contract data.

Data Source(s): AML Contract Data.

**WORKSHEET 15A
OTHER RECLAMATION ACTIVITY COSTS**

(Subsidence damage repair costs, water supply replacement costs, funds required to support long-term treatment of unanticipated acid or ferruginous mine drainage, etc.)

Description of Reclamation, Repair or Pollution Abatement Activity:

Grade to eliminate embankment of sediment pond No. 002 and construction of rock-lined drainage channel. Channel will be 300 feet long.

Assumptions:

Unit cost includes elimination of embankment.

Cost Estimate Calculations:

Dozer cost = \$16.20 per LF
\$16.20/LF x 300 LF = \$4,860

TOTAL COSTS = \$ 4,860 _____.

Other Documentation or Notes:

(Include additional sheets, maps, calculations, etc., as necessary to document estimate.)

Data Source(s): Permit Application; AML Data.

**WORKSHEET 15B
OTHER RECLAMATION ACTIVITY COSTS**

(Subsidence damage repair costs, water supply replacement costs, funds required to support long-term treatment of unanticipated acid or ferruginous mine drainage, etc.)

Description of Reclamation, Repair or Pollution Abatement Activity:

Basins and sedimentation ponds are acidic and require treatment. Treat basins and ponds prior to de-watering.

Assumptions:

Water volume is total of structures normal capacity; 696,000 cubic feet.

Cost Estimate Calculations:

**Combined treatment and de-watering cost is \$0.15 per 10 cubic feet.
\$0.15/cu ft x 696,000 cu ft/10 cu ft = 10,440**

TOTAL COSTS = \$ 10,440

Other Documentation or Notes:

(Include additional sheets, maps, calculations, etc., as necessary to document estimate.)

Data Source(s): Permit Application; AML Data.

**WORKSHEET 16
 RECLAMATION BOND SUMMARY SHEET**

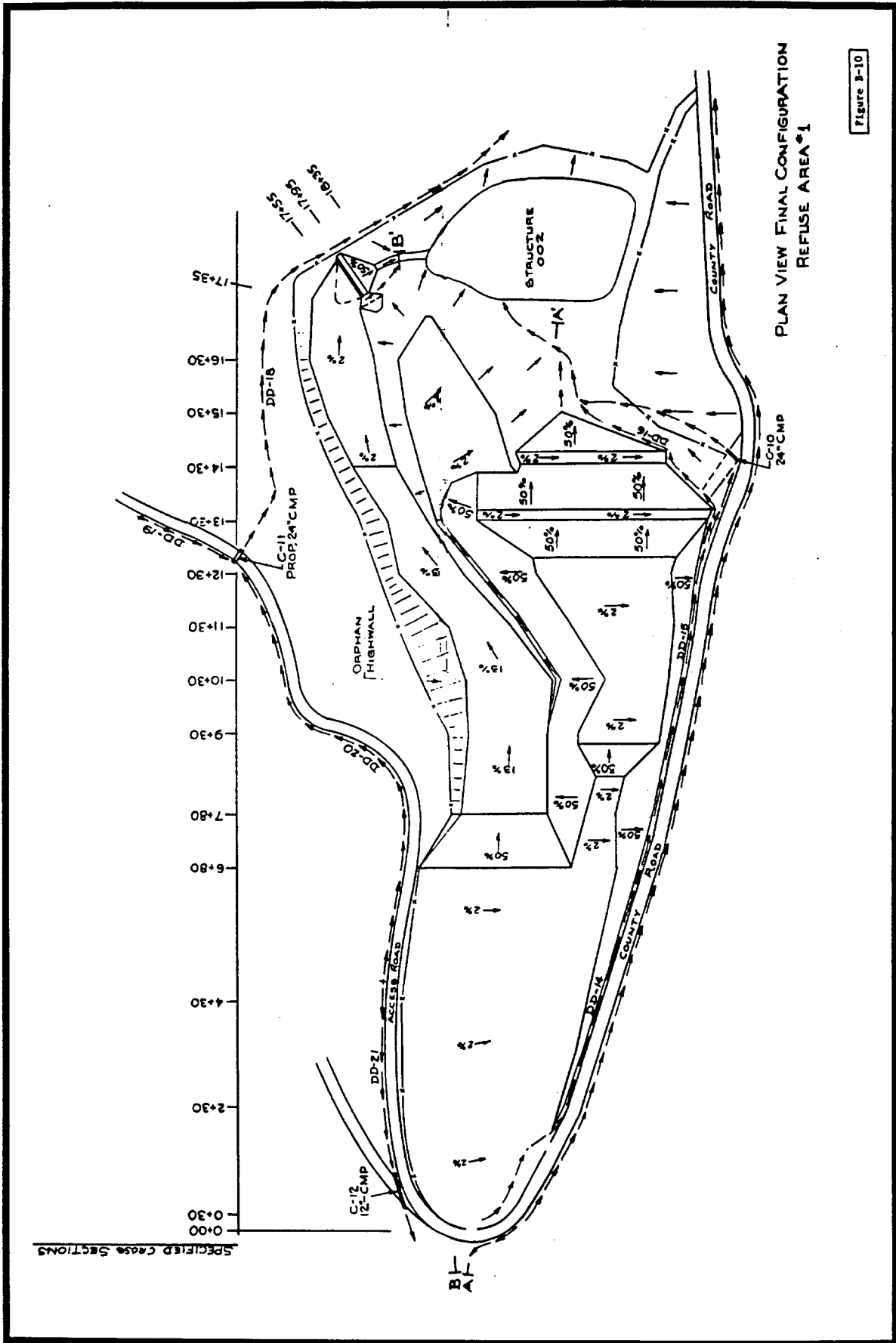
1.	Total Facility and Structure Removal Costs	\$	<u>55,097</u>	
2.	Total Earthmoving Costs	\$	<u>47,794</u>	
3.	Total Revegetation Costs	\$	<u>16,644</u>	
4.	Total Other Reclamation Activities Costs	\$	<u>15,300</u>	
5.	Total Direct Costs (sum of Lines 1 through 4)	\$	<u>138,835</u>	
6.	<u>Inflated Total Direct Costs</u> (Line 5 x inflation factor *)			\$ <u>149,883</u>
7.	Mobilization/Demobilization (<u>5</u> % of Line 6) (1% to 10% of Line 6)	\$	<u>7,494</u>	
8.	Contingencies (<u>5</u> % of Line 6) (3% to 5% of Line 6)	\$	<u>7,494</u>	
9.	Engineering Redesign Fee (<u>5</u> % of Line 6) (2.5% to 6% of Line 6)	\$	<u>7,494</u>	
10.	Contractor Profit/ Overhead (<u>30</u> % of Line 6) (see Graph 1)	\$	<u>44,965</u>	
11.	Project Management Fee (<u>5.7</u> % of Line 6) (see Graph 2)	\$	<u>8,543</u>	
12.	<u>Total Indirect Costs</u> (sum of Lines 7 through 11)			\$ <u>75,990</u>
13.	GRAND TOTAL BOND AMOUNT (sum of Lines 6 and 12)			\$ <u>225,873</u> (round to \$226,000)

