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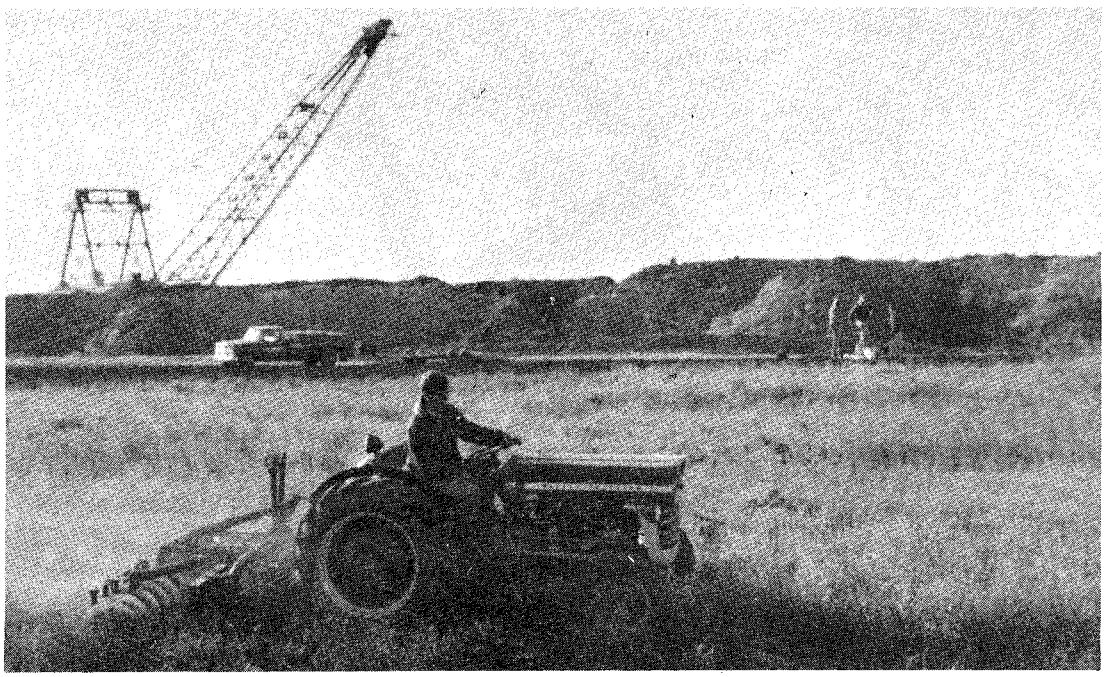
Reclamation Laws and Costs of Strip Mined Land in North Dakota



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FOREWORD

Coal is becoming more important as a source of energy. There are 16 billion tons of economically surface minable coal in North Dakota underlying 700,000 acres. The state has a comprehensive reclamation law; mining cannot be undertaken unless reclamation can be successfully completed. This report presents an overview of reclamation legislation passed in North Dakota, and estimates of reclamation costs are given.

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Highlights

This study defines the reclamation process and estimates the cost of reclaiming land in North Dakota. Reclamation costs are ultimately reflected in the price of coal and, therefore, are of concern to legislators, private citizens, public agencies, and firms engaged in the extraction and use of coal. North Dakota has a comprehensive reclamation law, but as more information becomes available, as technology changes, and as concern for the environment grows, amendments to the law are proposed. The results of this study can be used to determine the effect of proposed changes in legislation on reclamation costs, and in evaluating alternative policies pertaining to coal mining activity.

The reclamation process was separated into preparation and planning, topsoiling, recontouring, and revegetation. A set of mine conditions was assumed and a reclamation cost of $6,825 per acre was estimated. Recontouring and topsoiling accounted for 96 percent of the reclamation cost.

The effect that changes in overburden depth, slope, coal seam thickness, mine size, mine dimensions, the suitable plant growth material depth, and the average haul distance has on reclamation costs was estimated. Changes in all these conditions except coal seam thickness have a large impact on per acre reclamation costs.

Reclamation costs were estimated for the Larson, Gascoyne, and Glenharold mines in North Dakota. The per acre reclamation cost for the Larson Mine was $5,583; for the Gascoyne Mine, $5,936; and for the Glenharold Mine, $6,350.

RECLAMATION LAWS AND COSTS OF STRIP MINED LAND IN NORTH DAKOTA

Duane E. Gronhovd and Donald F. Scott*

In an era of dwindling domestic supplies of oil and natural gas and an increasing demand for energy, there has been an increase in coal production to fill this gap. The United States has only 6 percent of the world's proven oil reserves and 14 percent of the natural gas reserves, but has one-third of the recoverable coal reserves [Kenward].

The proven recoverable oil reserves in the United States will last 10 years at current rates of production,[1] while natural gas reserves will last 12 years.[2] However, recoverable coal reserves will last 349 years at current rates of production [Smith]. Coal reserves are clearly abundant in this country, and with the limited supply of natural gas and oil, coal will become more important as a source of energy in the near future.[3]

The increase in coal production is causing an increase in acreage disturbed by strip mining in North Dakota. There are 16 billion tons of economically surface minable coal in North Dakota underlying 700,000 acres [Gronhovd and Kube]. The locations of these coal deposits are shown in Figure 1. About 11 million tons of coal were mined in North Dakota in 1976, disturbing approximately 733 acres (estimated at 15,000 tons per acre). Current projections are for 44 million tons to be mined per year by 1985, with an increase to 119 million tons per year by 2000 (Figure 2). In the event of a national energy emergency, production is predicted to reach over 300 million tons per year in North Dakota, disturbing about 20,000 acres annually [Gronhovd and Kube].

Reclamation legislation pertaining to land disturbed by mining operations in North Dakota was originally passed in 1969 and biennial changes

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[1]Annual oil production in the United States has been estimated at 3.5 billion barrels and proved reserves at 35 billion barrels [Smith].

[2]Production in 1976 was 19,900 billion cubic feet and reserves were estimated at 228,000 billion cubic feet [Smith].

[3]The quantity of a resource classified as reserves depends on its price and the technology and costs associated with exploration and extraction. The quantity of reserves may change, therefore, as those variables change.

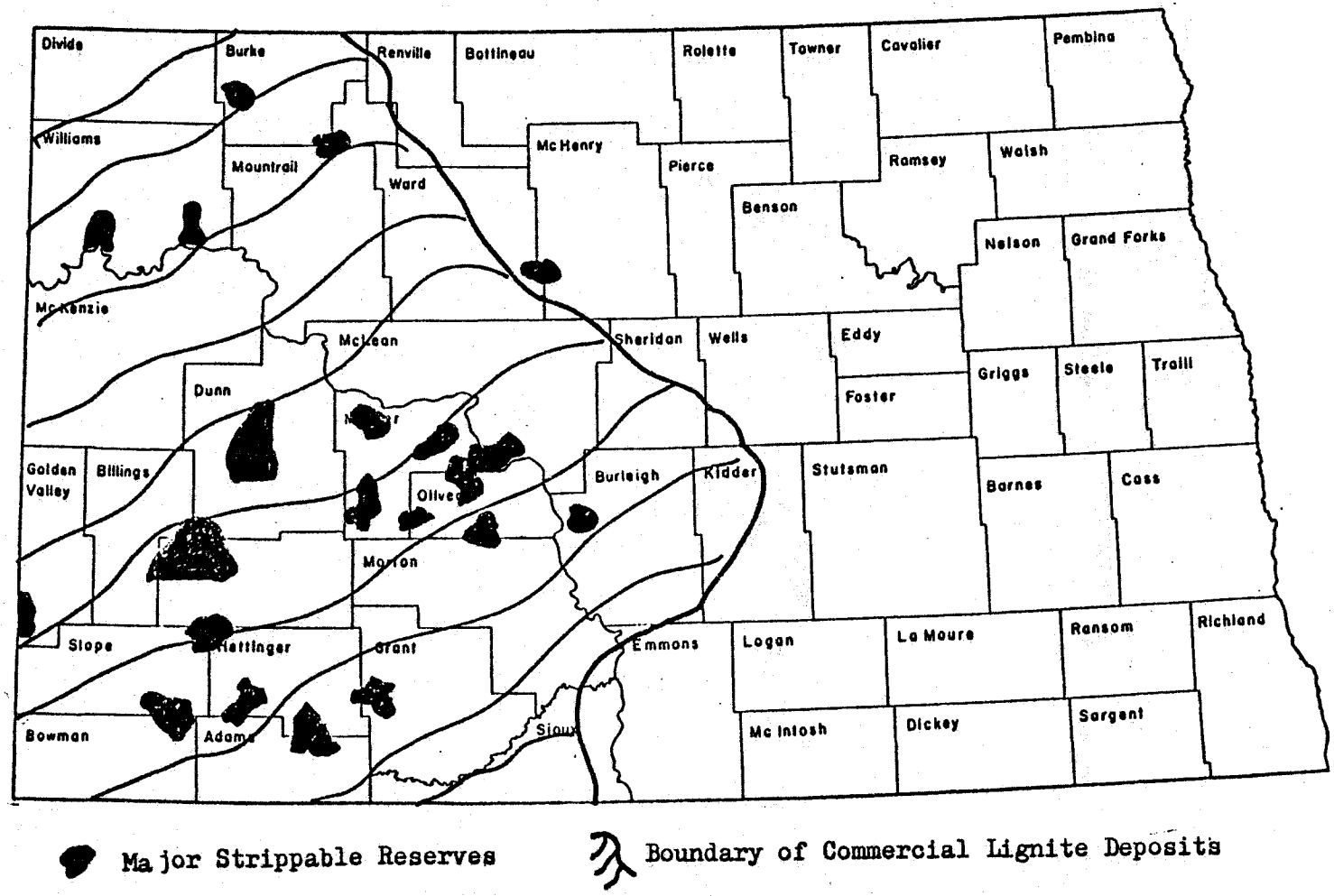

Figure 1. Area of Commercial Lignite Deposits and Locations of Major Strippable Reserves in North Dakota

SOURCE: Dalsted, Norman L., and F. Larry Leistritz, "North Dakota Coal Resources and Development Potential," Farm Research, Reprint No. 829, Vol. 31, No. 6, North Dakota Agricultural Experiment Station, July-August, 1974, p. 5.

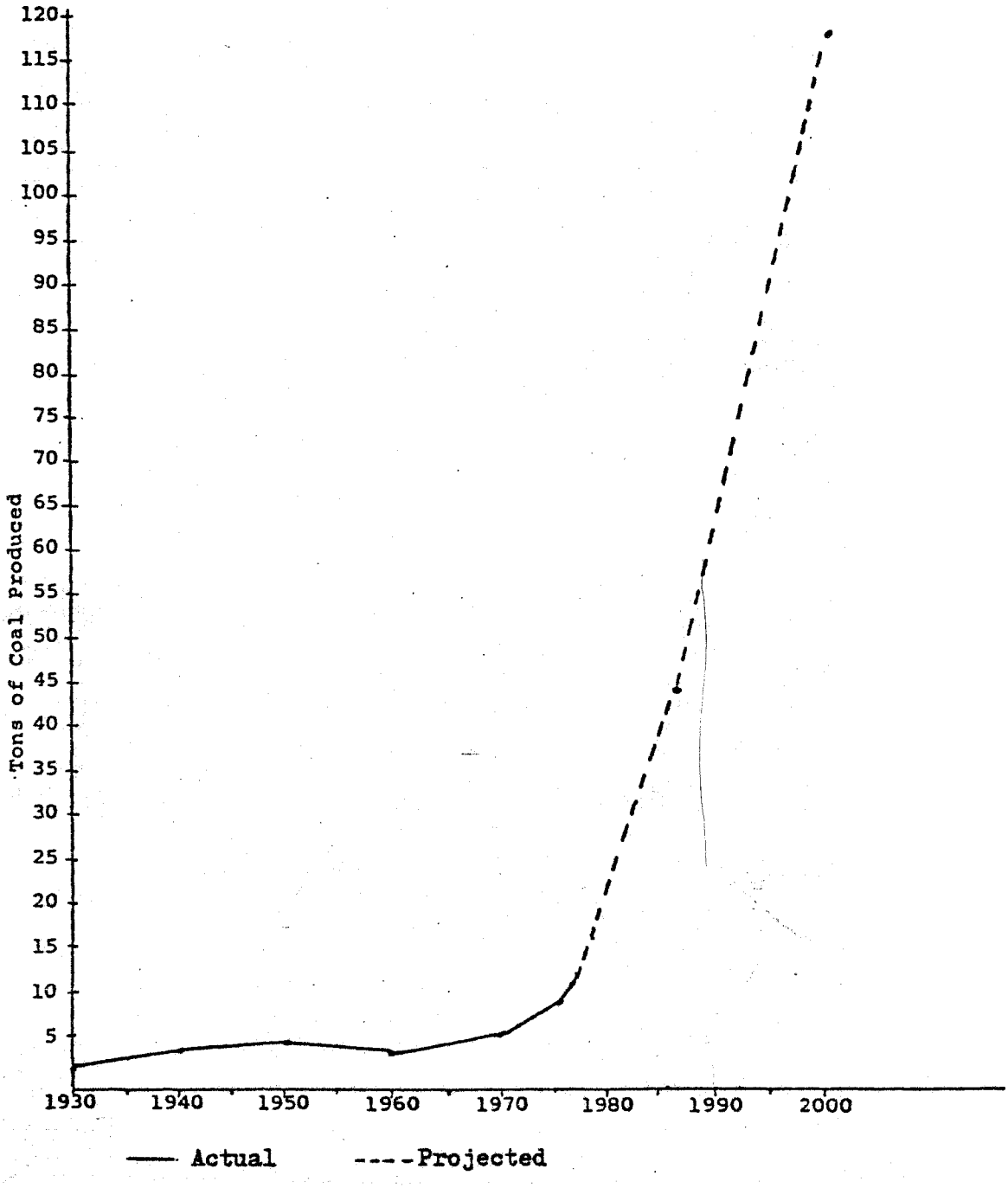

Figure 2. Actual and Projected Coal Production in North Dakota

SOURCE: Actual production figures from: Economic Research Service, Northern Great Plains Resource and Coal Development, U.S. Department of Agriculture, Washington, D.C., 1977, p. 29.

