DESIGN AND EVALUATION OF IMPROVED SURFACE COAL MINE OVERBURDEN HANDLING AND COAL EXTRACTION TECHNIQUES

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

by

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TB&A

FINAL REPORT

on

USBM Contract Report J0255023 Design and Evaluation of Improved Surface Coal Mine Overburden Handling and Coal Extraction Techniques

July 1976

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July 22, 1976

Mr. Gregory G. Miller
Spokane Mining Research Center
E. 315 Montgomery Avenue
Spokane, Washington 99207

Reference: USBM Contract No. J0255023

Dear Gregory:

We are pleased to submit the final report for the Design and Evaluation of Improved Surface Coal Mine Overburden Handling and Coal Extraction Techniques.

This report presents the results of the design and evaluation of four selected surface coal mining systems. The summary provides a brief description of each of the four systems and the methods used in the evaluations. For each system, the report presents a description of the mining system, a narrative description of a hypothetical model mine with schedules describing the investments and costs and a series of analyses that provide the basis for evaluation and comparison. Ten additonal mining concepts are briefly described and evaluated and recommendations for future research are included at the end of the report.

Photos, graphs and sketches have been used where appropriate to aid the reader in his comprehension and visualization of the concepts and data presented.

Gregory, we appreciate your and the Bureau of Mines' cooperation on this study.

Sincerely,

Dennis J. Callaghan
Principal

John A. Bowersmith
Project Manager

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16. Abstract
This report is the result of information obtained from a review of related literature, personal inquiry and on-site examination of active surface coal mining operations. Four improved surface coal mine systems are described in detail and evaluated for feasibility, implementation requirements, environmental benefit and costs. Engineering feasibility emphasizes equipment availability, compliance to design requirements, practicality and industry rating. Implementation potential emphasizes immediacy, ease, acceptability and constraints. Special attention was given to environmental responsiveness, both with regard to the solutions to mined-land reclamation problems and to the concurrency of reclamation. Each system description includes a hypothetical model mine with a depreciation schedule, capital summary, estimated annual production costs, sales price computation, production and operating cost summary, and a sensitivity analysis of mine price to stripping ratio. A program plan and time schedule for demonstrating a selected mining system covers site selection criteria, mine data collection, criteria for controlling and budgeting costs and reporting findings. Ten additional mining methods and techniques are briefly described and evaluated. Common reclamation problems are listed and described. Sixteen state reclamation laws and regulations are abstracted. Sixty-nine references are listed in the bibliography.

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This report is a summary of the work recently completed as a part of this contract during the period July 1975, to May 1976. This report was submitted by the authors on July 22, 1976.

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EXECUTIVE SUMMARY

The objective of this study is to design and evaluate new methods and techniques of coal extraction and overburden handling in surface coal mines in a safe and economically feasible manner while minimizing environmental impact and increasing domestic coal production.

The study gathered fourteen techniques and systems for preliminary evaluation. Four of those were chosen for detailed analyses and evaluations: the terraced pit mining system, the area haulback mining system, the peripheral mining system, and block area mining with a tower excavator.

The terraced pit system excavates overburden with loading shovels, scrapers, wheel loaders or other suitable mobile equipment and transports and deposits the spoil with either scrapers or trucks. Coal is removed with a loading shovel and transported to the tipple with large capacity off-highway trucks. The pit is bowl shaped and terraced at both ends. It is economically competitive under stripping ratios of 8:1 and provides for selective placement of all overburden. Its most logical application is in the western coal reserves where stripping ratios are lower.

The area haulback system excavates overburden with a dragline and deposits the spoil on the highwall. Front-end loaders transfer it to end dump trucks and it is hauled around either end of the pit to be used as backfill for filling the pit on the spoil side. The pit is relatively short and somewhat wider than conventional area mine pits, and there is only one coal haul road through the spoil. It is economically competitive in situations where dragline rehandling of spoil reaches about 50 percent. It can substantially increase coal production in deep pits and it provides for selective placement of overburden spoil. It can be applied in most of the western and midwestern coal deposits.