* Inflation factor = $\frac{\text{ENR Construction Cost Index (CCI) for current mo/yr}^{**}}{\text{ENR CCI for mo/yr 5 years prior to current mo/yr}^{***}} = \frac{6008}{5405} = 1.1116$

Identify current month/year used in formula above: 4/99
 Identify prior month/year used in formula above: 4/94

ENR = *Engineering News Record*, McGraw-Hill Construction Information Group, New York, NY; <http://www.enr.com>.

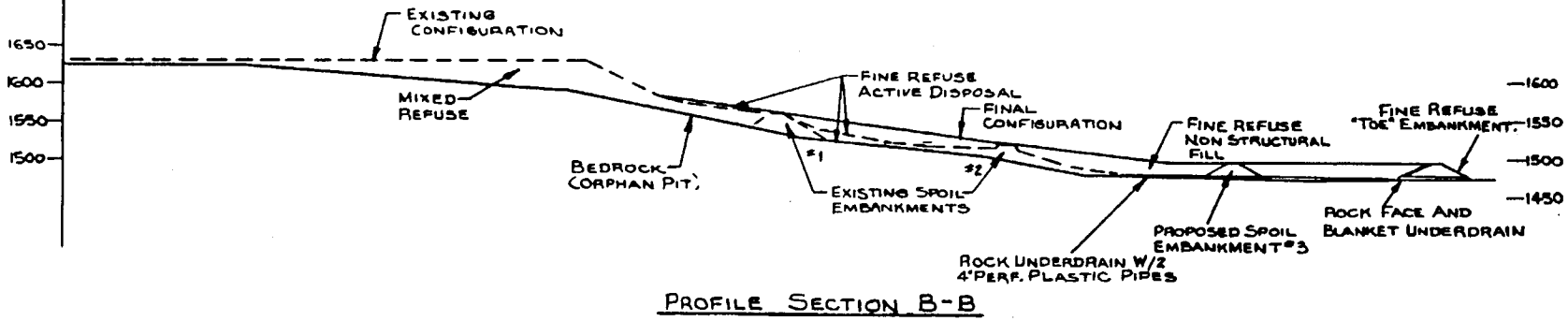
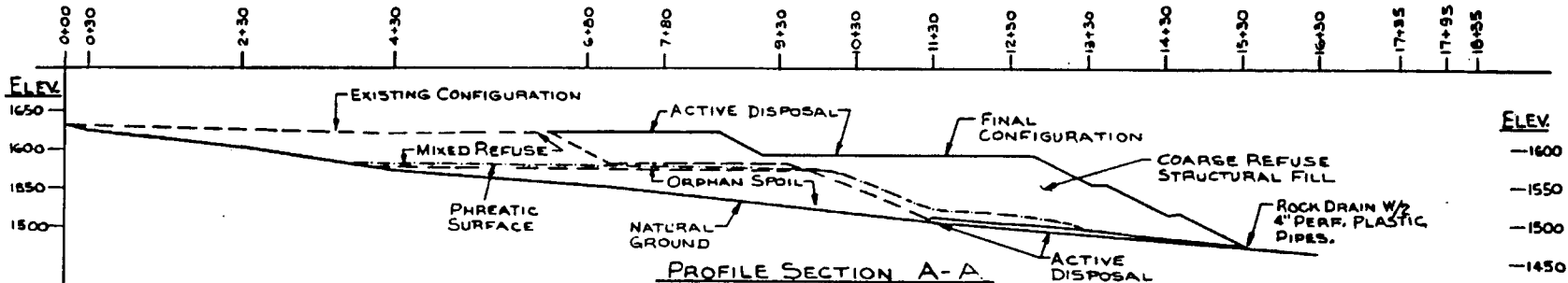
Formula assumes permit term or time until next bond adequacy evaluation is 5 years. Adjust timeframe as necessary.