Projected production figures from: Gronhovd, G. H., and W. Kube, Coal Development in North Dakota, Montana, and Wyoming, reprinted from Fuels: A Geological Appraisal, Saskatchewan Geological Society, Special Publication No. 2, 1974.

have been made since 1973. The present law makes reclamation an important and inseparable part of the mining process. Mining cannot be undertaken unless reclamation can be successfully completed. The most important changes in reclamation legislation occurred as a result of the 1975 law, but the full magnitude and effect of the law is just beginning to be seen and understood because most land mined to date has been reclaimed under previous laws.

The state's comprehensive reclamation law and a possible thirty-fold increase in coal mining in North Dakota in the next 25 years makes reclamation a vitally important issue. Proposed changes in the law are constantly being considered. It is important, therefore, to understand the reclamation process and how changes in the law will affect the process and the costs of reclamation. This report considers the cost of reclamation in North Dakota and the effect physical mine characteristics and reclamation law requirements have on cost.

Reclamation Laws

The first reclamation law in North Dakota was passed in 1969, and since then, reclamation has been a part of surface mining activity. The present (1977) law represents the product of biennial changes to the 1969 law. The general requirements of the past and present laws are reviewed in this section to provide an understanding of the reclamation process. Also included is a brief discussion of the federal reclamation law as it will apply to North Dakota.

1969 Reclamation Law

The 1969 law required a permit to mine where overburden[4] exceeded 10 feet in depth. An operator who failed to obtain a permit was subject to a fine levied by the Public Service Commission (PSC) of between $50 and $1,000 per day for each day of violation. A bond of $200 per acre mined was required along with a mining fee which varied with the number of acres permitted as follows:

10 acres or less = $25 + $7.50 per acre

10-50 acres = $100 + $3.50 per acre

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[4] All the earth and other materials lying above the coal deposits, and such earth and other materials disturbed during mining.

over 50 acres = $275 + $2.50 per acre

The main duties of the mine operator were:

1. grade ridges and peaks visible from public roads, buildings, or cemetaries to a rolling topography;
2. construct earth dams where lakes could be formed to impound water, provided the lakes formed would not interfere with mining;
3. keep certain mining operations a specified distance from property lines or established right of ways;
4. submit a reclamation plan and map to the PSC no later than December 1 following the first year of the permit term with a map of mining pits filed annually thereafter;
5. the area was deemed reclaimed after the second attempt at cover establishment.

1973 Reclamation Law

A permit was required where overburden exceeded 10 feet in depth. Failure to obtain a permit subjected the operator to a fine by the PSC of between $50 and $1000 per day. The PSC was required to publish notice of each permit application in the official newspaper of the county in which mining activity would occur. A bond of $500 was required for each acre mined, and a filing fee of the following amounts was required:

10 acres or less = $25 + $10 per acre
10-50 acres = $100 + $10 per acre
over 50 acres = $275 + $10 per acre

went up

Duties of a mine operator under the 1973 law were:

1. apply two feet of suitable plant growth material (SPGM) or as much as was available up to that depth;
2. regrade the area to approximately the original topography;
3. impound, drain, and treat runoff water to reduce stream pollution and damage to agricultural land;
4. backslope all final cuts and end walls to an angle not exceeding 35 percent from the horizontal; after backsloping, mining operations could not approach property lines or roads closer than 20 feet;
5. bury all refuse material resulting from the mining operation;
6. submit a reclamation plan and geologic, topographic, and soils maps to the PSC no later than December 1 following the first year of the permit term with a map of the mining pit or pits filed annually thereafter;
7. obtain the landowner's preference for restoration of his land.

Areas in North Dakota which were impossible to reclaim were deleted from all surface mining activities. Any knowing or willful violation of any regulation was subject to a fine of up to $10,000, six months in jail, or both. An operator who willfully failed to comply with the provisions of the law was ineligible for further mining in the state.

1975 Reclamation Law

The provisions of the 1975 law applied to all surface mining operations. An operator was required to submit an application to the PSC for a permit which contained a soil survey of the soil material overlying the coal and a limited and extended mining plan.

The limited and extended mining plans both required a description of the land to be affected by mining and included:

1. a legal description of the land;
2. the identity of the owner of the surface rights and subsurface mineral rights;
3. the source of the operator's legal right to mine the land;
4. hydrologic data and geologic, topographic, and soils maps;
5. a detailed soil survey.

The approximate number of tons of coal to be mined, along with the location and composition of the coal, was required. Annual amendments to the extended mining plan were required to reflect any proposed mining practices that would take place within 10 years.

The PSC was required to publish notice of each mining application in the official newspaper of counties where mining would occur, and the affected landowners and mineral owners had to be notified by the PSC.

A nonrefundable fee of $250 plus $10 per acre of land to be affected was required when filing for a permit. A bond of at least $1,500 was required for each acre affected. The PSC was given authority to require a larger bond. Release of the bond could be accomplished in the following stages:

Bond Release in Stages

1. after backsloping and grading--40 percent of the bond released;
2. upon completion of spreading SPGM--an additional 30 percent released;
3. the remainder released upon successful completion of reclamation.

Duties of a mine operator under the 1975 law were:

1. regrade the area to approximately the original contour or topography;

2. save, segregate, and respread SPGM to a maximum of five feet provided that if five feet was not available, the operator would respread all SPGM available;
3. impound, drain, or treat all runoff water so as to minimize damages;
4. obtain the owner's written preference for land use;
5. backslope all final cuts, end walls, and high walls to an angle not exceeding 35 percent from the horizontal;
6. remove or bury all refuse material;
7. submit to the PSC by October 25 of each year, a map showing the specific locations of mining pits;
8. make necessary repairs if the surface owner's domestic or live stock water supply was disrupted;
9. keep a book containing specific information on the permitted mines.

Mining applications were rejected for areas which could not be reclaimed. Violation of the permit requirement was subject to a class B misdemeanor, which consisted of a $500 fine, six months in jail, or both. A knowing or willful violation was a class A misdemeanor, subject to a $1,000 fine, one year in jail, or both.

1977 Reclamation Law

Any operator who wishes to engage in surface mining must obtain a permit from the PSC under the 1977 legislation. However, the PSC may delete or modify portions of the requirements for hydrologic data and geologic, topographic, and soils maps for operations which will affect less than two acres per year.

Both the limited and extended mining plans require a description of the land to be affected, which includes:

1. the legal description of the land;
2. identity of the owner of the surface rights and subsurface mineral rights;
3. the source of the operator's legal right to mine or affect the land;
4. hydrologic data and geologic, topographic, and soils maps;
5. a detailed soil survey for the limited plan.

The extended mining plan must be amended yearly to reflect any proposed mining practices which will take place within 10 years.

An expedited amendment may be granted to an existing permit to cover an additional 15 acres contiguous to the active permit area. The data and map requirements of a normal application can be waived in this case.

The PSC must publish notice of each mining application in the official newspaper of the county where mining would occur. The affected landowners and mineral owners must also be notified by the PSC.

An operator must be served with a notice of noncompliance by the PSC stating the needed remedial measures if any requirement of the reclamation law is not complied with. An order revoking the mining permit is issued if the operator does not take corrective measures.

The filing fee consists of a nonrefundable fee of $250 plus a refundable fee of $10 per acre. The bond is set at a minimum of $1,500 per acre, with the exact amount being determined by the Commission. The bond is released in stages in the same way as specified under the 1975 law.

Duties of the operator under the 1977 law include:

1. backfill and regrade the mined area to the gentlest topography consistent with adjacent unmined land;
2. save, segregate, and respread all soil material determined by the PSC to be suitable for plant growth;
3. establish natural drainage compatible with the topography of all reclaimed land and treat runoff water so as to minimize erosion;
4. obtain the landowner's written preference for land use;
5. backslope all final cuts, end walls, and high walls to an angle not exceeding 35 percent;
6. remove or bury all refuse material;
7. submit a map showing the specific locations of the mining pits to the PSC by October 25 of each year;
8. make necessary repairs if the surface owner's surface or domestic water supply is disrupted;
9. maintain records or specific information on the permitted areas;
10. restore all lands outside the permit area affected by road construction and related mining activities.

The operator, under direction of the PSC, may stockpile SPGM outside the permit area. An operator who violates the reclamation law is subject to a civil penalty of $10,000 for each day of the violation, as well as the class A and B misdemeanors specified in the 1975 law.

Federal Surface Mining Legislation

The Federal Surface Mining Control and Reclamation Act was signed into law on August 3, 1977. It takes precedence over the state law where the state law does not meet federal standards. This legislation will affect reclamation practices in North Dakota and, therefore, reclamation costs. The final version of the federal rules and regulations as they apply to North Dakota have not been completed, so related costs were not considered in this study. There are several points of controversy relating to interpretation of the law which have not been resolved. Some changes in the North Dakota law which may be brought about by the federal legislation are discussed here.

Separate provisions are contained in the federal law for prime farmland that is disturbed in the mining process. Prime farmland contains the best soils determined by the soil water capacity, temperature, ph, electrical conductivity, exchangeable sodium percentage, and soil erodibility factor. These soils will have to be handled and stockpiled separately from other soils which are suitable plant growth material (SPGM) but do not meet the federal specifications. This will significantly increase reclamation costs. The extent of this increase will be determined by the final guidelines.

The hydrologic requirements under the federal law are substantially greater than under present North Dakota law. All surface drainage from disturbed areas will have to be passed through a series of sedimentation ponds. Surface and groundwater monitoring programs will be required. In addition, essential hydrologic functions must be preserved for all alluvial valley floors. According to Ray Walton, Commerce Council for the Public Service Commission, the increased requirements imposed by the Federal Act are expected to double or triple the size of the present permit application. The bond will still be released in stages under the federal law, but the final bond release will not take place until 10 years after final seeding. All SPGM and prime farmland soils will have to be stockpiled within the permit area. Bond cost will more than double as a result of extending the bond period and the area under permit. The 1977 North Dakota reclamation law allows the final high wall to be returned to a 35 percent slope, while the federal law requires a slope consistent with the surrounding landscape. This will increase the cost of reclamation and complicate the

reclamation process since it will be necessary to move large amounts of overburden to fill the final high wall or do extensive backsloping.

Although the provisions of the federal rules and regulations as they apply to North Dakota are not fully understood, there is no doubt they will have a significant effect on the reclamation process in North Dakota. However, it will be several years before the effects of the Federal Surface Mining Law are known because land subject to the law will not be reclaimed for several years. Litigation pertaining to interpretation of the law also may delay its complete implementation.

Summary

The North Dakota reclamation law has undergone almost complete revision since its inception in 1969. The most significant change is the requirement that all SPGM (usually up to five feet) be saved, segregated, and respread. The recontouring requirements have progressed from grading all ridges and peaks visible from public roads to a rolling topography, to recontouring all mined land (except final high walls) to the gentlest topography of the surrounding landscape. The addition of the extended and limited mining plan requirements under the 1975 law places considerable emphasis on pre-mining analysis.

The federal surface mining law may cause major changes in the reclamation process in North Dakota. The separate handling of prime farmland, the hydrologic requirements, the leveling of the final highwall, and other requirements, if required in North Dakota, will significantly increase reclamation costs.

The Reclamation Process and Associated Costs

The type of mining conducted in North Dakota is area strip mining, which is practiced on relatively large tracts of land where the topography is level to gently rolling. An initial (box) cut is dug through the overlying material (overburden) to the top of the coal seam and extends the length of the coal seam or area being mined. The width of the cut is usually 100-150 feet. The overburden is either placed on adjacent unmined land or on adjacent land to be mined. The latter case requires that all spoils be rehandled before the second cut can be dug, but allows mining closer to the edge of the permit area. The overburden from succeeding cuts is placed in

the previous pit. This continues across the width of the permitted area with the final pit forming the final high wall.

