Reclamation Costs of strip-mined land in Western North Dakota

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Reclamation of strip-mined land in North Dakota is an important part of the mining process under present state law. Mining cannot be undertaken unless reclamation can be successfully completed. The reclamation process was divided into separate activities that must be performed, including preparation and planning, recontouring, topsoiling, and revegetation. The cost of reclamation was then estimated for a given set of mine conditions. The effects on reclamation cost of different physical characteristics of coal mines and requirements of the Federal Surface Mining Control and Reclamation Act of 1977 were also examined. The cost of reclamation under the conditions assumed was $6,500 per mined acre. The federal legislation would add an average of $2,900 per mined acre to the cost of reclamation.

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 help fill this gap. The United States has one-third of the world's recoverable coal reserves, but only 6 per cent of the proven oil reserves and 14 per cent of the natural gas reserves (Kenward).

The increase in coal production, along with a shifting emphasis from underground mining to surface mining, is causing an increase in acreage disturbed by strip mining in North Dakota. There are 16 billion tons of economically surface minable coal in the state underlying 700,000 acres (Gronhovd and Kube). About 14 million tons were mined in North Dakota in 1978, disturbing approximately 930 acres (estimated at 15,000 tons per acre). Current projections are that there will be 119 million tons mined per year by the year 2000. In the event of a national energy emergency, production may 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 first passed in 1969 with biennial changes made since 1973. Reclamation is an important and inseparable part of the mining process under the present law. Mining cannot be undertaken unless reclamation can be successfully completed.

Reclamation is an important issue in North Dakota because of the state's comprehensive reclamation law (and federal legislation that will take precedence over state law), and a possible 30-fold increase in coal mining in the state in the next 25 years. The cost of reclamation and the effect that physical characteristics of coal mines and requirements of the law have on cost are considered here.

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Recent North Dakota Reclamation Legislation

Present state reclamation legislation reflects the law passed in 1977 and amendments passed in 1979. The 1979 legislature amended the 1977 legislation to comply with federal law. The major differences in state and federal legislation and the effect on reclamation costs of the federal law are considered in a later section.

Any operator who wishes to engage in surface mining must obtain a permit from the Public Service Commission (PSC). However, the PSC may delete or modify portions of the requirement for hydrologic data, geologic, topographic, and soil maps for operations which will affect less than two acres per year. The permit must contain both limited and extended mining plans that require a description of the land to be affected. Duties of the operator under the 1977 law included:

1. **backfill and regrade the mined area to the gentlest topgography consistent with adjacent unmined land;**
2. **save, segregate, and respread all soil material determined by the PSC to be suitable for plant growth;[1]**
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 highwalls to an angle not exceeding 35 per cent;[1]**
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. **repair surface or domestic water supplies disrupted by mining operations;**
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 Reclamation Process

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. Area mining involves an initial (box) cut 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 varies, but is usually 100-150 feet. The overburden is placed either on adjacent unmined land or on adjacent land to be mined. The latter case requires that all the overburden be rehandled before the second cut is started, 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 highwall.

Reclamation is defined as the process whereby affected land[2] is reconstructed in the manner and to the contour, structure, and productivity specified by the North Dakota and federal reclamation laws. The reclamation process can be divided into the following tasks: preparation and planning; recontouring; topsoiling; and revegetation. Four mine regions of primary importance in reclaiming surface mined land are the final highwall area, initial spoil bank area, ramp roads, and the remaining spoil banks. The proportion of the total mine area that each of these regions accounts for depends on such factors as post-mining topography, length and width of mine, and overburden depth.

Model Mine Layout

A model mine layout was developed for estimating reclamation costs. The layout does not represent any one mine in North Dakota; rather it represents typical mine conditions encountered in the state and serves as a basis for estimating reclamation costs under the 1977 state law and the additional costs under the federal law. All cost estimates are based on 1977 dollars.

The conditions assumed are as follows. The area being mined contains 450 acres (1,760 yards by 1,237.5 yards).[3] The mine pit width is 120 feet. There is a uniform overburden depth of 58 feet, with the overburden swelling 20 per cent upon being handled. A uniform coal seam of 12 feet is assumed, with a coal recovery factor of .90. The highwall slope is 71.56 degrees and the spoil bank slope is 38.66 degrees. There is a uniform suitable plant growth material depth of five feet and all material is stockpiled. The average distance from the pick-up site to the stockpile is .65 miles.