PLAN VIEW FINAL CONFIGURATION
REFUSE AREA #1

Figure B-10

SECTION



100 0 100
scale, feet

PROFILE CROSS SECTIONS
REFUSE AREA #1

Figure B-11

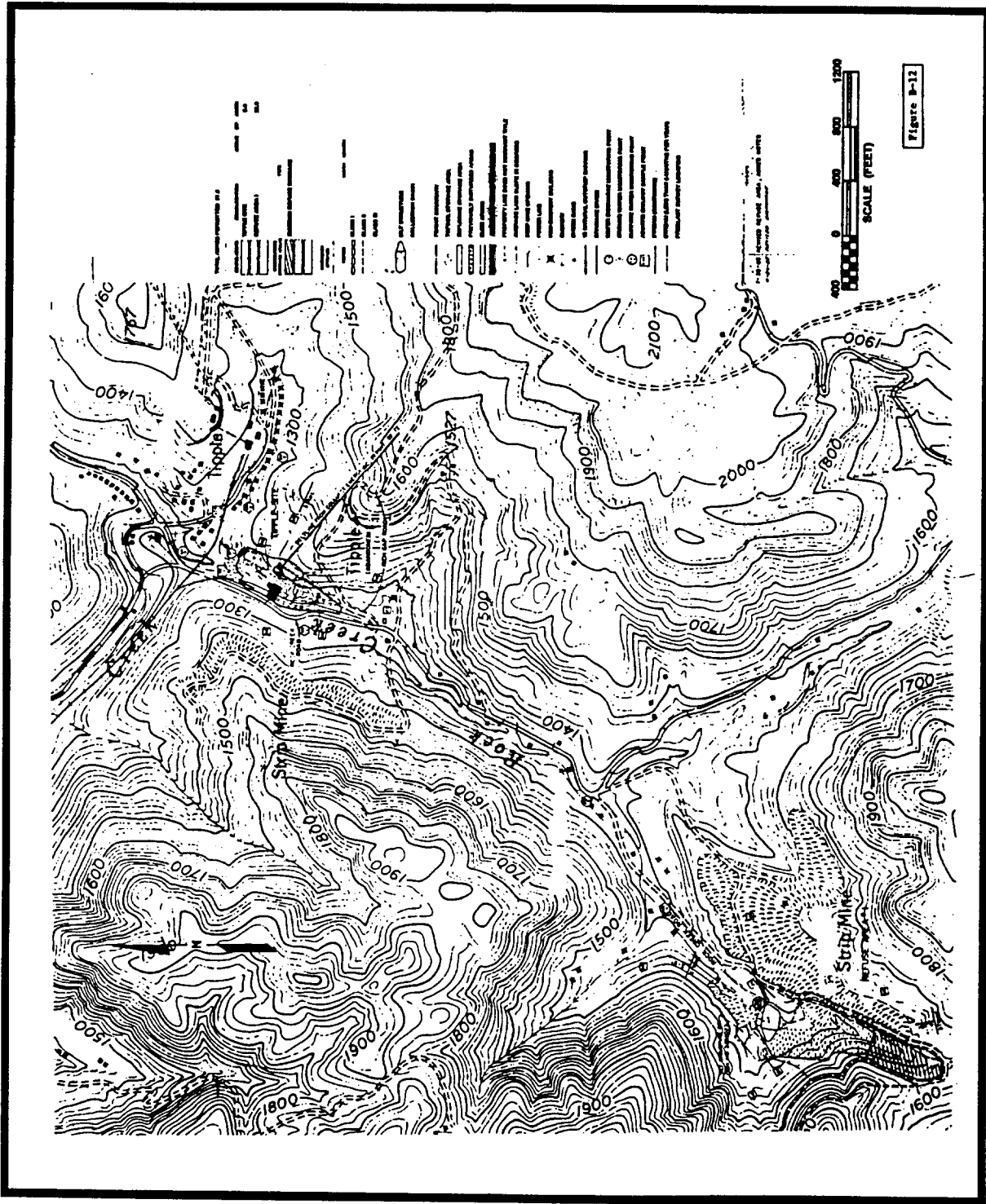
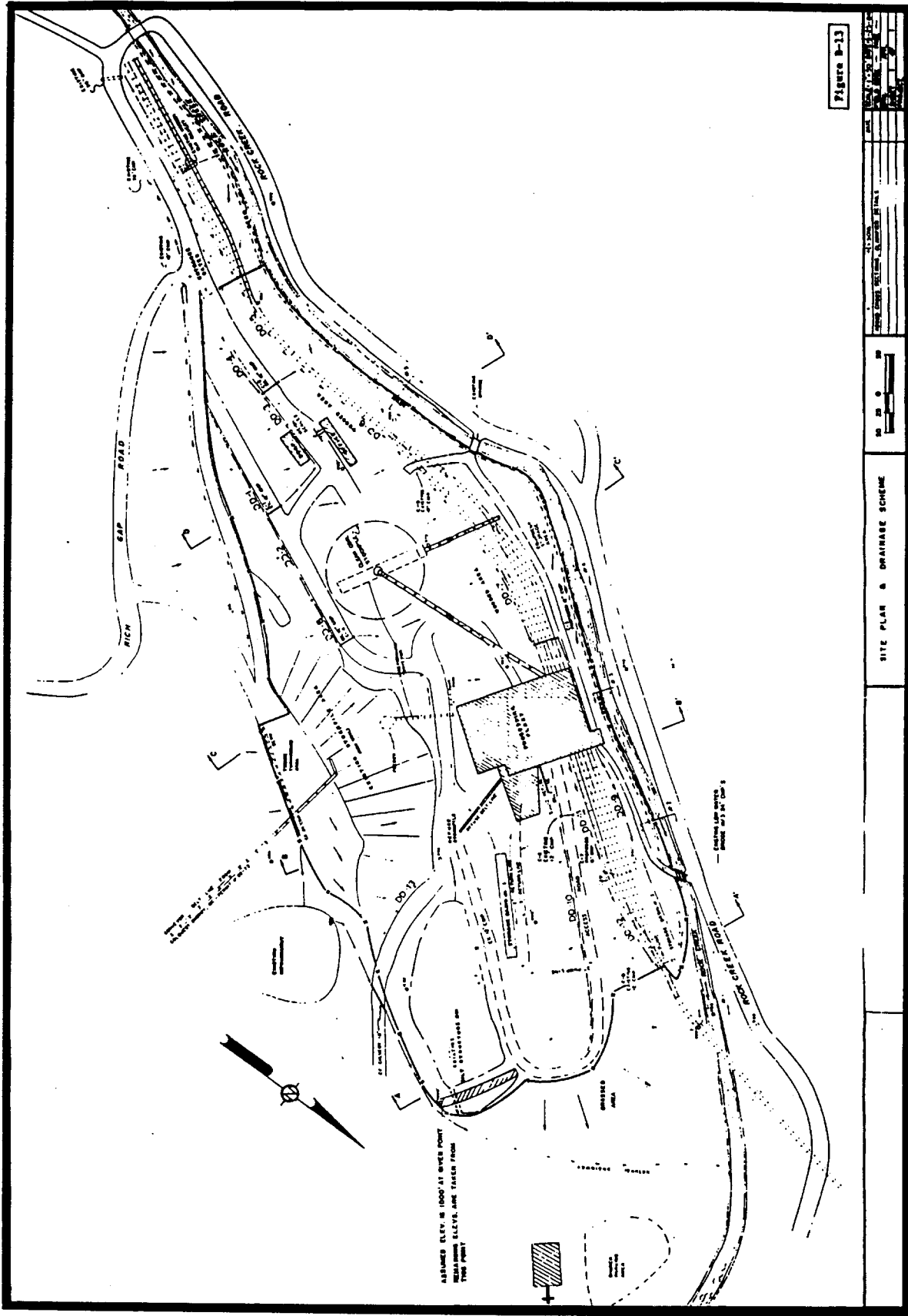