Reclamation is the process whereby affected land[5] is reconstructed in the manner and to the contour, structure, and productivity specified by the North Dakota reclamation law. For the purpose of this study, the reclamation process was divided into the following segments: preparation and planning, recontouring, topsoiling, and revegetation (Figure 3). Four areas of primary importance in reclaiming surface mined land are the final high wall area, initial spoil bank area, ramp roads, and the remaining spoil banks.

Mine Conditions Used to Estimate Reclamation Costs

A set of mine conditions were developed for the purpose of estimating reclamation costs. These conditions do not represent any one mine in North Dakota; rather, they represent typical mine conditions often encountered and serve as a basis for developing the methodology for estimating reclamation costs.

The area mined contains 450 acres,[6] 1,760 yards by 1,237.5 yards.[7] The mine pit width is 120 feet and ramp roads are spaced at quarter mile intervals. There is a uniform overburden depth of 58 feet, with the overburden swelling 20 percent upon being handled. A uniform coal seam of 12 feet is assumed, with a coal recovery factor of .90. The high wall slope is 71 degrees, the spoil bank slope is 38 degrees, and the final high wall slope is 19 degrees. There is a uniform suitable plant growth material depth of five feet, and all of the material is stockpiled. All initial spoil bank spoils are leveled toward the mine.

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[5]The area of land, whether located inside or outside the permit area from which suitable plant growth material or overburden has been removed for surface mining of coal or upon which suitable plant growth material, overburden, or refuse has been deposited; or any area on which roads or sediment ponds have been or will be constructed related to mining activity [North Dakota Century Code, 1977].

[6]Four of the latest permits granted in North Dakota include one for 1,016 acres at the Falkirk mine, one each for 261 acres and 640 acres to Consolidation Coal Co., and one for 445 acres to North American Coal Co. [Englerth].

[7]The dimensions of mines in North Dakota vary greatly, ranging in length from slightly over one-half mile to over 1.5 miles.

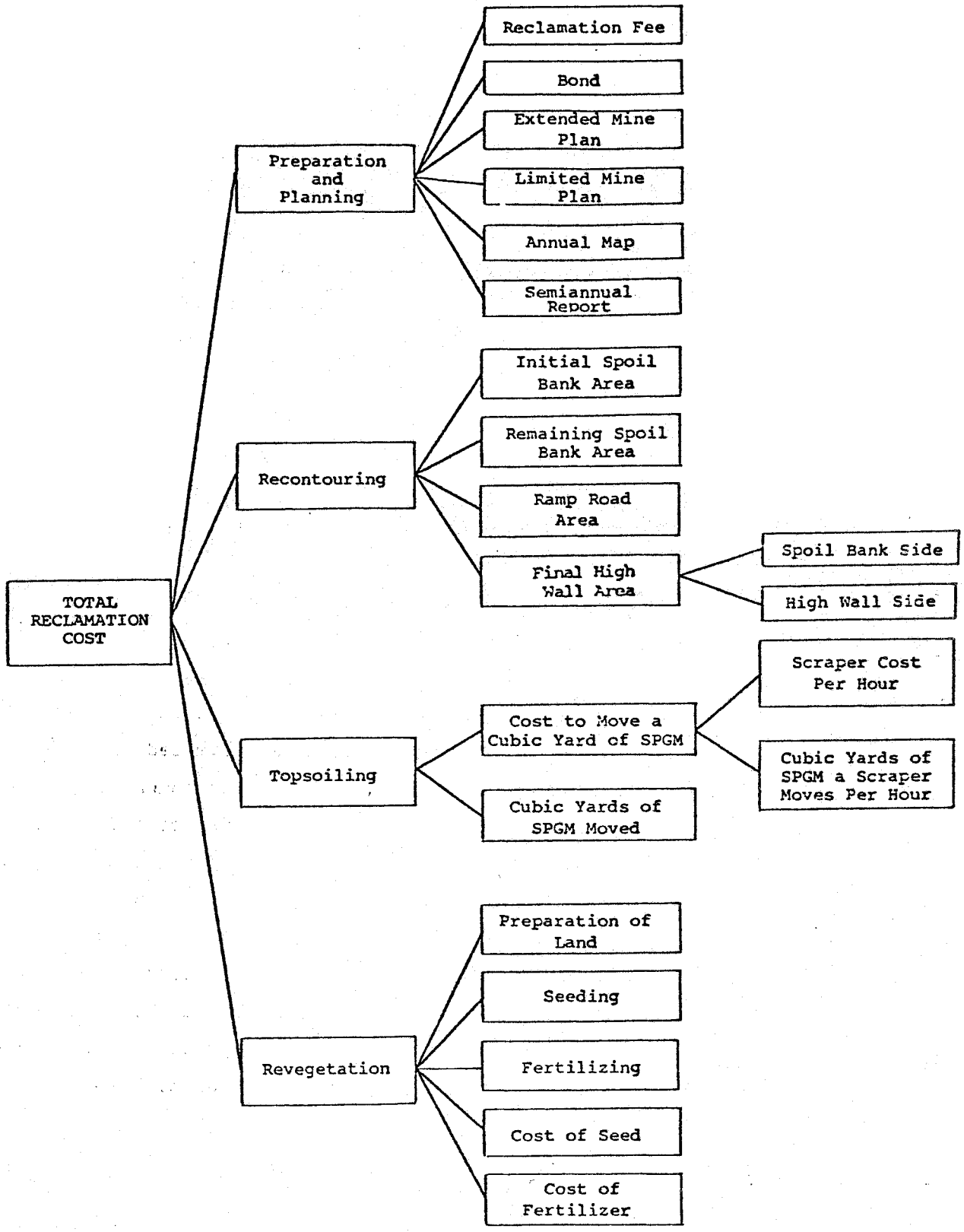

Figure 3. Elements of the Reclamation Process and Factors Contributing to Reclamation Costs

Preparation and Planning

Preparation and planning is an important and inseparable part of the reclamation process. Extensive maps, reports, and surveys are required of the mine operator on both a long-range and a short-range basis. The long-range information is contained in the "extended mining plan" which is a detailed written statement setting forth information required by the reclamation law. The extended plan covers not less than 10 years immediately succeeding the date it is filed with the Public Service Commission (PSC). Its purpose is to inform the PSC of conditions existing in an area proposed for mining sufficiently in advance of commencement of operations to allow an accurate assessment of the effects of such proposed operations.[8] The short-range information, or "limited mining plan," is for a period of three years. It is defined as a detailed statement setting forth certain information required by the reclamation law covering those years of mining included in the permit term.[9]

Preparation and planning can be defined as those procedures necessary to obtain a mining permit, including the requirements specified in the limited and extended mining plans. It also includes those procedures undertaken prior to mining for the purpose of securing more productive reclaimed land.

The six components of this portion of the reclamation process are the filing fee, bond, extended mining plan, limited mining plan, annual map, and semiannual report (Figure 4). The annual map and semiannual report provide specific information on the progress of the mining operation.

The filing fee consists of a nonrefundable fee of $250 plus a refundable fee of $10 per acre. A minimum bond of $1,500 per acre of land under permit is required, although the actual amount has typically been much higher. The bond reflects bondable costs and does not cover the total cost of reclamation. Bondable costs are those which the PSC would encounter if it had to complete the reclamation process. Costs associated with preparation and planning are not bondable. Also, since the suitable

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[8]Chapter 38-14-02, 20, of the North Dakota Century Code.

[9]Chapter 38-14-02, 19, of the North Dakota Century Code.

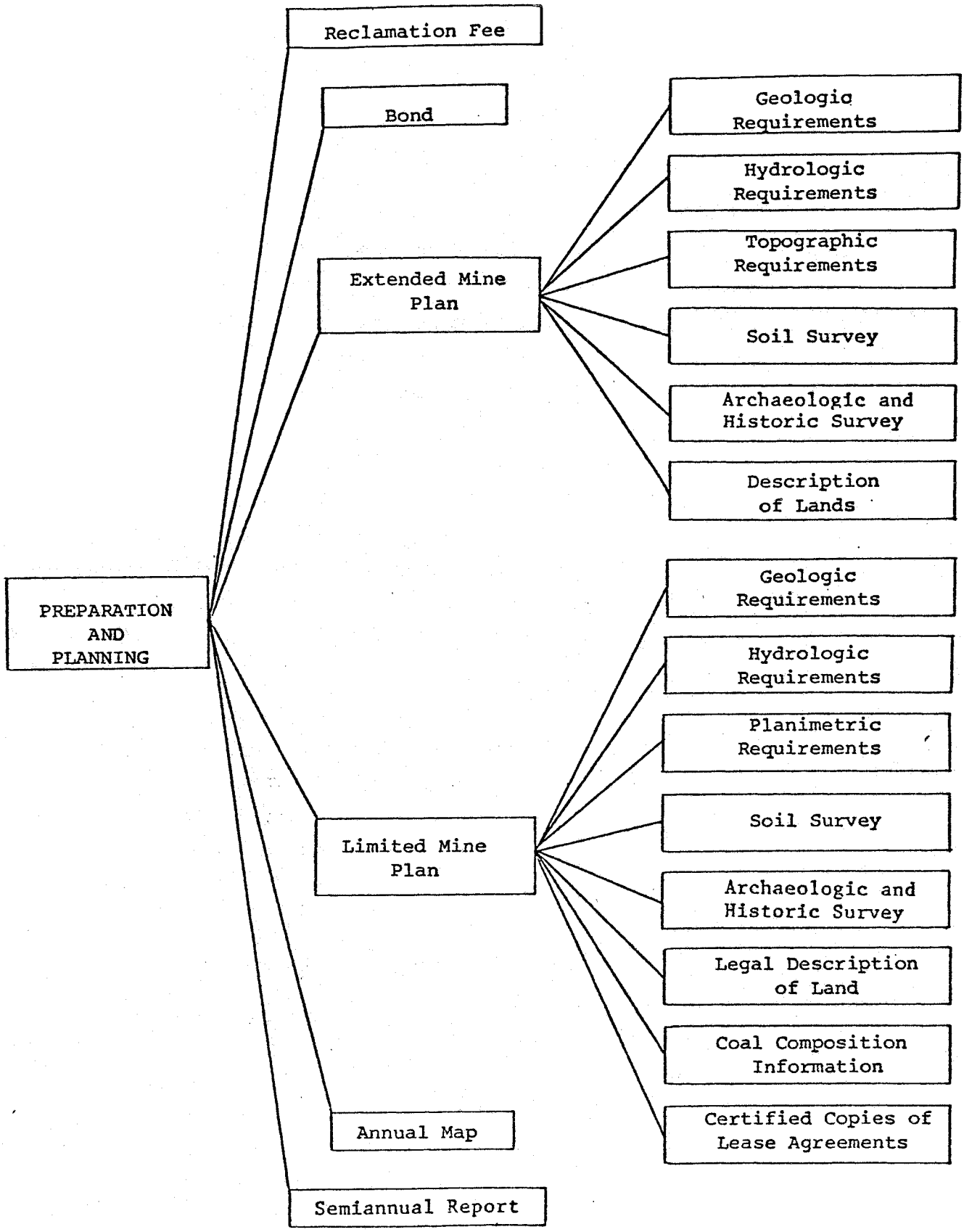

Figure 4. Elements of Preparation and Planning

plant growth material (SPGM) must be removed and piled before mining can take place, the removal of SPGM is not a bondable cost. Costs for backfilling and grading, returning of SPGM, and revegetation are bondable.

The extended mining plan, which must be updated annually, covers the land to be disturbed in the succeeding 10 years and usually covers about four times as much land as does the limited mining plan. The extended mining plan requires the following types of information:

1. geologic;
2. hydrologic;
3. topographic;
4. soil map;
5. archaeologic and historic survey;
6. legal description of the land.

The geologic information is obtained from a minimum of one drill hole per section corner[10], usually running to a depth 20 feet below the deepest coal seam to be mined. Chemical and physical analysis of the overburden is taken at five-foot intervals. The hydrologic information, which gives a general account of water resources and use, is collected from one set of drill holes per four square miles.

The topographic map must show the boundaries of the plan area, current land use, and the location of streams, watersheds, and natural drainways. The soils map must show both the kind and extent of soils in the extended mine plan area. The archaeological and historical survey must be conducted in accordance with the survey requirements of the North Dakota State Historical Society. The legal description of the land must be to the nearest quarter section.

The limited mining plan has much of the same type of information as the extended mining plan, but is much more intensive and only covers an initial three-year period, although extensions are granted. The limited plan can be divided into the following areas:

1. geologic;
2. hydrologic;

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[10]Drill holes must be located at each of the four corners of a section. Two sections located adjacent to one another would, therefore, require only 6 drill holes since two of the drill holes would be on the corners of both sections.

3. planimetric;
4. soil survey;
5. archaeologic and historic survey;
6. description of lands;
7. coal composition information;
8. certified copies of relevant lease agreements.