[1]These duties have been revised as a result of the Federal Surface Mining Control and Reclamation Act of 1979.

*[2]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***).*

Preparation and Planning

Preparation and planning can be defined as those procedures necessary to obtain a mining permit, including those specified in the limited and extended mining plans.[4] It also includes those procedures undertaken prior to mining for the purpose of securing more productive reclaimed land.

Preparation and planning can be divided into six components which include the filing fee, bond, extended mining plan, limited mining plan, annual map, and semiannual report. The annual map and semiannual reports provide specific information on the progress of the mining operation.

The filing fee under the 1977 law consisted of a nonrefundable fee of $250 plus a refundable fee of $10 per acre, or fraction thereof, which was returned to the operator if the application was rejected. Surety bonds are used to satisfy the reclamation bond which has averaged about $2,500 per acre. The bond is reduced as reclamation is completed.

The limited and extended mining plans require information on the surface and subsurface features of areas proposed for mining. The plans require detailed maps and analyses of area features that must be based on primary surveys, some of which are contracted for by coal companies. Also, legal descriptions and certified copies of relevant lease agreements must be submitted to the PSC.

Costs associated with preparation and planning are based on a permit application of 475 acres, with a mined area of 450 acres. The additional 25 acres are used to deposit the overburden from the initial cut. Costs for each component of preparation and planning were determined separately, based on information provided by industry sources and representatives of firms that contract with mining companies for work performed. The total cost for an area under permit of 475 acres is $90,000 under the 1977 law (Table 1).

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. 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 regions associated with a mine that must be considered in recontouring. These include the initial spoil bank area, the final highwall area, ramp roads,

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

[4]The limited mining plan covers the initial three-year period of mining operations; while the extended plan, which must be updated annually, covers a ten-year period from the date of its initial approval by the PSC.

and the remaining spoil banks. The initial spoil bank area is formed when the overburden from the initial cut is piled. A common procedure is to deposit the overburden from the first cut on the side not to be mined. It allows mining to be conducted immediately on the second cut upon completion of mining the first cut. The final highwall area is created when the last mining pass is made.

Table 1. Costs of Preparation and Planning, 1977 Law, 475 Acres Under Permit[a]

Item	Total Cost
Reclamation Fee	$ 5,000
Bond[b]	36,000
Extended Mine Plan	26,000
Limited Mine Plan	20,000
Annual Map	1,000
Semiannual Report	2,000
Total	$90,000
Total Per Acre	$189

[a]All figures rounded to the nearest thousand dollars

[b]The bond is reduced in stages over a six-year period as reclamation is completed.

Ramp roads are located at periodic intervals and run from the coal seam through the spoil banks to the leveled spoil area. It is assumed that ramp roads are located at half-mile intervals.

The remaining spoil banks can be leveled in one of two ways. The least cost method of leveling spoil piles is to move half of the spoils to one side and the other half to the other side of the spoil pile. In actual practice a mine operator is seldom able to do this, and the spoils are all moved toward the final highwall side of the spoil pile.

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 was estimated on the basis of equipment costs, equipment performance, and average push distances. Overburden moved was estimated on the basis of length of area, yardage of overburden moved per unit of distance, and a reclaimed slope of 5 per cent.

A D-9 Caterpillar with a universal blade was assumed to be the primary piece of equipment used in recontouring. 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 production and hourly cost. The total cost of recontouring can be found by summing the costs for each individual area (Table 2).

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 generally based on color change of the soil. These two lifts must be kept separate, with the second lift material being returned first and the first lift material being returned last.

Table 2. Costs of Recontouring, 1977 Law, 450-Acre Mine

Area	Cubic Yards of Overburden Moved[a,b]	Cost Per Cubic Yard[b]	Total Cost[a]
Initial Spoil Bank	1,385,000	$.20	$277,000
Remaining Spoil Bank Area	2,431,000	.05	122,000
Ramp Road Area[c]	1,060,000	.11	117,000
Highwall Area:			
Spoil Bank Side	1,479,000	.19	281,000
Highwall Side	84,000	.04	3,000
Total			$800,000
Total Per Acre			$2,000

[a]All figures rounded to nearest thousand cubic yards or dollars.