Figure B-12



ASSUMES ELEV. IN 1000' AT GIVES POINT
 DRAINAGE ELEV. ARE TAKEN FROM
 THIS POINT

Figure B-13

<p>DATE: _____</p> <p>SCALE: _____</p> <p>PROJECT: _____</p> <p>DESIGNER: _____</p> <p>CHECKER: _____</p>		<p>1" = 100'</p>	<p>SITE PLAN & DRAINAGE SCHEME</p>
<p>NO. _____</p> <p>REV. _____</p>			

APPENDIX C
GUIDANCE FOR EQUIPMENT SELECTION

04/05/00

APPENDIX C

GUIDANCE FOR EQUIPMENT SELECTION

INTRODUCTION

The selection and matching of equipment for a surface mining operation is a complex task requiring a knowledge of equipment productivity for the reclamation tasks that are typically encountered. Proper selection of equipment allows completion of reclamation tasks in an efficient manner and results in the lowest possible performance bond.

Factors governing equipment productivity are capacity; cycle time (the time required to complete the operation); and site conditions such as space limitations, grades, and material characteristics that affect the performance of the machinery. Equipment selection involves evaluating the advantages and disadvantages in using different types of equipment to perform reclamation tasks. Familiarity with earthmoving equipment suitable for surface mining reclamation can be gained through review of equipment production and cost-estimating guides available from firms such as Terex, Caterpillar, Komatsu, and others. The estimator, once familiar with the uses and capabilities of various pieces of earthmoving equipment, will be faced with the task of comparing two or more combinations of equipment to determine which is the most efficient for the reclamation task at hand.

EARTHMOVING EQUIPMENT

I. Track-type Tractors

Bulldozers outfitted with either semi-universal or universal (reclamation) blades for backfilling and rough grading and straight blades for final or contour grading, are normally appropriate for reclamation activities requiring dozers. In choosing a particular dozer, the estimator must consider the volume of material to be handled, the space available to maneuver the machine and any size restrictions needed because of the quality of the access roads to the site.

Additionally, dozers can be equipped with a ripper for breakage of consolidated material prior to dozing. The seismic velocity of material may be used to determine whether the material can be ripped. However, because this information is rarely available in permit applications, stratigraphic information from borehole logs and cross-sections must be used. Most shales, siltstones, interbedded shale and sandstone, and thin-bedded limestone can be ripped with the larger ripper-equipped dozers. However, thick-bedded sandstone, limestone, or conglomerate formations would probably require blasting.

Other reclamation tasks in which rippers are often employed include ripping of the subbase of road and facility areas to eliminate vehicle compaction prior to topsoil replacement. Reclamation plans also require contour ripping of backfill areas prior to topsoil replacement to improve soil cohesion on slopes and/or reduce compaction. In order to achieve the necessary post-mine land use deep (3 to 4 feet) ripping may be required in areas where prime farmland soils are replaced. This compaction elimination allows the necessary root penetration for agricultural crops such as corn and is especially if scrapers are used in replacement of the rooting medium. This ripping activity is conducted with large bulldozers pulling specialty rippers and the reclamation is often estimated on a per-acre basis.

II. Trucks

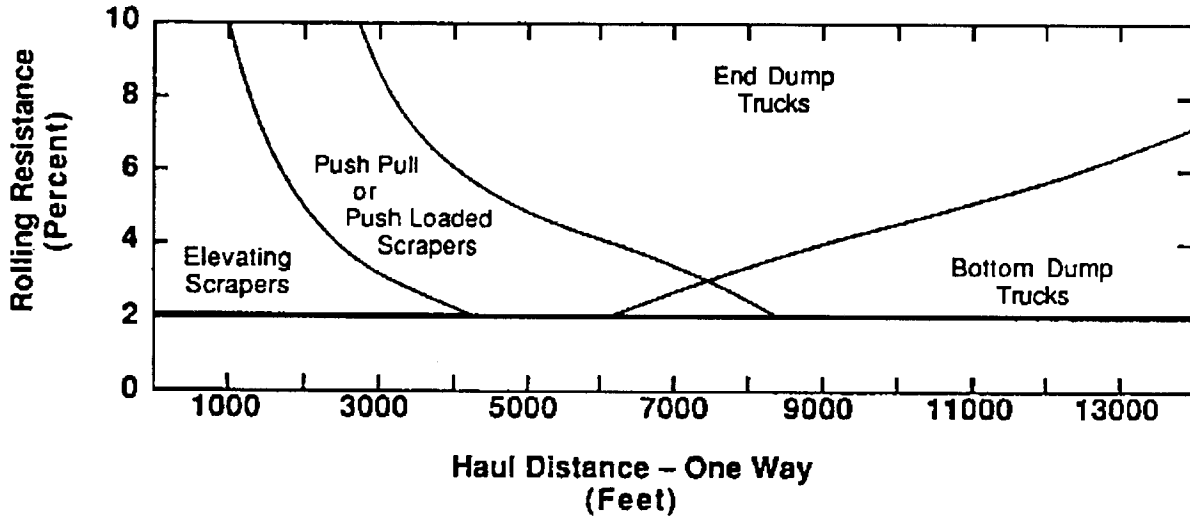
Most reclamation tasks requiring off-highway trucks can be accomplished with trucks having capacities of 35 tons (26 cubic yards) to 150 tons (100 cubic yards). Larger off-road trucks are available with greater capacities. However, these larger trucks are not commonly used in bond forfeiture site reclamation. As with dozers and loaders, selection of trucks is based on the amount of material to be handled and the space available to maneuver the truck. Generally, trucks similar to these used by the operator are the largest that can be selected because of limitations of haul road capabilities.