The peripheral system of area mining is very similar to a straight pit area mine using a dragline. The difference lies in the configuration of the pit and the associated consequences. The first box cut completely surrounds the property, and the highwall ramps are used for coal transport for economy and to achieve the retreat mining objective. The potential for designing outside curves can reduce rehandling in deep overburden and facilitate reclamation. A dragline is the preferred machine for excavation and cross pit casting. Coal is removed with a loading shovel and transported to the tipple with large capacity, off-highway trucks. Reclamation grading is done with dozers and topsoil placement is accomplished with pan scrapers. The concept is applicable to western, midwestern and eastern coal fields.

The block area mining system using the twin tower excavator machine begins the mining operation by removing and transporting topsoil and subsoil with pan scrapers. The major portion of overburden is removed and placed with the twin tower excavator. Bulldozers and front-end loaders remove the remainder and transport it or push it into the empty pit behind the coal loading operation. Coal is removed with a coal loading shovel and is transported to the tipple with large capacity, off-highway trucks. Reclamation grading is combined with working bench preparation for the head tower machine. The application of this principal would be limited to mining in areas of unconsolidated overburden. Machines of a size and capacity comparable to draglines and and stripping shovels have yet to be built.

The four elected mining systems were each carefully analyzed both with regard to methods and equipment alternates. A model mine was then designed and estimated to provide detailed cost and production data. At that point, an analysis was made of the engineering feasibility, the implementation requirements, the environmental benefits, the financial implications and the limitations of each mining system.

With this data the systems were subjected to an objective comparison of relative merit by each category and one of the four systems was then chosen to be the subject of a field demonstration and evaluation program.

The terrace pit was elected as being the best of the four candidates around which to design a field demonstration program in terms of the study objectives and the anticipated degree of applicability. It can very well be a more economical and environmentally responsive way to mine much of the western coal reserves, and the delay time for equipment delivery is much less.

INTRODUCTION

Filling the energy demand of the United States is partially contingent upon domestic coal production. One of the most important factors in closing the energy gap is increased production levels. New coal-mining capacity of 492.6 million tons is presently in development, or being scheduled by 1985. This projection would increase domestic production from 603 million tons during 1974 to approximately 1.1 billion tons per year. Surface mining will account for 56.7 percent of the new capacity.

In order to meet our energy objectives in an economic and environmentally responsive manner, new advances in extractive technologies and strip mining methods must be developed. To minimize the environmental impact of strip mining, it is necessary to integrate mining and reclamation operations into a materials handling system that will expedite coal extraction and contemporaneous reclamation of the affected areas.

A large amount of new coal production will originate in the western states with Wyoming and Montana accounting for 179.6 million tons. The present surge in the West arises from accelerated growth in electric power generation and shipment of low sulphur western coal to points east and south to permit those distant utilities to meet sulphur emission standards. Reserves of strippable coal in the West have been estimated to be about 34 billion tons. These reserves represent about 23 percent of the total in the country which are categorized as recoverable under present technology.

Surface mining has had an increasing role in supplying low cost fuel for our expanding national energy requirement, and is the only practical way to mine the thick seams underlying shallow overburden that are characteristic of most of the western reserves. The surface mining industry will play an even greater role in the fulfillment of future demands partly because of the nature and quantity of the western coal reserves.

Surface mining has its problems, however. Public concern for the environmental impact of surface mining is strong. The past land degradation in the Appalachian Region will not be allowed to occur in the future. Recently, state and federal agencies, universities and coal mine operators have conducted research to improve reclamation methods and techniques. Rigid state laws and the Department of the Interior regulations guarantee the compliance of operators in reclaiming mined lands. The effect of these laws and regulations is to make low cost, tried and true mining methods more expensive and less desirable from an environmental impact point of view.