[b]For calculation of cubic yards moved and costs per cubic yard, see Gronhovd (1978).

[c]Ramp road spacing of one-half mile, giving one ramp road.

SPGM refers to that portion of the soil material (normally the A,[5] and in some cases the upper portion of the B[6] 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. First lift material 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 ten;**
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 ten.

The depth of SPGM can vary greatly from area to area and often varies within a particular area. The 1977 law requires all soil material within the permit area determined by the Public Service Commission to be suitable for plant growth to be saved, segregated, and returned. 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. A uniform SPGM depth of five feet was assumed since this depth is most often encountered (Scherbinske).

[5]The uppermost layer in the soil profile, often called surface soil. It is the part of the soil in which organic matter is most abundant and where leaching of soluble or suspended particles is the greatest.

[6]The layer immediately beneath the A horizon. This layer commonly contains more clay, iron, or aluminum than the A horizon.

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 spoils from previous cuts. Direct application, where possible, is the least costly method of topsoiling since the SPGM is handled only once. However, direct application of SPGM is very difficult because of the mine design and land ownership patterns. Many times, certain coal seam properties make irreguar 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 and the one assumed here.

The cost of topsoiling depends on the type of machinery used, method of topsoiling, SPGM depth, and the haul distance. The cost of handling the topsoil material was based on the cost to move a cubic yard of SPGM and the cubic yards moved per acre. A 637 Caterpillar push-pull scraper was assumed to be the primary piece of equipment used. The Caterpillar Performance Handbook was used as the source for much of the performance and cost data. This was supplemented by interviews with equipment dealers and representatives of coal companies.

The cost was estimated to be $.26 per cubic yard for both stockpiling and reapplication of SPGM. There are 8,066 cubic yards of SPGM per acre.[7] Multiplying the cost per yard ($.26) times the yardage moved (8,066), the cost to stockpile is $2,100 per acre, and $2,100 per acre to return the SPGM to the leveled spoils. The total cost for topsoiling is, therefore, $4,200 per acre—or $1,995,000 for 475 permitted acres.

Revegetation

Four revegetation goals including cropland, tame pasture, native grass, and wildlife habitat were considered. Cropland and tame pasture occur on land which has a gentle slope, while land returned to native grasses normally has a steeper slope than tame pasture or cropland. The land in some instances is returned to wildlife habitat. Although the revegetation goals require different seed mixtures (which affect costs of revegetation), the management practices are similar.

Land to be returned to cropland or tame pasture has the same grass mixture applied. The grass mixture varies depending on whether the land has sandy, dry soils or heavier, moist soils. Total cost for revegetation of reclaimed land to different revegetation goals is given in Table 3. A summary of the costs of reclaiming a 450-acre strip-mined area under 1977 legislation is presented in Table 4.

Effect of Alternative Mine Conditions on Reclamation Costs

Physical, geologic, and topographic conditions vary greatly between and even within mine areas so that reclamation costs are site specific. The effect some of these conditions have on reclamation costs is considered in this section.

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

Table 3. Per Acre Costs of Revegetation, 1977 Law

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

[a]Statistical Reporting Service, USDA, Custom Farm Rates–1977, Fargo, North Dakota.

[b]Two hundred pounds of 18-46-0 fertilizer per acre.

Table 4. Total Reclamation Cost for a 450-Acre Mine, 1977 Law

Activity	Cost
Preparation and Planning	$ 90,000
Recontouring	800,000
Topsoiling	1,995,000
Revegetation[a]	18,000
Total	$2,903,000
Cost Per Mined Acre	$6,500
Cost Per Permitted Acre	6,100
Cost Per Million BTU[b]	.03
Cost Per Ton of Coal[c]	.43

[a]Cropland revegetation goal assuming dry soil.

[b]Based on 7,000 BTU's per pound of coal and 15,000 tons of coal per acre.

[c]Based on 15,000 tons of coal per acre.