Bottom dump haul trucks should be considered for spreading large volumes of subsoil material needed to reclaim surface mines especially in prime farmland areas where the hauls are of 10,000 feet or more and prevention of soil compaction is critical (see Figure C-1).

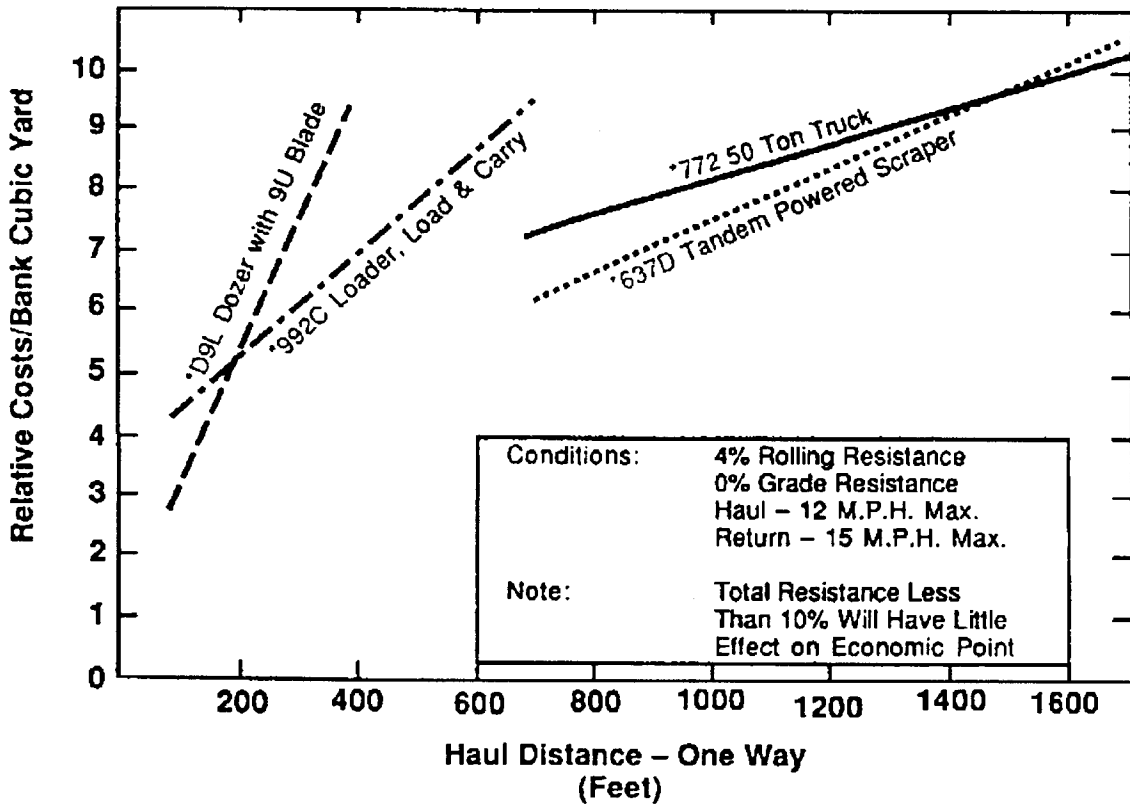
The graph shown in Figure C-2 can be used to estimate speed limits for off-highway trucks with favorable grades and good conditions (firm, smooth roadways with low rolling resistance). When the grade is not favorable (total resistance is a positive number) speed limits are not imposed. For example, for a loaded truck with a (-) 4% total resistance (grade plus rolling resistance), the maximum safe speed would be 35 mph. In comparison, for an empty vehicle with the same favorable grade, the maximum safe speed would be 40 mph.

Figure C-3 can be used to estimate speed limits for off-highway trucks required for safe operation on curves. Based on the road design and the curvature of the turn, the limiting speed can be applied to the curve segment of the haul. If the coefficient of friction and super-elevation are not known, the most conservative curve should be used (coefficient of friction = 0.1 and super-elevation = 0).

Figure C-1 - Application Zones for Representative Reclamation Equipment



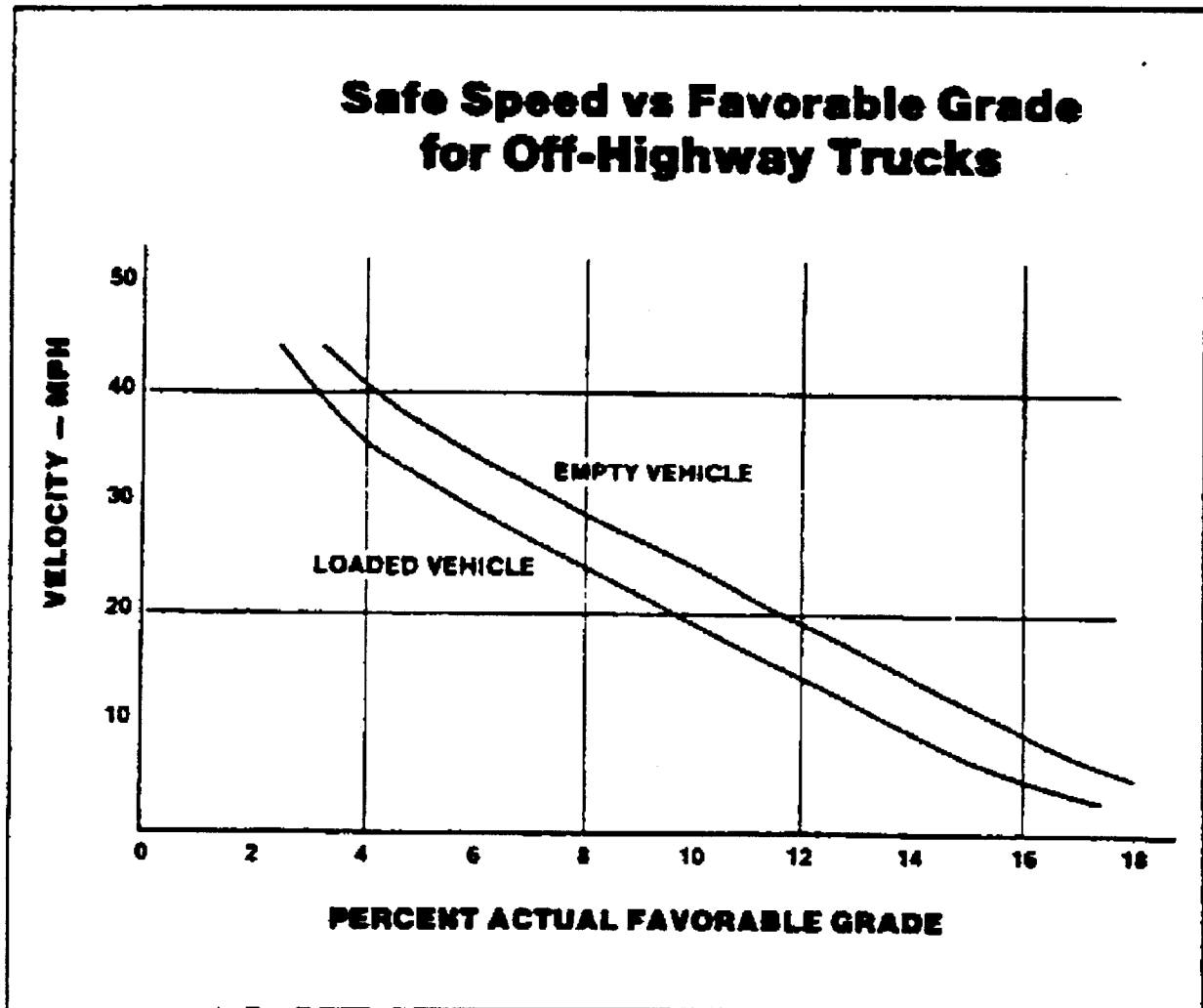
Adapted From
International Harvester, 1975