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1. "Coal Mine Development Survey Shows 492.6 Million Tons of New Capacity by 1985," Coal Age, February 1976, page 106.

The old methods were very efficient when no particular regard had to be given to reclamation. With the demand for concurrent reclamation, burying of toxic material, neutralized mine drainage, guaranteed growth of cover plants and other similar regulations it became evident there was an inconsistency between the objectives of efficient mining and modern, concurrent land reclamation which requires not only approximate original contour with a layer of topsoil on the surface, but in many cases, it demands selective placement of spoil. Some of the mining industry's response to land reclamation requirements has been to "add on" the reclamation activities after the other parts of the production operation have been completed. This approach has greatly increased the cost of coal production and met with limited acceptance of its environmental impact.

This study will assist the surface coal mining industry by identifying some alternative means of resolving the conflict between low cost coal and high quality concurrent reclamation.

STUDY METHODOLOGY

The study was organized into three distinct phases, (1) design new mining systems, (2) analyze, evaluate and select one mining system for demonstration, and (3) determine the field demonstration site, design the field demonstration plan and submit the final report. The evaluation phase included engineering feasibility, implementation potential, environmental benefit and cost feasibility. The field demonstration program is designed to provide the greatest potential for increasing production and improving land reclamation.

An extensive literature survey was made in the beginning of the study to identify the pertinent written information that was available regarding mining methods and reclamation requirements and practices. Concurrent with this search, a wide variety of surface coal mine operations were visited in representative areas of the major United States coal fields and state reclamation personnel were interviewed in a number of states.

This accumulated experience plus the technical written data base were then applied to defining the principal surface coal mine parameters and their quantitative ranges within the categories of physical requirements, production requirements and legal requirements.

Numerous mining concepts, both novel and unusual were explored, tested and evaluated on a preliminary basis. By comparing and rejecting in an iterative process, the original group of ideas was reduced to four. These four then become the subjects of detailed costs analysis and design of four complete mining systems and corresponding model mines using each system.

Finally, the four systems were analyzed for engineering feasibility, implementation ease, environmental benefit and cost impact. All the limitations of each system then were delineated. And, based on this final evaluation, one system was selected for demonstration.

The final phase of the study was the determination of a suitable site to demonstrate and evaluate the system. Concurrently, a field demonstration and evaluation program was prepared to monitor, measure and report the data required for a comprehensive evaluation.

Background Information Collection

To provide a data base for new surface coal mining concepts, a review was made of available technical literature in libraries, the National Technical Information Service, trade journals, equipment supplier catalogues, state reclamation laws and regulations, impact statements and other similar references. Large works were indexed when indexes were lacking. Numerous mines in diverse locations were visited for a first hand look at current surface coal mining practices and to hear the operators' ideas involving reclamation and mining methods. State and federal agencies were visited and reclamation personnel were interviewed. Equipment manufacturers were also visited and interviewed.

Definition of Engineering Parameters

Using the data base obtained in the first step, definitions of engineering parameters and their limits within major geographical regions were documented and classified. The engineering parameters provided physical production and operating guidelines in designing the new mining systems. They included temperature, precipitation, general terrain, slopes, vegetative cover, topsoil depth and characteristics, coal thickness and kind, tons of coal per acre of disturbed land, size of mines in tons per year, average stripping ratios, F.O.B. mine price per ton and conditions that are unique to the region. See Exhibit I.

All the major state reclamation laws were abstracted and classified in regard to the requirements for: overburden samples, refuse and drainage, final graded contour, topsoil removal and placement, final cuts and water impoundments, general reclamation, reclamation time limit, interim of liability, bonds, fees, filing requirements, conditions for revocation or denial of permit and the name of the regulating state agency. This information provided legal constraints with which the new mining systems would have to comply.