Costs

The costs associated with preparation and planning are based on the assumption that the permit application is for 475 acres, although the area mined would be 450 acres. The additional 25 acres are used to deposit the overburden from the initial cut. Other assumptions applicable to this phase of reclamation are discussed on page 12. The cost of each component of preparation and planning was estimated separately based on information provided by industry sources and representatives of firms that contract with mining companies for work performed.

The reclamation bonding requirement is site specific and, therefore, varies depending on the site for which a permit is applied for. The average bond requirement is about $2,500 per acre, and this figure was used in estimating preparation and planning costs.

Surety bonds, which cost $10 per year per thousand dollars of bond, are used to satisfy the reclamation bond [Jordan]. All of the bond is in effect until the land is recontoured, one and one-half years; 60 percent of the bond is in effect from this point until the land is topsoiled, one-half year; 30 percent of the bond is in effect from the time topsoiling is completed until revegetation is successfully completed, about four years. The total bond cost is calculated as follows:

$25 x 1 x 1.5 years x 475 acres = $17,812.50
$25 x .6 x .5 years x 475 acres = $ 3,562.50
$25 x .3 x 4 years x 475 acres = $14,250.00
$35,625.00

The extended mining plan normally covers four times the acreage of the limited plan, or about three sections if the limited plan covers 475 acres. The geologic section of this plan requires one drill hole per section corner. The cost of this drilling, which would run to a depth of 20 feet below the deepest seam mined, is $3 per foot. A soil sample is required for every five feet of depth, with the analysis costing $65 [Jordan].

The hydrologic portion of the extended mining plan requires one piezometric nest per four square miles. A piezometric nest consists of one drill hole for each aquifer at a particular location. The cost of drilling is $3 per foot, with total cost depending on the number and depths of the aquifers.[11] The common ion analysis and trace mineral analysis cost $60 and $300 per sample, respectively.

Mylar drawings[12] are used for the topographic information. These drawings and the soil map were assumed to be compiled by the mining company. Mining firms contract for the archaeologic and historic survey. The cost is $3 per acre, or $5,760 for three sections [Jordan].

Eight drill holes for obtaining geologic information were assumed. The rest of the geologic information and costs are the same as for the extended plan. The hydrologic costs are the same for both the limited and extended plans; therefore, a separate listing of costs for the limited plan is not needed. The archaeologic and historic survey done for the extended plan contains enough detail to also be used for the limited plan.

An aerial map (cost: $500) is used to help satisfy the planimetric requirements of the limited plan. In addition, about two and one-half months are needed to compile the information and write the report [Dudley].

Soil survey work is contracted to a professional soils scientist at a cost of $7.50 per acre [Howey]. The costs associated with compiling the legal description of the land and providing certified copies of lease agreements were estimated to be $64 and $264, respectively. Three annual maps are required, one each year for the length of the limited mine plan. The cost per map is $384. The cost of compiling semiannual reports is $512 per year.

The cost of each part of preparation and planning is provided in Table 1. The total cost of preparation and planning for an area under permit of 475 acres is $89,005.

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[11] Four aquifers, occurring at depths of 30 feet, 135 feet, 300 feet, and 500 feet, were found in a groundwater survey in Ward County [Schmid], the average depth of these aquifers, 241.25 feet, was used in this study.

[12] Transparent overlays placed on baseline maps which show the contour of the mine area.

TABLE 1. COSTS OF PREPARATION AND PLANNING, 475 ACRES UNDER PERMIT

Activity		Total Cost
Reclamation Fee	$ 5,000	$ 5,000
Bond:		
Stage I	17,812	
Stage II	3,562	
Stage III	14,250	$35,624
Extended Mine Plan:		
Geologic		
Drilling (8 drill holes to depth of 90 feet)	2,160	
Analysis (18 samples each for 8 drill holes)	9,360	
Office Work	960	
Hydrologic		
Drilling (4 aquifers averaging 241.25 feet)	2,895	
Analysis (2 samples per aquifer)	2,880	
Office Work	960	
Topographic		
Office Work	320	
Soil Map		
Office Work	200	
Archaeologic and Historic Survey ($3 per acre for 1,920 acres)	5,760	
Description of Lands		
Office Work	64	$25,559
Limited Mine Plan:		
Geologic		
Drilling (8 drill holes to depth of 90 feet)	2,160	
Analysis (18 samples each for 8 drill holes)	9,360	
Office Work	960	
Hydrologic	—	
Planimetric		
Aerial Maps	500	
Office Work	3,200	
Soil Survey		
Survey Cost ($7.50 per acre)	3,562	
Office Work	64	
Archaeologic and Historic Survey	—	
Legal Description of Land		
Office Work	64	
Coal Composition Information	—	
Certified Copies of Lease Agreements	265	$20,134
Annual Map	1,152	$ 1,152
Semiannual Report	1,536	$ 1,536
TOTAL		$89,005
Total Per Acre		$ 187.38

Recontouring

Recontouring is the process by which the post-mining contour is altered to be the same as the gentlest topography of the surrounding landscape or other contour consistent with state and federal law. The major factors affecting the cost of recontouring are the volume of overburden to be moved, distance the overburden is moved (push distance), and the operating cost of machinery.

There are four areas associated with a mine that must be considered in recontouring. These include the initial spoil bank area, the final high wall area, ramp roads, and the remaining spoil banks (Figure 5). The initial spoil bank area is formed when the overburden from the initial cut is piled. It extends from the initial spoil bank (ISB) toward the mine side for the entire distance in which the ISB spoils are moved (Figure 6). Overburden from the first cut can be deposited in three ways. It can be deposited on the side of the cut not to be mined, it can be deposited on the side of the cut to be mined, or a combination of the two can be done.

The least cost method for leveling spoil piles would be to move half of the spoils in each direction. However, in most cases, the leveling of the initial spoil bank does not allow this. For this study, it was assumed

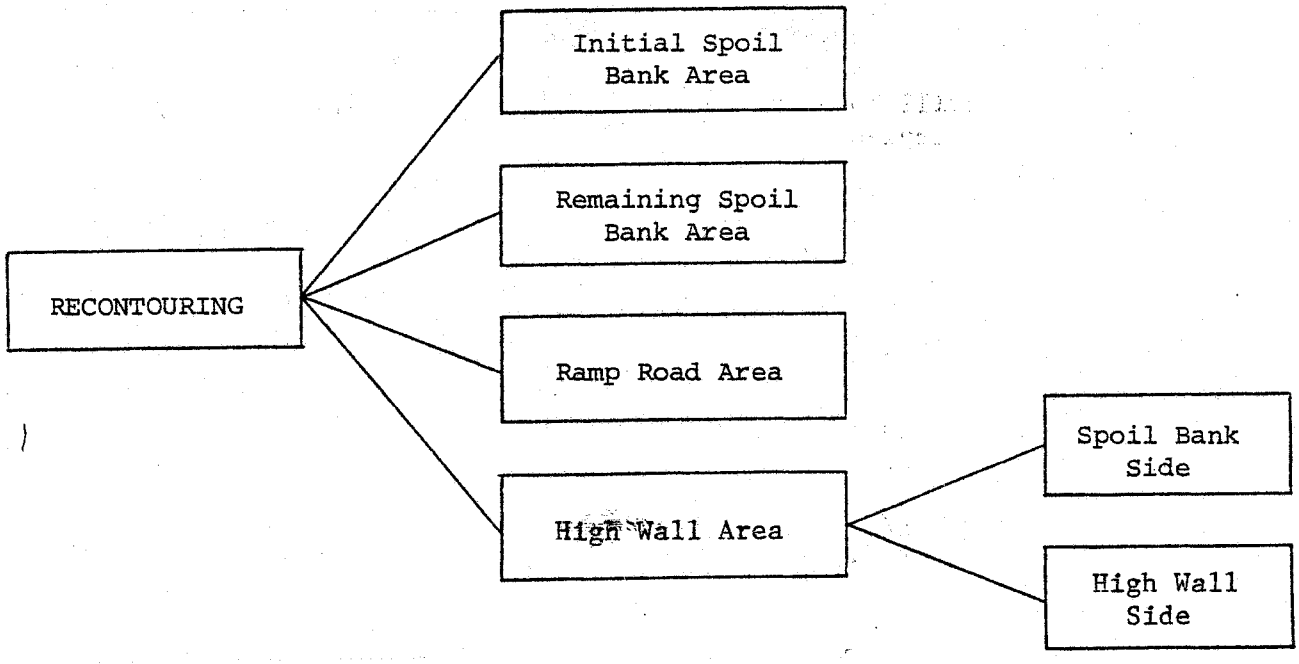

Figure 5. Areas of Mine to be Recontoured

that the remaining spoil banks are leveled by moving all the spoils toward the final high wall side. An average push distance of 60 feet was assumed.

It was assumed that the primary piece of equipment used in recontouring is a D-9 caterpillar with a universal blade. Although the D-9 is not used in all reclamation operations, it is a common machine in most reclamation operations. The Caterpillar Performance Handbook (with appropriate performance correction factors) was used to estimate the production of a D-9. The cost estimator from the Caterpillar Performance Handbook was used as the basis for hourly cost estimations with appropriate changes made to adapt the estimator to North Dakota situations.

Multiple coal seams are often encountered in North Dakota. Generally, the first layer of coal is removed and then the overburden above the second seam is removed and deposited in the same manner as the overburden above the first seam. This has the effect of increasing the depth of the overburden but has no other effect on reclamation. A uniform overburden depth (58 feet) and coal seam thickness (12 feet) were assumed.

Costs

The cost to move a cubic yard of overburden and the yardage of overburden to be moved were estimated for each of the mine areas. The cost to move a cubic yard of overburden was estimated on the basis of equipment and labor costs, equipment performance, and average push distances. Total overburden moved was estimated on the basis of length of area and cubic yards of overburden moved per unit of distance.

Dozer performance correction factors were taken from the Caterpillar Performance Handbook. An operator with average abilities was assumed (correction factor of .75); the ground was assumed to be frozen one-fifth of the time (correction factor of .96); and a 50 minute per hour job efficiency was used (correction factor of .84). A total correction factor of .6048 is obtained by multiplying these factors.

Dozer production factors were estimated by applying the average push distances[13] to dozer production estimators found in the Caterpillar

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[13]Under the mine conditions assumed, the average push distance is 413 feet for the ISB area, 381 feet for the spoil bank side of the final high wall area, 51 feet for the final high wall side of the final high wall area, 450 feet for the ramp road area, and 60 feet for the remaining spoil bank area [Gronhovd, 1978].

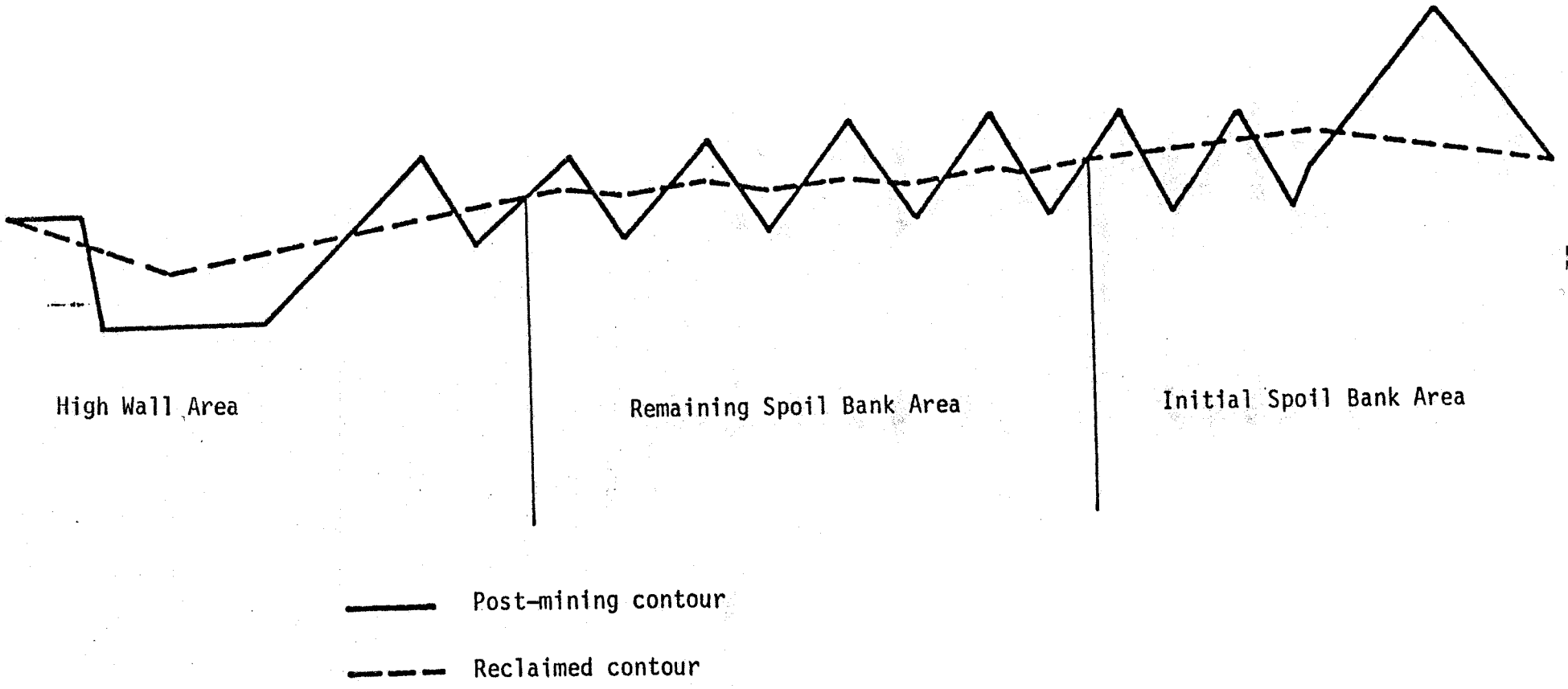

Figure 6. Cross-Section of Mining Area

Performance Handbook. The production of a D-9 dozer is obtained by multiplying estimated production by the total correction factor. The cost of moving a cubic yard of overburden is estimated by dividing the operating cost of a D-9 dozer by production.