Caterpillar Tractor Co., used to illustrate equipment class and does not imply endorsement by the Office of Surface Mining Reclamation and Enforcement

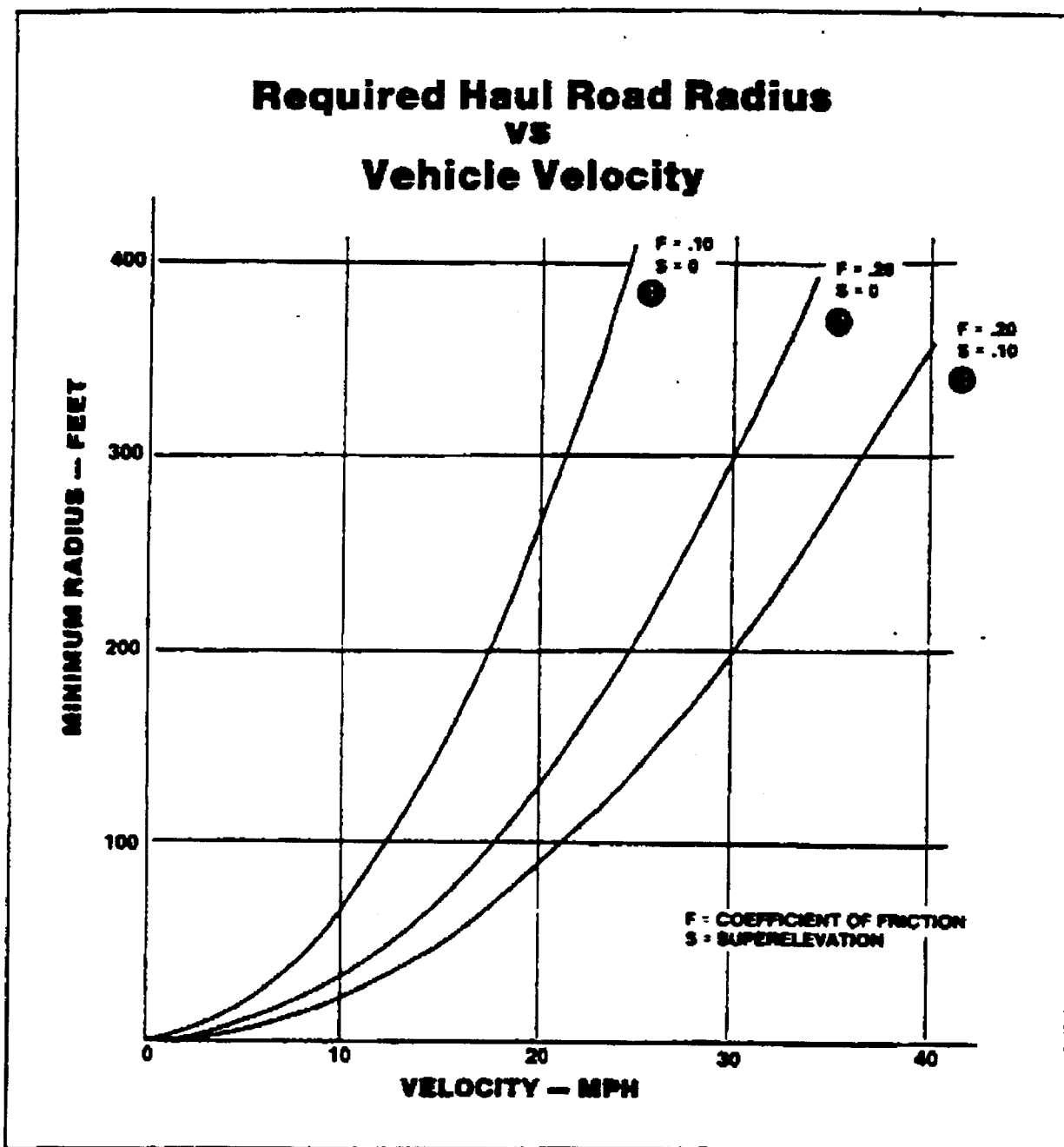
Adapted From
Haley, 1974

Figure C-2 - Safe Downhill Speeds for Off-Highway Equipment.



Source: Vehicle Simulation (VEHSIM) Program User Manual, page E-1, Caterpillar, Inc., 1993.

Figure C-3 - Safe Speeds for Off-Highway Equipment on Curved Road Segments



Source: Vehicle Simulation (VEHSIM) User Program Manual, page F-2, Caterpillar, Inc., 1993 .