Mining System Development

Based upon the engineering parameters, the existing state-of-the-art of surface coal mining technology, and reclamation requirements, we conceptualized fourteen mining methods or systems that would meet the objectives of improving land reclamation while integrating the reclamation activity with the mining production operation.

Preliminary evaluation of the fourteen conceptualized systems was conducted evaluating how well each system:

- Fit the objective of the study.
- The technical feasibility, practuality and applicability to surface mining of newly conceptualized systems.
- "Common Sense" evaluation.

In addition to internal evaluations, we also discussed the fourteen systems with mining industry personnel. The fourteen preliminary designs were reduced to four by this process.

Detailed Development and Evaluation of Systems

The detailed development of the four mining systems included the determination of the operating methodology, equipment requirements, and the design of the active mine area including the pit. In addition, the operations of a hypothetical model mine, using the new system was described. The physical, production and legal compliance of each of the four systems was documented as was the expected benefits and limitations of utilizing the new system.

Analysis was conducted on each of the four systems, evaluating the system's engineering feasibility, implementation potential and environmental benefits. A cost/benefit analysis was conducted on each system utilizing the hypothetical model mine. Capital requirements and mining costs were estimated and a life-of-mine cash flow was constructed to determine the required cost of coal from the new system.

The information was organized so that a comparison could be made between the four alternatives on the basis of costs, environmental benefits and expediency of implementation. As a result of the inter-system comparisons, the terrace pit mining method was selected for development of a demonstration program and for determining locations for demonstration sites.

Field Demonstration and Evaluation Program

The implementation of a new mining system for demonstration purposes was planned to include site selection, data collection and organization, and a demonstration time schedule. Specifications for site selection were developed, a detailed description of a data collection system pertinent to study objectives was compiled and an estimated time schedule for field demonstration activities was summarized in gantt chart form.

Major coal mining companies were contacted to determine their interest in cooperating with a field evaluation of the selected system in a suitable region, and strong desire has been expressed to participate in a demonstration program.

A field demonstration and evaluation program was then prepared detailing the data collection procedures, time schedules and responsibilities necessary for complete evaluation of the surface coal mining system. It is a general plan, not specific to any one mine and will serve as a guide in developing the specific program.

EXHIBIT I
ENGINEERING PARAMETERS

REGION	REGIONAL MINING METHODS	STATES	MEAN TEMPERATURE (CLIMATE)	PRECIPITATION (CLIMATE)	GENERAL TERRAIN (TOPOGRAPHY)	SLOPES (TOPOGRAPHY)	VEGETATION/COVER (TOPOGRAPHY)
APPALACHIA	•Conventional Contour •Lateral Movement -Haul Back-Controlled Placement •Mountain Top Removal -Valley Fill- •Head of Hollow Fill •Multi-Seam •Modified Box Cut	E. Kentucky Tennessee Virginia West Virginia	20° - 85°F	30" - 60"	Deeply dipping valleys and ridges	Average 50-60% (up to 80%)	Forest
EASTERN	•Conventional Contour •Box Cut Contour •Two-cut Box Contour •Modified Block Cut •Modified Area •Block-Area	Pennsylvania Maryland S.E. Ohio Alabama	39° - 86°F	36" - 64"	Mountainous Woodland	10-30%	Partially wooded, grazing land
INTERIOR	•Area Mining •Modified Area •Block Area •Multi-Seam Scraper	N.W. Ohio W. Kentucky Indiana Illinois Iowa Missouri Kansas Arkansas Oklahoma	40° - 76°F	13" - 56" (30"-40" snow)	Gently rolling hills and very flat plains	up to 20%	Grazing, Farmland
ROCKY MT./ GREAT PLAINS	•Area Mining •Open Pit Dipping Seam •Open Pit Thick Seam	Arizona Colorado Montana New Mexico N. Dakota Wyoming	0° - 105°F	up to 100" (mainly snow) (some flash flooding)	Rolling Prairies to Mountainous	Average 5% (up to 40%)	Scrubgrass, small trees