The cubic yards of overburden moved in a particular section of the mine were estimated by multiplying the yardage of overburden moved per unit of distance for each area by the effective length of each area.[14] The total cost of recontouring can be found by summing the costs for each individual area. These costs are presented in Table 2.

TABLE 2. COSTS OF RECONTOURING, 450 ACRE MINE[a]

Area	Cubic Yards of Overburden Moved	Cost Per Cubic Yard[b]	Total Cost
Initial Spoil Bank	1,274,224	$.221	$281,603
Remaining Spoil Bank Area	2,238,569	.0464	103,870
Ramp Road Area[c]	3,179,598	.092	292,523
High Wall Area			
Spoil Bank Side	1,359,944	.1856	252,406
High Wall Side	82,016	.0442	3,625
Total			$934,027
Total Per Acre			2,075.62

[a]The dimensions of the mine are 1,760 yards by 1,237.5 yards.
[b]See Gronhovd (1978) for calculation of costs per cubic yard.
[c]Three ramp roads are assumed.

Topsoiling

Topsoiling is the process whereby suitable plant growth material (SPGM) is removed, stored, and reapplied or put directly on recontoured spoils. The process involves two lifts that are based on color change of the soil. These two lifts must be kept separate, with the second lift

[14]The length, less ramp road widths, of the ISB area, remaining spoil bank area, and spoil bank side of the final high wall area is 4,668 feet; the length of the final high wall side of the final high wall area is 5,280 feet; and the length of the ramp road area is 1,252 feet.

material being returned first and the first lift material being returned last.

SPGM refers to that portion of the soil material (normally the A, and in some cases, the upper portion of the B soil horizon) lying above the coal which, based on a soil survey, is found to be acceptable for respreading on the surface of regraded areas to provide a medium for plant growth. Material to be used for the first lift must meet the following conditions:

1. electrical conductivity of less than two millimhos per cm.;
2. sodium adsorption ratio of less than four;
3. a free lime percentage ($CaCO_3$ equivalent) of less than 10;
4. organic matter percentage of one and one-half or greater.

Second lift material must have an electrical conductivity of less than four millimhos per cm. and a sodium adsorption ratio of less than 10.

The depth of SPGM can vary greatly from area to area and often varies within a particular area. The 1975 reclamation law required that all SPGM to a depth of five feet be saved, segregated, and respread. The 1977 law requires all soil material within the permit area determined by the Public Service Commission to be suitable for plant growth be saved, segregated, and returned. In other words, the PSC can require that where SPGM has accumulated to depths greater than five feet, it must be saved and respread over the permit area. For this study a uniform SPGM depth of five feet was assumed since this depth is most often encountered [Scherbinske].

There are two methods for removing and reapplying SPGM. It can be removed, stockpiled, and reapplied on the site from which it is removed, or it can be directly applied to leveled overburden from previous cuts. Direct application, where possible, is the least cost method of topsoiling since the SPGM has to be handled only once. It eliminates the need for stockpiling except for the first few cuts. It also eliminates the need to remove first lift material from second lift material stockpiles and the need for maintaining stockpiles to insure SPGM quality.

Direct application of SPGM is very difficult because of mine design and land ownership patterns. Many times certain coal seam properties make irregular mining patterns necessary. Since SPGM from a surface owner's

property must be returned to that property, this also becomes a roadblock to direct application of SPGM. For these reasons, stockpiling is the most common method of topsoiling.

When the stockpiling method is used, the SPGM is returned to the mining pass from which it was removed after the spoils have been leveled. Most of the material is stockpiled within approximately one-half mile of the mine.

The type of machinery, method of topsoiling, SPGM depth, and haul distances must be known to determine the cost of topsoiling. The method of topsoiling (stockpiling) and the SPGM depth (five feet) have previously been determined. The cost of physically handling the topsoil material was based on the cost to move a cubic yard of SPGM and the cubic yards moved per acre. The cost to move a cubic yard of SPGM depends on equipment and labor costs and equipment performance. Cubic yards moved per acre depend on the depth of SPGM (Figure 7). Equipment costs and performance were based on a 637 caterpillar push-pull scraper. An average haul distance of 3,432 feet was assumed, based on the average of longest and shortest haul distances.

The Caterpillar Performance Handbook was used as the source for much of the performance and cost data. Interviews with equipment dealers, tire dealers, representatives of coal companies, and others were used to supplement this information.

The cost of stockpiling and returning the SPGM was estimated to be $.265 per cubic yard. There are 8,066 cubic yards of SPGM per acre.[15] Multiplying the cost per yard ($.265) times the yardage moved (8,066), the cost to stockpile is $2,137 per acre, and an additional $2,137 per acre to return the SPGM to the leveled spoils. The total cost for topsoiling is, therefore, $4,274 per acre, or $2,030,150 for the 475 acre mine.

Revegetation

The four different reclamation goals considered were cropland, tame pasture, native grass, and wildlife habitat. Cropland and tame pasture

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[15]There are 4,840 square yards per acre, and with five feet of SPGM, this amounts to 8,066 cubic yards.

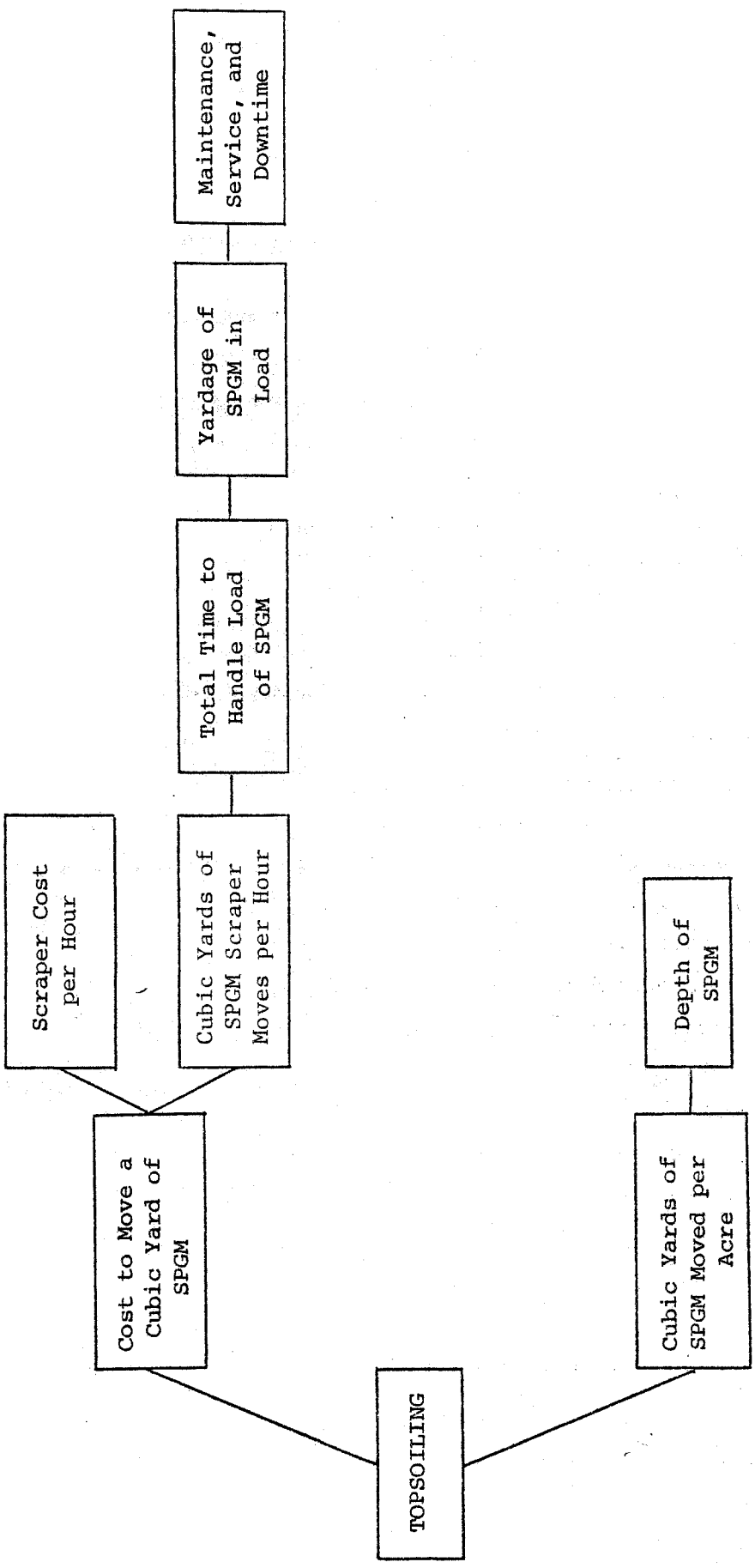

Figure 7. Elements of Topsoiling and Factors Contributing to Topsoiling Costs

occur on land that has a gentle slope. Land that will be returned to native grasses normally has a steeper slope than tame pasture or cropland. In some instances the land is returned to wildlife habitat. The elements of revegetation costs are presented in Figure 8. Although the reclamation goals require different seed mixtures (which affect costs of revegetation), the management practices are similar.

The normal ground preparation for land to be revegetated is one trip over the land with a chisel, one trip with a disc, and one trip with a harrow. Groundwork, seeding, and fertilizing costs were determined using the custom farm rate schedule for 1977, published by the Statistical Reporting Service, USDA [Statistical Reporting Service].

Normally, 200 pounds of 18-46-0 fertilizer per acre is put on land to be revegetated. Mulch is not applied to soils that have less than a 6 percent slope, unless the soil is sandy. One ton of straw is applied per acre to land with a 6 to 10 percent slope and two tons of straw applied where the slope is greater than 10 percent [Doutch].

The total cost for revegetation of reclaimed land to the different revegetation goals is given in Table 3. A summary of the costs of reclaiming a 450 acre strip-mined area is presented in Table 4.

The Effect of Alternative Mining Conditions on Reclamation Costs

Physical, geologic, and topographic conditions vary greatly between and even within mine areas. Reclamation costs, therefore, are site specific. The effect each of these conditions has on reclamation costs is considered in this section.

Mine conditions which commonly vary are the slope of reclaimed land, overburden depth, coal seam thickness, mine size, mine dimensions, depth of suitable plant growth material (SPGM), and the average distance the SPGM must be hauled (average haul distance). The effect on reclamation costs of changes in each of these conditions taken separately is considered in this section. All other assumptions pertaining to original mine conditions remain unchanged.