III. Excavators

Because of their ability to excavate solid bank material--such as shaley bedrock and compacted fill material--and to work in confined areas, there are certain applications where hydraulic excavators may substitute for wheel loaders. Two types of excavators are used, the front excavator shovel and the backhoe. The front shovel is used to excavate above-grade material while the hydraulic backhoe will excavate below grade. Both machines are useful in reclamation where backfill material must be obtained from the solid bank state or a compacted fill. Backhoes also are useful in cleaning sediment from diversion ditches and siltation structures. The estimator must be careful to ensure that the excavator matches the haul trucks to be used so that excavator loading cycles are minimized.

IV. Scrapers

Scrapers are used for some reclamation activities. Maneuvering space and the volume of material to be moved will dictate the size of the scraper to be selected. If push-pull scrapers are used in pairs, no pushers will be required. However, where large scraper fleets are employed or pusher dozer tasks, such as site cleanup, are available to fill wait times, the non-push-pull scrapers/pusher dozers combination may be more productive.

Conventional (single-engine) scrapers may be economically substituted for tandem-powered units where grades and rolling resistance are low. Elevating or self-loading scrapers may be used where soft, fine-grained, or unconsolidated materials free of hard rock are encountered. Elevating scrapers have an advantage of working alone without support equipment (other than haul road maintenance) and are well suited for work requiring the flexibility to adjust to small variations in the cut and fill. They have traditionally been used for fine or finish grading. Tandem-powered scrapers can be operated independently if the materials loaded are soft and loading is downhill. However, due to the earthmover's inability to completely fill the bowl in this mode of operation, capacity should be reduced by one-third. When selecting auxiliary equipment, the estimator must determine the requirements for dozer pushers. There must be a match between the scraper selected, the dozer used, and the style of push-loading. Generally, track dozers are used as pushers.

Safety speed limitations presented in Figures C-2 and C-3 should also be applied to the downhill and road curve haulage segments.

V. Motor Graders

Motor graders (motor patrols) can be used in a wide variety of reclamation tasks, but they are used primarily for haul road maintenance. In some instances, it may be cost-effective to use a grader as a substitute for a track dozer for final grading, light leveling work, and diversion ditch construction. Graders used for surface mining can be equipped with a rear-mounted ripper or scarifier.

EQUIPMENT SELECTION OVERVIEW

When making the initial decision about what types of equipment -- for example, dozers versus scrapers--are needed for each earthmoving activity, the estimator should refer to *Worksheet 3*, the Material Handling Plan Summary Sheet. If the one-way haul distance is less than 500 feet, bulldozers of appropriate size will be the optimum equipment for the job in most cases. If the distance is between 500 and 1,000 feet, then scrapers will probably be optimal, assuming underfoot conditions and operating room allow their use and the material does not contain large boulder-size rocks. For distances over 1,000 feet, off-road trucks with compatible wheel loaders or hydraulic shovels become more efficient. Generally, as rolling resistance increases scrapers tend to be less efficient and trucks should be used. As the distance increases to a mile, truck-loader combinations are usually optimal.

After the type of equipment is initially selected, the equipment size must be determined. To do this, the estimator should note the volume and characteristics of material to be moved and the underfoot conditions. The larger pieces of equipment are more appropriate for moving large amounts of materials. Most equipment manufacturers can provide performance books that contain information to guide model selection. When in doubt, select a model and calculate the cost of the job. Next, make the same calculation using a smaller model and again using a larger model. With a little experience, the proper type and size of equipment can usually be determined in the first iteration. However, it is generally good practice to try another iteration with different-sized equipment to make certain that optimal equipment has been selected.

Table C-1 lists advantages and disadvantages of earthmoving equipment typically employed in reclamation of mine sites. Reclamation equipment can also be rated by the suitability to perform backfilling and grading tasks and topsoil removal and replacement (see Tables C-2 and C-3). The influence of haul distance and rolling resistance on the proper selection of reclamation equipment is illustrated in-Figure C-1.

Table C-1.--Advantages and Disadvantages of Reclamation Equipment

Excavators

Wheel Loaders:

1. Can give high production.
2. Larger sizes can handle all types of material, including large blocky material.
3. Where haul distance is less than 800 feet, can operate independently.
4. Have high mobility.
5. Production decreases in poor conditions.

Hydraulic Front Shovels:

1. Can give high production.
2. Can handle all types of material, including large blocky material.
3. Usually require supporting equipment.
4. Have a limited mobility.

Hydraulic Backhoes:

1. Have the ability to dig well below and above grade (i.e., to trim an unstable highwall).
2. Can function in less rigid operating conditions than shovels.
3. May or may not require supporting equipment.
4. Are normally used for handling softer material, but larger units can perform mass excavation of rock.
5. Have a limited mobility.

Scrapers:

1. Have excellent mobility.
2. Are limited to fairly soft and easily broken material for good production, although material up to a 2-foot diameter can be handled.
3. Usually require either pusher tractors or a push-pull team mate for loading assistance.
4. Usually operated without supporting disposal equipment where the distance to the dump area is less than 1 mile.

Bulldozers:

1. Are economically limited to a push distance of 500 feet.
2. Do not require roads.
3. Production decreases rapidly as grade increases.
4. Can operate in poor underfoot conditions.

Haulers

Rear Dump Trucks:

1. Require good roads to minimize tire costs.
2. Can negotiate steep ramps.
3. Usually economically limited to a haul distance of 3 miles.
4. Are very flexible.
5. Can handle coarse, blocky material.

Bottom Dump Trucks:

- 1. Require good roads to minimize tire costs.**
- 2. Are fast and have a greater economic haul distance than rear dump trucks.**
- 3. Are better suited for long, level hauls.**
- 4. Requires free-flowing materials.**
- 5. Can spread dumped material into furrows, reducing disposal grading requirements.**

Table C-2.--Reclamation Equipment Rating--Regrading and Backfilling

<u>LEGEND</u>		<u>EQUIPMENT</u>				
1	Should be considered					
2	May be considered					
3	May be considered under certain conditions					
4	May be considered--special situations					
-	Should not be considered					
		Dozers	Graders	Scrapers	Front-End Loader	Front-End Loader & Trucks
	High Peaks	1	-	2	3	3
Spoil Configuration	Moderate Peaks	1	3	1	1	2
	Low Peaks	1	1	1	1	1
	50'-150'	1	2	1	1	-
	150'-300'	1	-	1	1	-
Transport Distance	300'-500'	2	-	1	2	4
	500'-1000'	-	-	1	3	1
	1000'	-	-	1	-	1
	Flat & Smooth	1	1	1	3	-
	Flat & Rough	1	2	1	2	-
Final Surface Contour	Steep & Smooth	1	-	-	3	-
	Steep & Rough	1	-	-	2	-

Source: Modified from Skelly and Loy, 1975.