EXHIBIT I
ENGINEERING PARAMETERS

REGION	REGIONAL MINING METHODS	STATES	GEOLOGY: TOP SOIL DEPTH	GEOLOGY: TOP SOIL CHARACTERISTICS	GEOLOGY: OVERBURDEN AVERAGE DEPTH	GEOLOGY: OVERBURDEN CHARACTERISTICS	GEOLOGY: COAL THICKNESS	GEOLOGY: COAL KIND
APPALACHIA	●Conventional Contour ●Lateral Movement -Haul Back-Controlled Placement ●Mountain Top Removal -Valley Fill- ●Head of Hollow Fill ●Multi-Seam ●Modified Box Cut	E. Kentucky Tennessee Virginia West Virginia	0-3 1/4'	A Horizon 2"-3" B/C Horizons to 4'	36'-41'	Shale, Blocky Sandstone	to 6'	Bituminous (some sub-bituminous)
EASTERN	●Conventional Contour ●Box Cut Contour ●Two-cut Box Contour ●Modified Block Cut ●Modified Area ●Block-Area	Pennsylvania Maryland S. E. Ohio Alabama	up to 3'	A Horizon 6"-10" B/C Horizons to 2 1/2'	38'-51'	Clay, Sandstone, Shale	2.5'-5.5'	Bituminous (some anthracite) (some lignite)
INTERIOR	●Area Mining ●Modified Area ●Block Area ●Multi-Seam Scraper	N.W. Ohio W. Kentucky Indiana Illinois Iowa Missouri Kansas Arkansas Oklahoma	2'-5'	A Horizon 6"-24" B/C Horizons 2'-4'	29'-56'	Clay, Sandstone, Limestone	1.5'-6' (Up to 25')	Bituminous (some sub-bituminous)
ROCKY MT./ GREAT PLAINS	●Area Mining ●Open Pit Dipping Seam ●Open Pit Thick Seam	Arizona Colorado Montana New Mexico N. Dakota Wyoming	0-4'	A Horizon 6" B Horizon 1 1/2'-2 1/2' C Horizon consolidated and deep	40'-60'	Sandstone, Shale	5'-90'	Bituminous/ sub-bitum. (some lignite)

EXHIBIT I
ENGINEERING PARAMETERS

REGION	REGIONAL MINING METHODS	STATES	TONS/DISTURBED ACRE	RANGE OF PRODUCTION MINE SIZE	AVERAGE STRIPPING RATIOS	FOB MINE PRICE/ TON	UNIQUE CONDITIONS
APPALACHIA	•Conventional Contour •Lateral Movement -Haul Back-Controlled Placement •Mountain Top Removal -Valley Fill- •Head of Hollow Fill •Multi-Seam •Modified Box Cut	E. Kentucky Tennessee Virginia West Virginia	7,074 0 0 0 0	6,000 to 575,000 TPY	8.78:1	$18.41 to 28.44	•Acid Forming Materials in and near seams •Dense Forests •Steep Slopes •Heavy Rainfall
EASTERN	•Conventional Contour •Box Cut Contour •Two-cut Box Contour •Modified Block Cut •Modified Area •Block-Area	Pennsylvania Maryland S.E. Ohio Alabama	6,360 0	2,000 to 4,300,000 TPY	11.92:1	$12.42 to 18.49	•Acid Forming Materials •Heavy Rainfall
INTERIOR	•Area Mining •Modified Area •Block Area •Multi-Seam Scraper	N.W. Ohio W. Kentucky Indiana Illinois Iowa Missouri Kansas Arkansas Oklahoma	5,767	5,000 to 5,000,000 TPY	12.70:1	$ 4.63 to 20.63	•High Stripping Ratios
ROCKY MT./ GREAT PLAINS	•Area Mining •Open Pit Dipping Seam •Open Pit Thick Seam	Arizona Colorado Montana New Mexico N. Dakota Wyoming	26,903	118,000 to 6,900,000 TPY	2.96:1	$ 2.19 to 6.19	•Thick-Seam Coal

INTRODUCTION AND SUMMARY

Terrace pit mining is a new system integrating the mining and reclamation operations. It is a flexible way to begin the surface mining of coal in a relatively short period of time. The equipment needed can be delivered quickly compared to draglines and shovels.