Slope

The cost of recontouring and, therefore, the cost of reclamation depend on the grade of the reclaimed slope. Reclamation costs vary

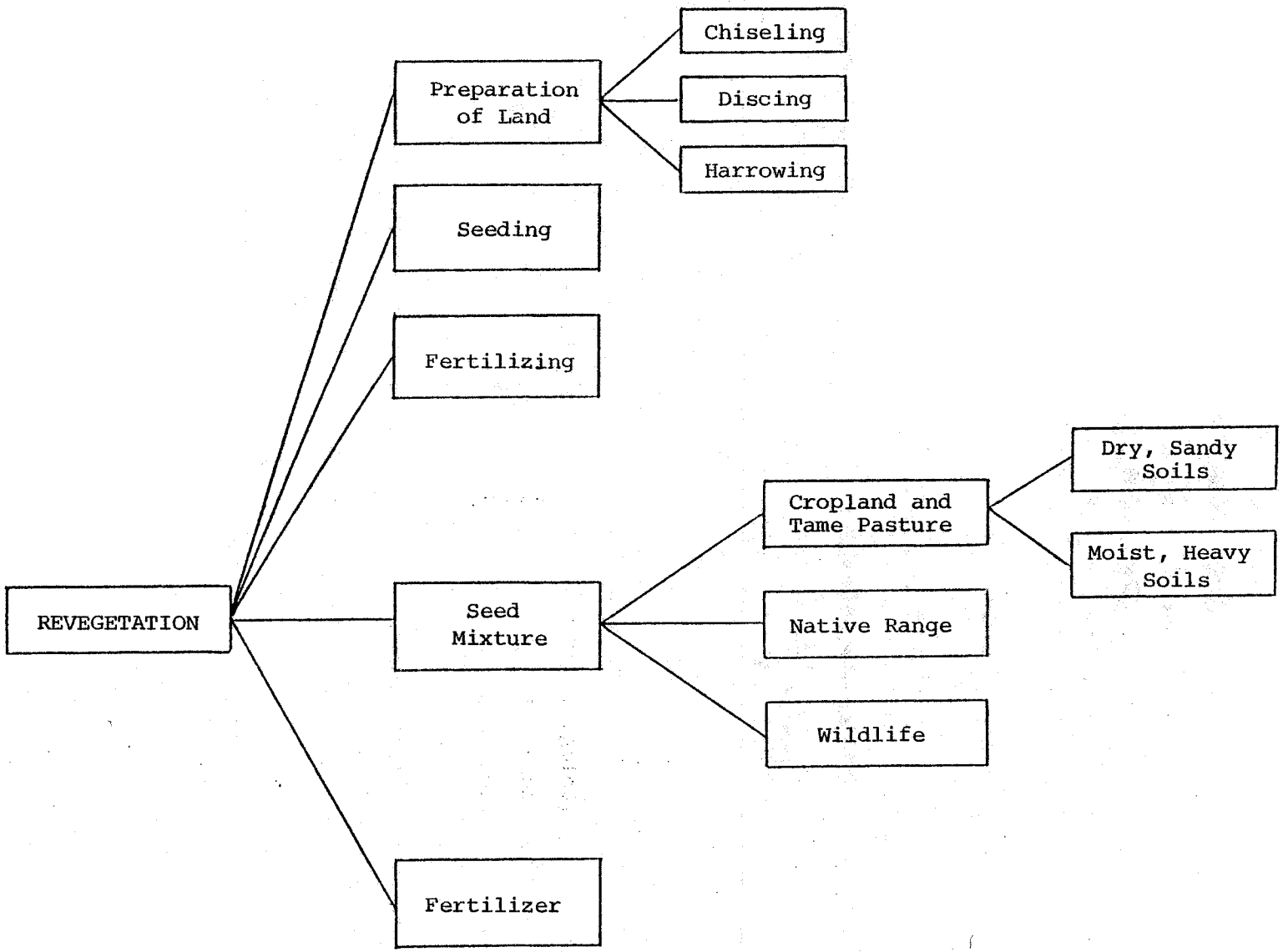

Figure 8. Elements of Revegetation and Factors Contributing to the Cost of Revegetation

TABLE 3. PER ACRE COSTS OF REVEGETATION

Activity	Cropland and Tame Pasture Mix		Native Mix	Wildlife Mix
	Dry Soil	Moist Soil		
Preparation of Land				
Chiseling	$ 3.40	$ 3.40	$ 3.40	$ 3.40
Discing (tandem)	2.59	2.59	2.59	2.59
Harrowing	1.34	1.34	1.34	1.34
Seeding	2.95	2.95	2.95	2.95
Fertilizer Application	1.61	1.61	1.61	1.61
Seed Mixture	10.06	10.31	53.23	12.52
Fertilizer	16.50	16.50	16.50	16.50
Total	$38.45	$38.70	$81.63	$40.91

TABLE 4. TOTAL RECLAMATION COST FOR A 450 ACRE MINE

Activity	Cost
Preparation and Planning	$ 89,005.00
Recontouring	934,027.00
Topsoiling	2,030,150.00
Revegetation[a]	18,263.75
Total	$3,071,445.75
cost per mined acre	$ 6,825.44
cost per permitted acre	$ 6,463.27
cost per M BTU[b]	$ .033
cost per ton of coal[c]	$ .454

[a]Cropland revegetation goal.
[b]Figured at 7,000 BTU per pound of coal and 15,000 tons of coal per acre.
[c]Figured at 15,000 tons of coal per acre.

from $8,200 per acre with a 2 percent reclaimed slope to $5960 per acre for a 20 percent slope.

The only portion of reclamation costs significantly affected by varying slope is recontouring costs. As reclaimed slope is increased, the average dozer push distance for the initial spoil bank (ISB) area and the spoil bank side of the final high wall area decreases. This decrease is quite large for changes in relatively gentle slopes, and then levels off as slope increases. The average push distances for other areas of the mine remain the same.

There is an inverse relationship between reclaimed slope and yardage of overburden moved for all mine areas except the final high wall side of the final high wall area. The decrease in overburden moved for the spoil bank side means that the area that must be covered by overburden from the final high wall side increases. Figure 9 shows the effect of reclaimed slope on per acre reclamation costs.

Overburden Depth

The depth of overburden has a significant effect on reclamation costs. An increase in overburden depth increases the size of the base of the ISB and, therefore, the number of acres under permit. This increases the number of acres that must be topsoiled.

The main effect of an increase in overburden depth, however, is the increase in recontouring costs. Recontouring costs for all areas but the remaining spoil bank area increase as overburden depth increases. Overburden depth has no effect on per acre recontouring costs for the remaining spoil bank area. An increase in both the average push distance and the cubic yards of overburden moved increases recontouring costs for the final high wall area, ramp road area, and the ISB. The effect of overburden depth on per acre reclamation cost is presented in Figure 10.

Coal Seam Thickness

Coal seam thickness has a small effect on per acre reclamation costs but has a substantial effect on cost per ton of coal mined. The only portion of the reclamation process affected by coal seam thickness is the recontouring process. Coal seam depth does not affect the yardage of overburden to be moved for the ISB area, but it does affect the push distance. A

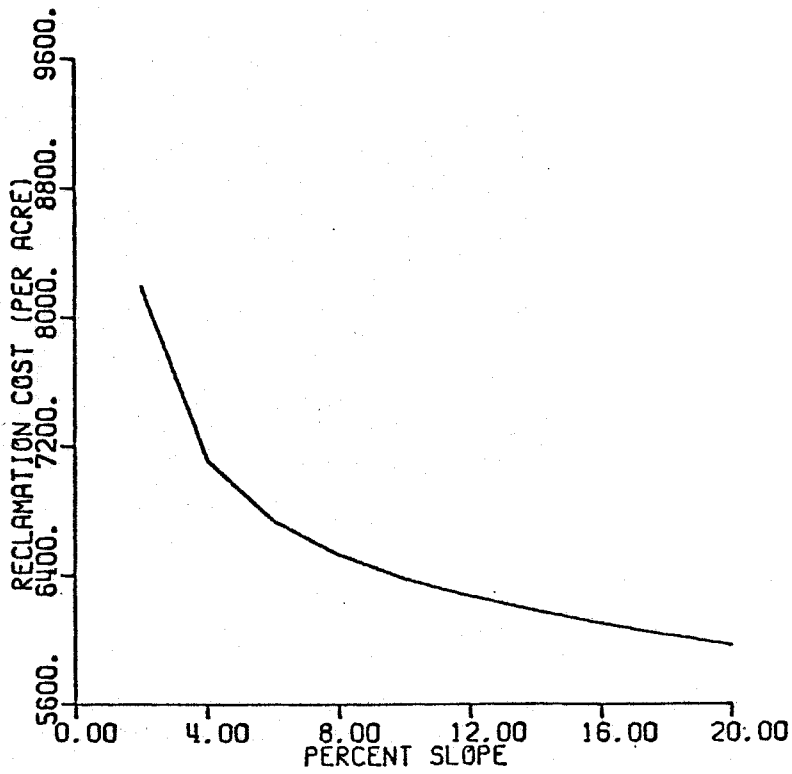

Figure 9. Effect of Slope on Reclamation Costs

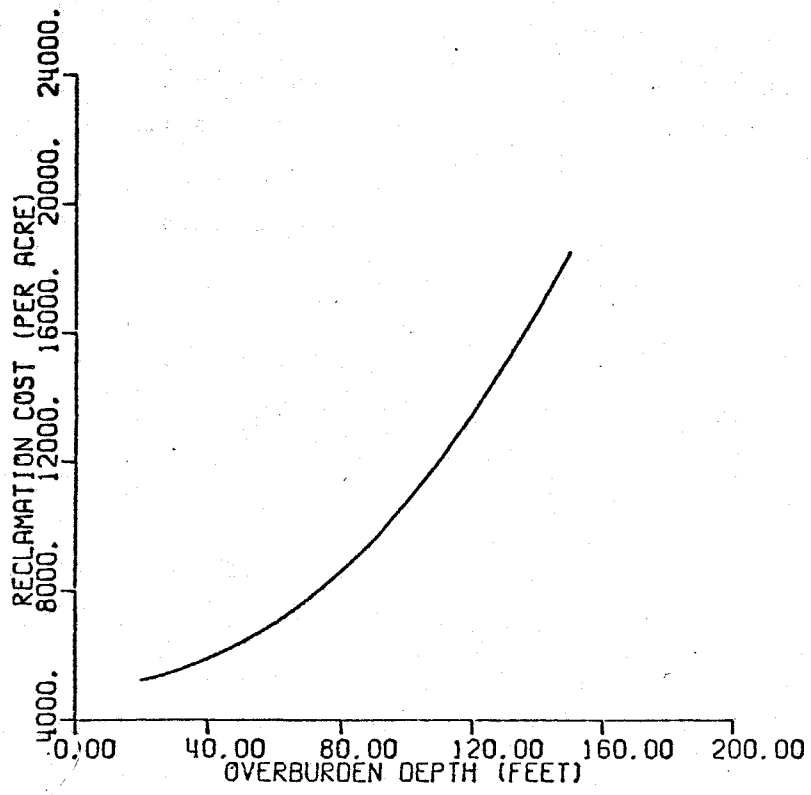

Figure 10. Effect of Overburden Depth on Reclamation Cost

thinner coal seam increases the height of the leveled spoil banks and, therefore, results in a longer push distance to level the ISB spoils. This increases the cost of recontouring the ISB area.

A change in the coal seam thickness changes the height of the final high wall. This affects both the yardage of overburden to be moved per unit of distance and the distance it must be moved. These two factors act together to form a direct relationship between coal seam thickness and the cost to reclaim the final high wall side of the final high wall area. Coal seam thickness has no effect on the recontouring cost for the other mine areas.

The interaction of the changes in reclamation costs for the ISB area and the final high wall area cause per acre reclamation costs to decrease for seam thicknesses up to 12 feet and to increase thereafter. Figure 11 shows the effect of coal seam thickness on per acre reclamation costs.

Mine Size

Per acre reclamation costs are $7,681 for a 100 acre mine, assuming other mine conditions originally specified do not change. Costs decrease sharply as mine size increases to 400 acres, and then increases gradually thereafter.

All costs associated with the reclamation process except per acre revegetation costs are affected when mine size is changed. The per acre cost of preparation and planning decreases sharply as mine size increases to about 300 acres and gradually increases thereafter.

Mine length is the length of the high wall and mine width is the distance mining progresses from the ISB to the final high wall. A change in length and width, with the ratio of mine length to width remaining constant, changes the proportion of the total mine area accounted for by the initial spoil bank area, ramp road area, final high wall area, and the remaining spoil bank area. As the width of the mine area increases, the proportion accounted for by the remaining spoil bank area increases. This area is relatively inexpensive to recontour, so per acre reclamation costs tend to decrease. The number and length of ramp roads increase as mine dimensions increase and this increases per acre reclamation costs.

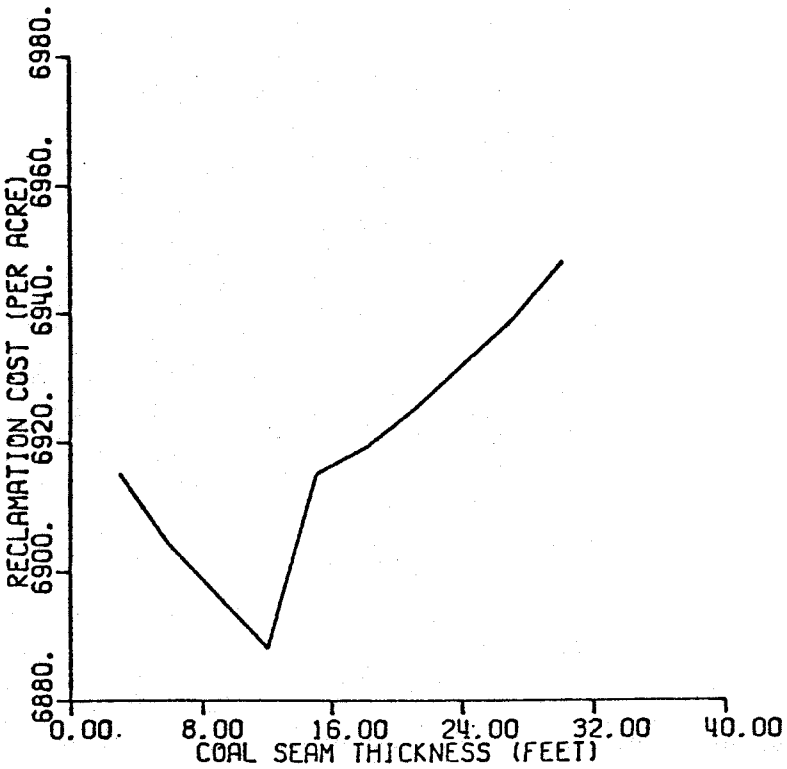

Figure 11. Effect of Coal Seam Thickness on Reclamation Cost

An increase in mine size also increases the average haul distance to the topsoil stockpile, and this increases topsoiling costs.