Table C-3.--Reclamation Equipment Rating--Topsoil Removal and Replacement

		<u>LEGEND</u>						
		1	2	3	4	-		
		Should be considered	May be considered	May be considered under certain conditions	May be considered--special situations	Should not be considered		
		Dozers	Front-End Loaders	Scrapers			Shovel & Truck	Front-End Loader & Truck
			Elevating	Full-Power	With Push Tractor			
Topsoil Thickness (Removal)	0'-2'	1	1	1	1	1	-	1
	2'-5'	1	1	1	1	1	4	1
Haul Distance	0-300'	1	1	2	2	1	-	-
	300'-500'	2	2	1	1	1	-	-
	500'-1000'	-	-	1	1	1	4	3
	1000'-1500'	-	-	1	1	1	4	2
	1500'-5000'	-	-	2	2	2	4	1

Source: Modified from Skelly and Loy, 1975.

Skelly and Loy, "Economic Engineering Analysis of U.S. Surface Coal Mines and Effective Land Reclamation," U.S. Bureau of Mines Contract Report No. S0241049, 1975.

APPENDIX D

**CALCULATION OF BOND AMOUNTS FOR LONG-TERM
TREATMENT OF POLLUTIONAL DISCHARGES**

04/05/00

APPENDIX D

CALCULATION OF BOND AMOUNTS FOR LONG-TERM TREATMENT OF POLLUTIONAL DISCHARGES

The March 31, 1997, acid mine drainage statement calls for the approval of only those permit applications where the operation is designed to prevent off-site material damage to the hydrologic balance and minimize both on- and off-site disturbances to the hydrologic balance. The policy emphasizes that in no case should a permit be approved if the determination of probable hydrologic consequences or other reliable hydrologic analysis predicts the formation of a postmining pollutional discharge that would require continuing long-term treatment without a defined endpoint.

However, the policy also recognizes that unanticipated discharges will develop on occasion despite the use of the best science available. In these situations, the policy requires that the permittee post sufficient financial assurance to cover all foreseeable long-term treatment costs. This assurance may take the form of a conventional bond, a trust fund, or other appropriate instrument that meets the requirements of 30 CFR Part 800.

Costs associated with long-term treatment of pollutional discharges include the capital costs to replace the treatment system, operation and maintenance costs, sampling and analysis costs, labor costs, and an allowance for contingencies. The following items are an example of what may be included in a procedure to calculate the amount of bond required to cover these costs.

1. Evaluate all available hydrologic and geologic data to estimate treatment needs and horizons. Collect additional data if necessary.
2. Determine the average operating life of the treatment facility (conventional or passive) and the capital costs of replacing that facility (a chemical treatment plant or wetland, for example).
3. Determine the annual operating and maintenance costs of the treatment system. For passive systems, these costs would include berm and channel repair expenses.
4. Determine annual monitoring costs (periodic inspection of treatment systems and analysis of effluent samples). Inspection and sampling

frequencies will vary with the type of system and quality of influent, as will the parameters monitored.

5. Calculate the present value of the capital costs of replacing the treatment facility at the end of its useful life. More than one replacement may be necessary.
6. Calculate the present value of annual operation and maintenance costs for the entire period during which treatment will likely be necessary.
7. Calculate the present value of annual monitoring costs (sample collection and analysis) for the entire period during which treatment will likely be necessary.
8. Establish a reasonable contingency factor for unexpected events and cost overruns.
9. Identify the actuarial equations used in Steps 5 through 7 and the basis for the interest and inflation rates selected.

INFORMATION SOURCES

Research publications from universities (such as West Virginia University and Pennsylvania State University), the National Mine Land Reclamation Center, the former U.S. Bureau of Mines and its successor, the Federal Energy Technology Center, and the Tennessee Valley Authority may prove helpful in determining treatment system capital and operation and maintenance costs. In addition, the permittee may be willing to provide historical treatment cost data for the site in question or other mines.

**E. Metric Conversion
Table**

APPENDIX E
METRIC CONVERSION TABLE

APPENDIX E

METRIC CONVERSION TABLE

Approximate Conversions to Metric Measures

<u>Symbol</u>	<u>When You Know Number of</u>	<u>Multiply By</u>	<u>To Find Number of</u>	<u>Symbol</u>
<u>LENGTH</u>				
in	inches	2.54 (exact)	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
<u>AREA</u>				
in ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
mi ²	square miles	2.6	square kilometers	km ²
	acres	0.4	hectares	ha
<u>WEIGHT (mass)</u>				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 pounds)	0.9	metric tons	t

<u>Symbol</u>	<u>When You Know Number of</u>	<u>Multiply By</u>	<u>To Find Number of</u>	<u>Symbol</u>
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VOLUME

tsp	teaspoon	5	milliliters	mL
Tbsp	tablespoons	15	milliliters	mL
in ³	cubic inches	16	milliliters	mL
fl oz	fluid ounces	30	milliliters	mL
c	cups	0.24	liters	L
pt	pint	0.47	liters	L
qt	quarts	0.95	liters	L
gal	gallons	3.8	liters	L
ft ³	cubic feet	0.03	cubic meters	m ³
yd ³	cubic yards	0.76	cubic meters	m ³

PRESSURE

inHg	inches of mercury	3.4	kilopascals	kPa
psi	pounds per square inch	6.9	kilopascals	kPa

TEMPERATURE (exact)

°F	degrees Fahrenheit	5/9 (after subtracting 32)	degrees Celsius	°C
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Source: U.S. Department of Commerce, National Institute of Standards and Technology.