The pit is rectangular or square in shape. Topsoil removal is the first step in overburden excavation and is typical of other mining systems except for the haulage of topsoil around the ends of the pit and its placement on the leveled spoil pile by mobile equipment. Drilling and blasting may or may not be done on the terraces depending upon the geology and the number of coal seams. Close control of this operation is necessary.

It is a distinctive system because of the terraced highwall and backfilled spoil, and because the excavation equipment used is relatively small and highly mobile. The terrace surfaces may be level or inclined depending upon the type of equipment that excavates the overburden. Level terraces excavated with power shovels or end-loaders, are cut in narrow strips along the terrace face to maintain pit dimension stability.

Haulage roads for overburden and coal run along the sides of the pit to intersect terraces on the spoil side. The roads are constantly being constructed and maintained with material from the excavations.

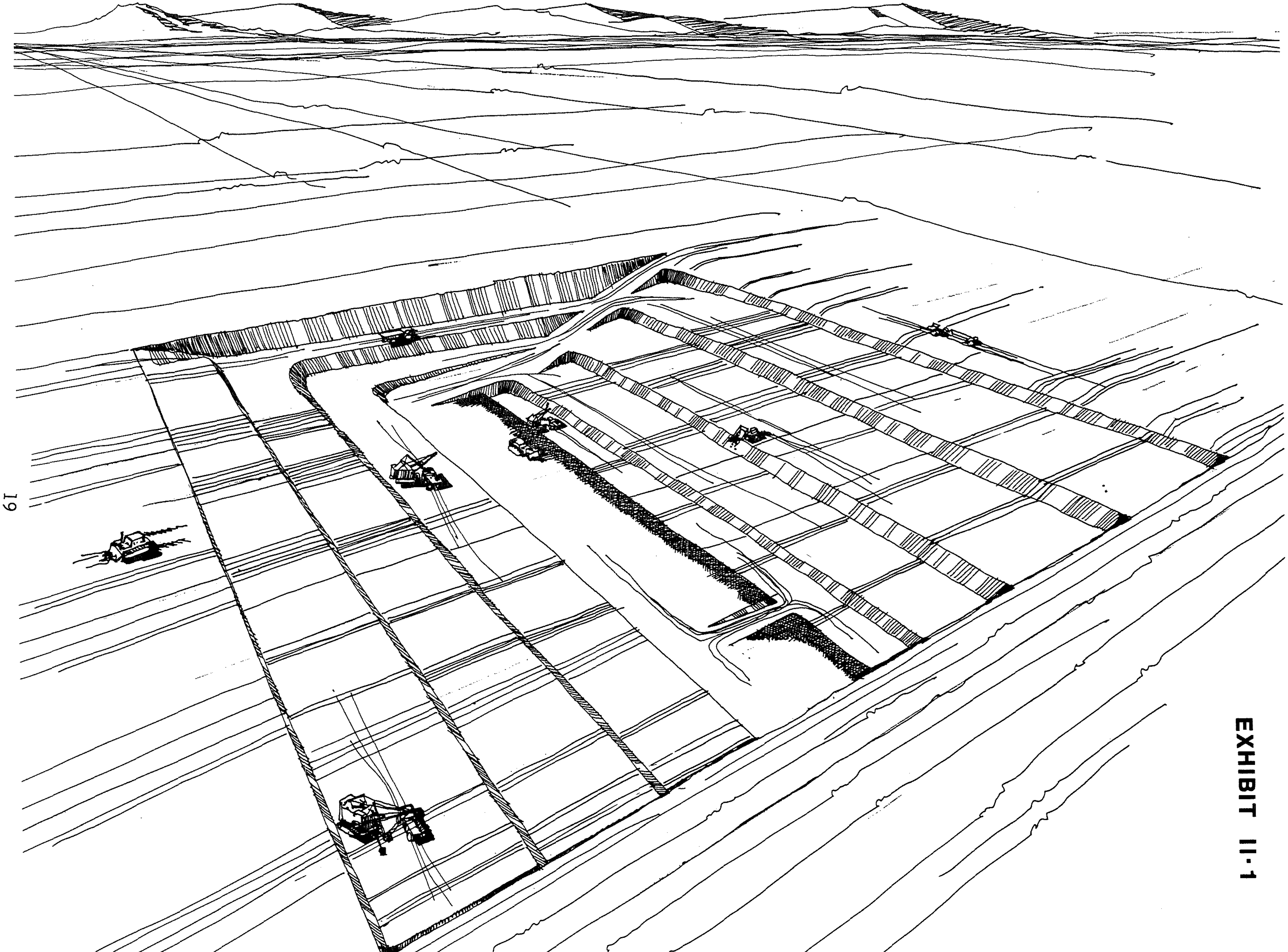
Coal removal and haulage differs little from those operations in other surface mining systems. Truck movements require sequencing with the other mining activities, and coal haulage routes should be separate from overburden haulage roads to minimize congestion.