The interaction of these factors forms the cost curve depicted in Figure 12. The sharp upturns in per acre costs noted in this figure are caused by an increase in the number of ramp roads at each point.

Mine Dimensions

A change in mine dimensions affects reclamation costs by changing both recontouring and topsoiling costs. There is a direct relationship between mine length and per acre reclamation costs.

The proportion of the mine accounted for by the initial spoil bank, final high wall area, and ramp road area increases as the ratio of mine length to width increases. These are expensive areas to reclaim and, therefore, the total cost of reclamation will tend to increase.

The increase in high wall length increases the distance the scraper must travel to reach the stockpile if it must travel along the mining pass to the edge of the mine when removing and replacing topsoil. This increase in travel distance increases haul time and, therefore, topsoiling cost. These factors together form the cost curve depicted in Figure 13.

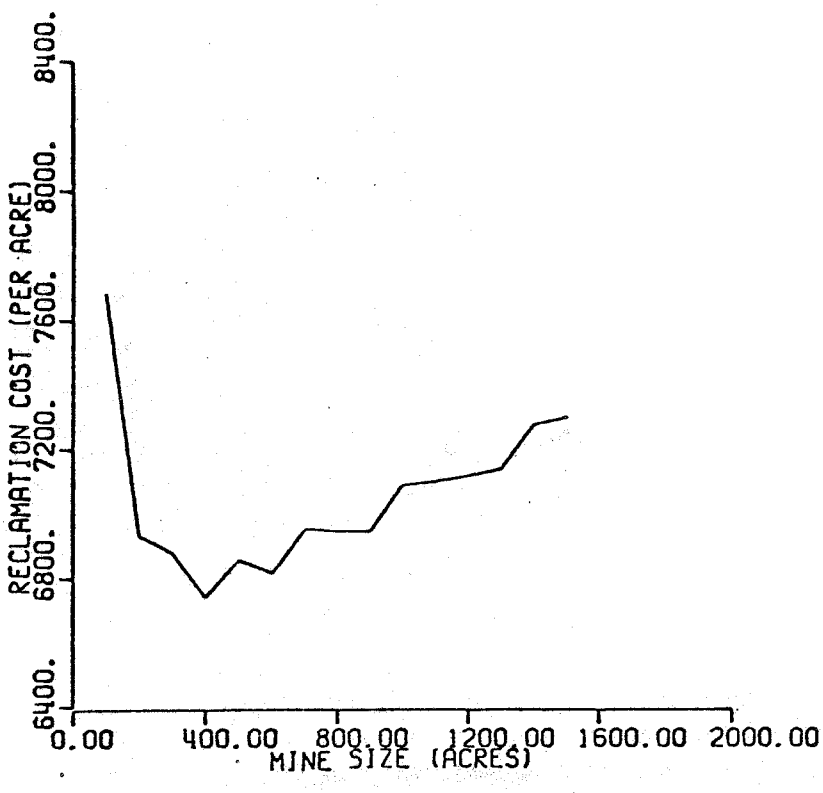

Figure 12. Effect of Mine Size on Reclamation Cost

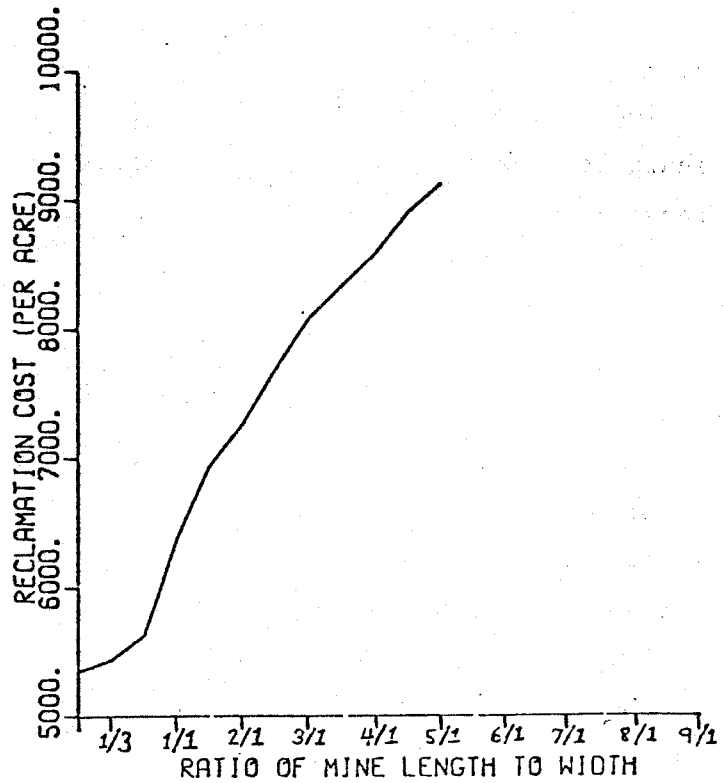

Figure 13. Effect of Changes in the Ratio of Mine Length to Width on Reclamation Cost

Depth of SPGM

The cost of removing, stockpiling, and reapplying a cubic yard of SPGM is $.53. The total cost of topsoiling an acre of land, assuming all material is stockpiled, varies directly with the depth of SPGM (Figure 14).

Average Haul Distance

The average haul distance by itself is an important factor in determining reclamation costs. Previously, it was assumed the scraper traveled along the mining pass to the edge of the mine when removing and replacing topsoil, and this made average haul distance a direct function of the length of the mining pass. In some cases, however, the average haul distance is not related to the length of the mining pass.

Reclamation costs are $4,700 per acre for an average haul distance of 1,000 feet, and increase to over $8,700 per acre when the distance is 5,500 feet (Figure 15). The reason for this increase is the extra travel time needed to reach the stockpile.

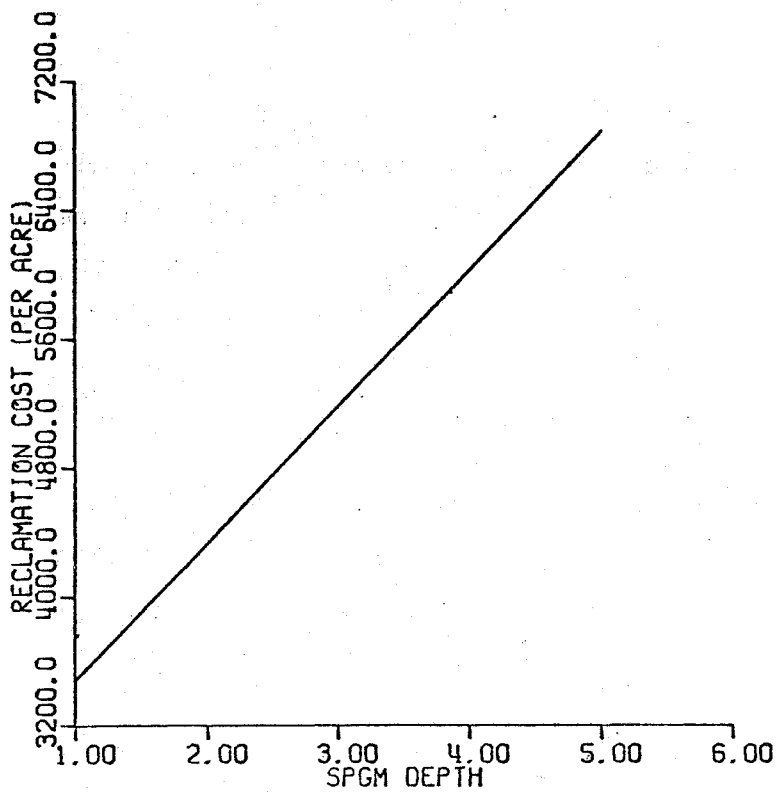

Figure 14. Effect of SPGM Depth on Reclamation Cost

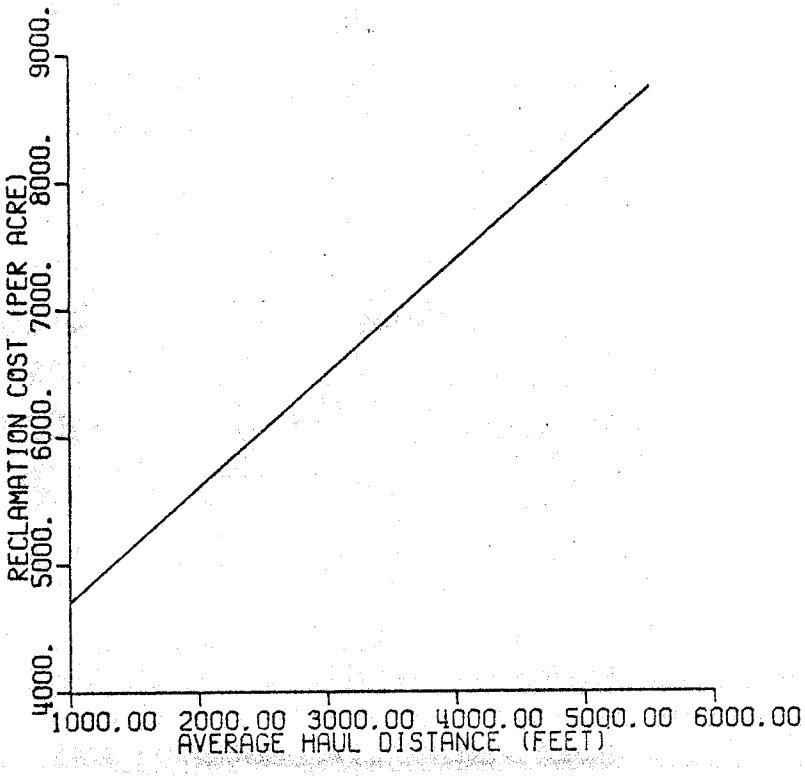

Figure 15. Effect of Average Haul Distance on Reclamation Cost

Summary

Many factors affect the cost of reclamation. Overburden depth is the most important determinant of recontouring costs with the reclaimed slope also significantly affecting these costs. Coal seam thickness has little effect on recontouring costs. The depth of SPGM and the average haul distance greatly affect topsoiling cost and, therefore, the cost of reclamation. Each foot of SPGM adds $855 to the cost of reclamation while each 1,000 foot increase in average haul distance increases per acre reclamation cost by about $667.

Both mine size and mine dimension affect reclamation costs. Reclamation costs fall sharply as mine size increases to 400 acres, then gradually increase to about $7,300 per acre for a 1,500 acre mine. Reclamation costs increase as the length of the high wall increases in relation to the width of the mine.

North Dakota Mines

Currently, there are nine active coal mines in North Dakota. Coal production at most of these mines has been increasing, and several companies are adding new and larger draglines. With an increase in coal production comes an increase in the number of acres disturbed by mining activity.

Reclamation costs were estimated for the Larson, Glenharold, and Gascoyne coal mines in North Dakota (Figure 16) to show how reclamation costs vary from mine to mine within the state. Mining conditions may vary significantly within each mine; therefore, a series of pits was selected at each mine to represent average conditions.

Larson

The Larson (Noonan) Mine operated by Baukol-Noonan Coal Co. is located in Burke County in the northwestern corner of the state. The series of pits for which reclamation costs were estimated has a high wall length of 4,200 feet (Table 5). The width of the mining operation is 3,000 feet and encompasses 290 acres. There are an additional 16.36 acres which are used to stockpile overburden from the initial cut.

The average haul distance for the suitable plant growth material (SPGM) is quite long--5,000 feet. The depth of SPGM is 3.12 feet. The cost to move a cubic yard of SPGM is $.3462 or $3,485.38 per acre.

The average overburden depth of 40 feet is relatively shallow in comparison to 58 feet assumed in the original mine layout, while the reclaimed slope of 3 percent is more gentle than 5 percent assumed in the Mine model. Although the shallower overburden depth tends to lower recontouring costs, the more gentle slope increases them. The result is recontouring costs of $1,652 per mined acre which is $424 lower than the mine model.

The per acre reclamation cost is $5,583 for the Larson Mine. A summary of the reclamation costs for the mine is presented in Table 6.

Gascoyne

The Gascoyne Mine, which is operated by Knife River Coal Co., is located in Bowman County in the southwest corner of the state. There are four main series of pits in the Gascoyne Mine; the one considered here has a high wall length of 4,800 feet. The mine encompasses 606 acres and is 5,500 feet in width.