Mine conditions which commonly vary are the slope of reclaimed land, overburden depth, 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 presented in Table 5. All other assumptions of the model mine remain unchanged.

The depth of overburden bears a direct relationship to reclamation cost by affecting recontouring costs. Although overburden depth does not affect the recontouring cost for the remaining spoil bank area, it does have a large impact on recontouring for the other mine regions.

The cost of recontouring is affected when the grade on reclaimed slope is altered. As slope increases, while all other conditions remain the same, recontouring costs decline and, therefore, total reclamation costs are reduced (Table 5).

Table 5. Effect of Alternative Mine Conditions on Reclamation Costs[a], 1977 Law

Item	Cost	
	Per Acre Mined[b]	Per Ton of Coal[c]
Overburden Depth (Feet)		
30	$ 5,500	$.36
58[d]	6,500	.43
70	7,200	.48
90	8,500	.57
110	10,300	.69
Slope (Percent)		
2	$ 7,911	$.53
5[d]	6,500	.43
8	6,100	.41
10	6,000	.40
15	5,780	.39
Average SPGM Haul Distance (Feet)		
1,000	4,300	$.29
3,432[d]	6,500	.43
4,000	7,000	.47
5,000	7,900	.53
6,000	8,800	.59
SPGM Depth (Feet)		
1	$ 2,900	$.20
2	3,800	.26
3	4,700	.32
4	5,600	.37
5[d]	6,500	.43
Mine Dimensions (Ratio of Length/Width)		
1/2	$ 5,800	$.38
1/1	6,300	.42
2/1	6,700	.45
3/1	7,200	.48
4/1	7,500	.50

[a]Each item listed is the only one that varies from model mine conditions.

[b]450 acres.

[c]Estimated at 15,000 tons of coal per acre.

[d]Model mine condition.

The average SPGM haul distance and SPGM depth are primary determinants of topsoiling costs. The cost of removing, stockpiling, and reapplying an acre foot of SPGM given an average haul distance of 3,432 feet is $840. The cost per mined acre is greater than this, however, since more acres are topsoiled than actually mined. The effect on reclamation cost is $897 per 1,000 feet of haul distance using other mine model conditions and varying average haul distances.

Mine dimensions affect reclamation costs as shown in Table 5. As the ratio of mine length to width increases, the proportion of the mine made up by the final highwall area and initial spoil bank area increases. These mine regions are much more expensive to recontour in relation to the remaining spoil bank area; and, therefore, total recontouring cost and reclamation cost increases.

Federal Reclamation Law

The Federal Surface Mining Control and Reclamation Act was signed into law on August 3, 1977, and the rules and regulations were finalized in March of this year. The federal law takes precedence over state law when state legislation does not meet federal standards. Major differences between the federal law and the 1977 state law are considered here along with preliminary estimates of costs associated with the federal legislation.

The federal law imposes a reclamation fee of $.02 per ton of coal, up to a maximum of $.10 per ton. The final highwall must be completely eliminated under the federal law; whereas, the 1977 North Dakota reclamation law allowed the final highwall to be returned to a 35 per cent slope from the horizontal. The federal law changes the procedure by which the bond is released and requires that part of the bond remain in effect for 10 years after final seeding. Areas determined to have prime farmland soils must have those soils handled and stored separately from the SPGM. Prime farmland must be returned to its former state and productivity. Considering these factors, the additional cost of reclamation per mined acre under the federal legislation will vary greatly from mine to mine (preliminary estimates range from $1,900 to $4,600)–the average is $2,900 per mined acre.[8]

Conclusions

The cost of reclamation is quite high–$6,500 per acre mined under the conditions assumed. Topsoiling and recontouring comprise the largest portion of reclamation costs, with recontouring accounting for 30 per cent and topsoiling 66 per cent of the total cost. The depth of suitable plant growth material has a significant effect on reclamation costs, $840 per foot of SPGM. Preparation and planning and revegetation, though important to the reclamation process, have relatively little effect on costs. The federal reclamation law, with its increased requirements, will add an average of $2,900 per mined acre to the cost of reclamation.

[8]*The presence or absence of the final highwall and the coal seam depth, which affects the reclamation fee, are the factors which will cause the greatest variance in this amount.*

References

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