Pit design depends upon a number of geological factors including the number of coal seams, the thicknesses of seams and interburden, safe highwall and spoil angles, the availability and quality of road building material and the necessary in-pit coal inventory quantity.

Equipment requirements are specific to the mining site. They are all mobile types and the largest would be a loading shovel or a small bucket wheel excavator. The use of trucks and shovels for both coal and overburden offers the opportunity for standardization and interchangeability of equipment. One variation using pan scrapers for all overburden excavation is described later in this section.

This system and variations of it will, no doubt, play an important role in increasing national production of western coal. The terrace pit, however, is somewhat limited in that it becomes less economical at simultaneously high production levels and high stripping ratios.

The quality of reclamation is inherently high in this technique and the cost of mining is competitive. Exhibit II-1 shows a perspective sketch of a single seam, shovel/truck, terrace pit mining system. Overburden and coal are similarly loaded into haulage trucks which travel along side-pit routes as shown.



SINGLE SEAM SHOVEL TRUCK TERRACE PIT SYSTEM

EXHIBIT II-1

DESCRIPTION OF THE MINING SYSTEM

Terrace pit mining is a new system utilizing medium capacity mobile equipment to excavate, haul, and spoil overburden in a rectangular shaped terrace pit. The terrace pit system may be utilized in coal fields where the terrain is flat or sloping; however, because of the system's higher unit cost for overburden removal, the western coal fields are preferred. A detailed description of the operating methodology, equipment requirements and a description of a hypothetical mine using the terrace pit mining system is included in this section of the report.

Operating Methodology

In the terrace pit mining system, overburden excavation consists of three primary steps:

- Ground preparation
- Drilling and blasting overburden
- Overburden excavation, loading and hauling

These will be discussed below in detail.

The terrace pit system would commence along the outcrop or subcrop line. At its origin, box cut spoil would be excavated and stockpiled in a suitable location until a complete pit is opened. Once the pit is established, mining continues overburden excavation on the leading pit side and deposition on the trailing side of the pit. Once the pit is established, the terrace pit covers the entire permit area exposing the coal reserves.

The ground preparation consists of building access roads for exploration drilling and the removal of obstacles. It can also include topsoil excavation if required for drilling benches.