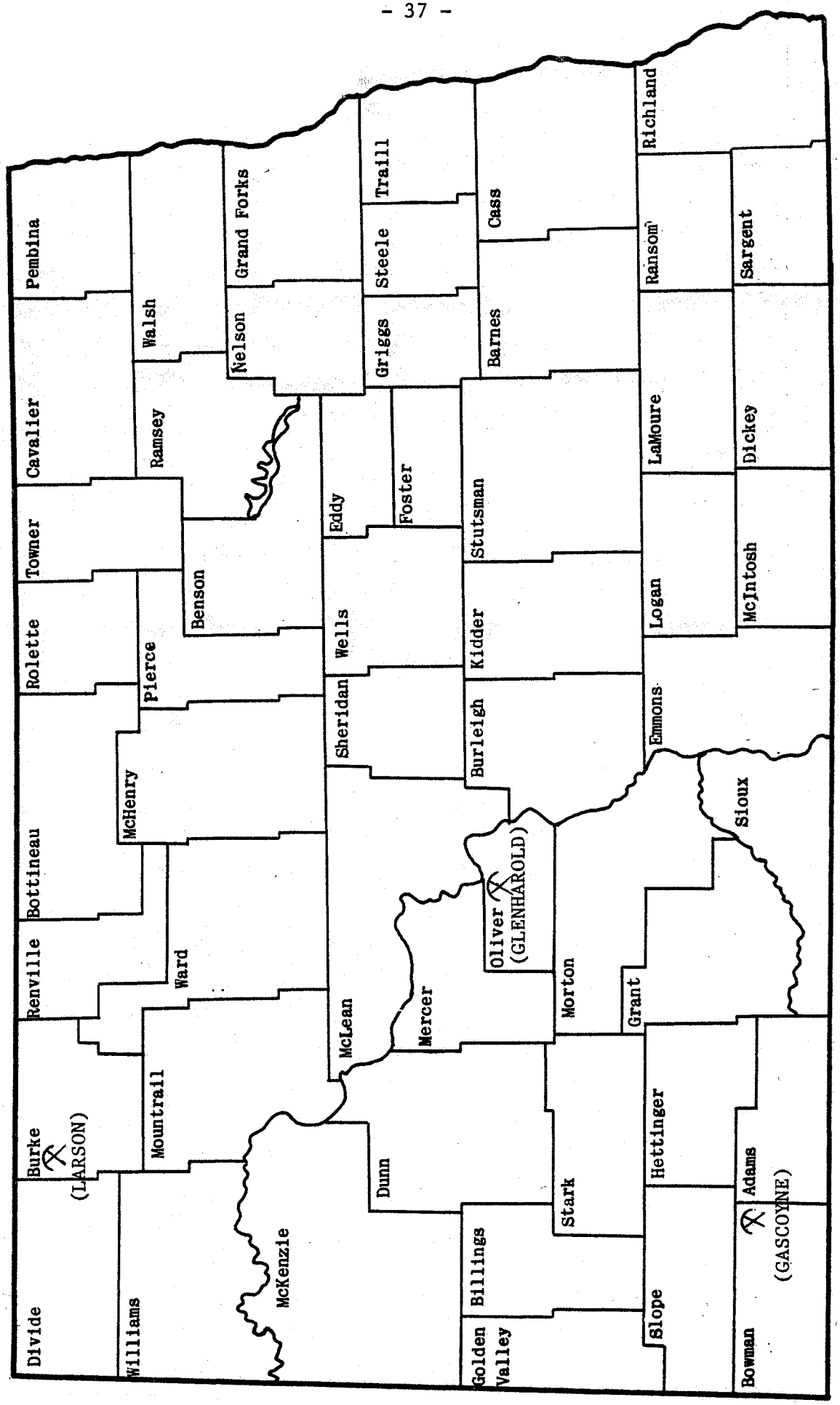

Figure 16. Location of the Larson, Gascoyne, and Glenharold Mines

TABLE 5. CHARACTERISTICS OF SELECTED SURFACE MINES IN NORTH DAKOTA[a]

Mine	Location (county)	Operator	Overburden Depth (average)	Coal Seam Thickness (average)	SPGM Depth	Average Scraper[b] Haul Distance	Length of High Wall	Width of Mine	Percent Slope
Gascoyne	Bowman	Knife River Coal Co.	65'	25'	5'	2,250'	4,800'	5,500'	5
Larson	Burke	Baukol-Noonan Coal Co.	40'	7.5'	3.12'	5,000'	4,200'	3,000'	3
Glenharold	Oliver-Mercer	Consolidated Coal Co.	50'	11'	5'	3,500'	5,000'	3,200'	8

[a]Characteristics are for a selected series of pits in each mine.
[b]The average distance the scraper travels from the suitable plant growth material pickup site to the stockpile.

TABLE 6. RECLAMATION COSTS FOR A SERIES OF PITS AT THE LARSON MINE

Activity	Cost	
Preparation and Planning		
Reclamation Fee	$ 3,313	
Bond Cost	22,977	
Extended Mine Plan Cost	18,473	
Limited Mine Plan Cost	12,749	
Annual Map Cost	1,152	
Semiannual Report Cost	1,536	$ 60,200
Topsoiling ($3,485.38/acre x 306.36 acres)		1,067,781
Recontouring[a]		
Initial Spoil Bank Area ($.2141/yd^3 x 771,674 yd^3)	165,232	
Remaining Spoil Bank Area ($.0484/yd^3 x 1,195,572 yd^3)	57,908	
Final High Wall Area		
Spoil Bank Side ($.2022/yd^3 x 881,106 yd^3)	178,200	
Final High Wall Side ($.023/yd^3 x 26,117 yd^3)	714	
Ramp Road Area ($.083/yd^3 x 929,515 yd^3)	77,117	479,171
Revegetation ($38.45/acre x 306.36 acres)		11,780
TOTAL RECLAMATION COST		$1,618,932
PER ACRE RECLAMATION COST (290 mined acres)		$ 5,583
RECLAMATION COST PER TON OF COAL[b]		$ .5359
RECLAMATION COST PER MILLION BTU's[c]		$ .0383

[a]Cost per cubic yard figures have been rounded.
[b]10,417 tons of coal per acre.
[c]7,000 BTU's per pound of coal.

The average haul distance of 2,250 feet is less than half that of the Larson Mine. However, the five foot SPGM depth offsets the shorter haul distance so the per acre topsoiling cost is only slightly less than for the Larson Mine.

The 65 foot overburden depth and 25 foot coal seam depth at Gascoyne are the deepest of the three mines considered. The slope is the same as assumed in the model mine, 5 percent. The above factors result in a recontouring cost of $2,324 per mined acre, which is $247 higher than the recontouring cost for the model mine. The per acre reclamation cost for the Gascoyne Mine is $5,936 (Table 7).

Glenharold

The Glenharold Mine is operated by Consolidation Coal Co. and is located on the border of Oliver and Mercer counties in North Dakota. The series of pits considered here covers 367 acres, having a high wall length of 5,000 feet and a mine width of 3,200 feet.

The average haul distance of 3,500 feet and the SPGM depth of five feet combine to produce a topsoiling cost of $4,311 per acre. This is $1,063 higher than the Gascoyne Mine and $826 higher than the Larson Mine.

The overburden depth of 50 feet and the coal seam thickness of 11 feet are greater than those for the Larson Mine but less than the Gascoyne Mine. The 8 percent reclaimed slope is greater than either of the other two mines. The increased slope acts with the overburden depth and coal seam thickness to produce a recontouring cost of $1,532 per acre, a figure less than either the Larson or Gascoyne mines. The larger topsoiling cost offsets the lower recontouring cost to produce a reclamation cost per mined acre of $6,350, the highest of three mines considered in this study (Table 8).

Summary

Reclamation costs were estimated for a series of pits at the Larson, Gascoyne, and Glenharold Mines. The cost of reclamation per acre ranged from $5,583 at the Larson Mine to $6,350 at Glenharold. The composition of the reclamation cost varies considerably across mines. Topsoiling and recontouring accounted for 72 percent and 24 percent, respectively, of the

TABLE 7. RECLAMATION COSTS FOR A SERIES OF PITS AT THE GASCOYNE MINE

Activity		Cost
Preparation and Planning		
Reclamation Fee	$ 6,548	
Bond Cost	47,238	
Extended Mine Plan Cost	33,516	
Limited Mine Plan Cost	29,136	
Annual Map Cost	1,152	
Semiannual Report Cost	1,536	119,126
Topsoiling ($3,248.59/acre x 629.84)		2,046,093
Recontouring[a]		
Initial Spoil		
Bank Area ($.2256/yd^3 x 1,261,931 yd^3)	284,662	
Remaining Spoil		
Bank Area ($.0484/yd^3 x 3,298,259 yd^3)	159,752	
Final High Wall		
Area		
Spoil Bank		
Side ($.2048/yd^3 x 1,477,071 yd^3)	302,516	
Final High Wall		
Side ($.052/yd^3 x 142,798 yd^3)	7,884	
Ramp Road Area ($.113/yd^3 x 5,734,062 yd^3)	653,358	1,408,172
Revegetation ($38.45 x 629.84)		24,217
TOTAL RECLAMATION COST		$3,597,608
PER ACRE RECLAMATION COST (606 mined acres)		$ 5,936
RECLAMATION COST PER TON OF COAL[b]		$ .1709
RECLAMATION COST PER MILLION BTU's[c]		$ .0122

[a]Cost per cubic yard figures have been rounded.
[b]34,722 tons of coal per acre.
[c]7,000 BTU's per pound of coal.

TABLE 8. RECLAMATION COSTS FOR A SERIES OF PITS AT THE GLENHAROLD MINE

Activity	Cost	
Preparation and Planning		
Reclamation Fee	$ 4,138	
Bond Cost	29,158	
Extended Mine Plan Cost	22,068	
Limited Mine Plan Cost	17,042	
Annual Map Cost	1,152	
Semiannual Report Cost	1,536	$ 77,094
Topsoiling ($4,311.36/acre x 388.78 acres)		1,676,171
Recontouring[a]		
Initial Spoil Bank Area ($.1692/yd^3 x 973,267 yd^3)	164,722	
Remaining Spoil Bank Area ($.0484/yd^3 x 2,002,828 yd^3)	97,008	
Final High Wall Area		
Spoil Bank Side ($.1521/yd^3 x 684,250 yd^3)	104,053	
Final High Wall Side ($.045/yd^3 x 89,670 yd^3)	3,900	
Ramp Road Area ($.096/yd^3 x 2,026,796 yd^3)	194,643	564,326
Revegetation ($38.45/acre x 388.78 acres)		14,949
TOTAL RECLAMATION COST		$2,330,540
PER ACRE RECLAMATION COST (367 mined acres)		$ 6,350
RECLAMATION COST PER TON OF COAL[b]		$ .4156
RECLAMATION COST PER MILLION BTU's[c]		$ .0296

[a]Cost per cubic yard figures have been rounded.
[b]15,277 tons of coal per acre.
[c]7,000 BTU's per pound of coal.

reclamation cost at Glenharold, while at Gascoyne, topsoiling accounted for 57 percent and recontouring 39 percent. The remaining 4 percent of the cost was made up by preparation and planning and revegetation. Recontouring represented 29 percent of the reclamation cost at Larson, topsoiling accounted for 66 percent, and the rest was due to preparation and planning and revegetation.

Summary and Conclusions

The purpose of this study was to define the reclamation process as it occurs in North Dakota and to estimate the costs associated with this process. This study can be used by policy makers as well as the general public to better understand reclamation and determine the effect policy decisions have on reclamation costs. Reclamation was defined as the process whereby affected land is reconstructed in such a manner as to return it to the contour, structure, and productivity specified by the North Dakota Reclamation Law. The reclamation process was divided into four segments--preparation and planning, recontouring, topsoiling, and revegetation.

Topsoiling and recontouring comprise the largest portion of reclamation costs. The cost of reclamation was $6,825 per mined acre in the mine model, with recontouring accounting for 30 percent and topsoiling 66 percent of the total cost. The total reclamation cost decreases by 40 percent to $3,988 if only two feet of SPGM are available. In this case, recontouring accounts for 50 percent of the total cost while topsoiling accounts for only 44 percent. There is a direct relationship between topsoiling cost and SPGM depth. The cost is $.53 times the cubic yards of SPGM moved per acre.

The influence on reclamation costs of overburden depth, reclaimed slope, mine size, mine dimensions, coal seam depth, SPGM depth, and average haul distance were considered. All of these factors, except coal seam thickness, have a significant influence on reclamation costs per acre. Coal seam thickness does, however, have a large impact on reclamation costs per ton of coal mined.

The cost of reclamation for the Larson, Gascoyne, and Glenharold mines was found to be considerably less than the $6,825 reclamation cost for the model mine. The reclamation costs ranged from $5,583 at the Larson Mine to $6,350 at the Glenharold Mine and averaged $5,956 for the three mines considered.

Reclamation costs are site specific. The procedure set forth in this study for estimating reclamation costs is not accurate for all situations. Factors such as weather, the use of other equipment, and specialized reclamation practices at certain mines will alter the cost of reclamation. These factors must be considered when estimating the reclamation cost for a particular mine site.

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