The first terrace is formed by scrapers removing topsoil and hauling it around the pit to cover other spoil. Because this system uses mobile equipment only for hauling and depositing overburden, the spoil pile is relatively level and does not have the spoil ridges typically found in area mining. This system allows the scrapers to lay down topsoil in its final location and minimizes the need for stockpiling or rehandling this material. In many western mining areas topsoil is non-existant and in others it reaches five feet in thickness. Where topsoil is very thin or absent, soil is sometimes relocated from other areas in order to revegetate the reclaimed land.

Following the topsoil removal operation, a drilling and blasting crew first drills and then blasts consolidated overburden if it is present. This may be done on the ground surface prepared by the previous operation or on one or more of the pits' terraces depending upon the elevation at which the consolidated strata occurs.

If drilling and blasting is done on a terrace, excavation work in the immediate vicinity must be stopped until the area is graded after blasting to allow rubber-tired vehicles access to the area. Close control of the drilling and blasting operation must be maintained to prevent unnecessary production interferences or safety hazards from developing between the drilling and blasting operation and the other overburden removal operations.

The overburden drilling operation will use vertical drills working on top of the consolidated overburden. The hole spacing, depth and charge per hole varies and depends on overburden thickness and hardness. A typical burden ratio is between two and three cubic yards of rock per pound of oxidizer. Hole spacing, diameter and charge per hole is calculated to produce the desired burden ratio. If front-end loaders excavate overburden, it may be necessary to reduce the burden ratio to insure sufficient rock breakage to facilitate digging and to maintain scheduled production levels.

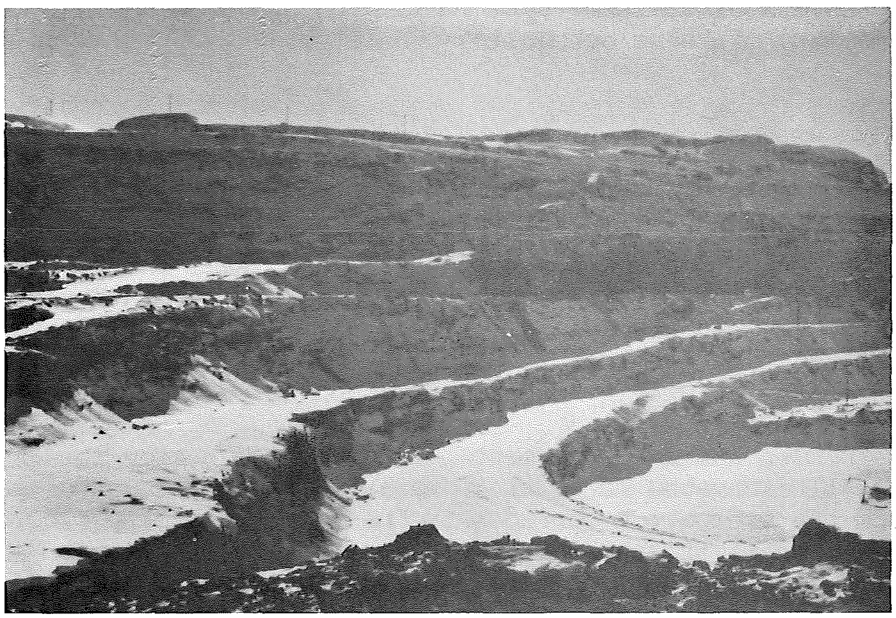
The terrace pit system of surface mining coal is distinctive because of the terraced highwall and terraced back-filled spoil, and because the excavation equipment used is relatively small and highly mobile compared to draglines and stripping shovels. The size of the mine can be highly variable. There can be a single seam or a number of them. The overburden can be unconsolidated or it may require blasting. The pit does not assume the traditional long narrow configuration but is rectangular shaped.

Overburden is excavated from the faces of the terraces in the highwall. If it is a truck and shovel operation, the terraces are level and the shovel digs into the side of the terrace. If pan scrapers are used, the terraces are inclined along their length to reduce the number of haulage roads and to enable the scrapers to gain access to upper terraces while minimizing the steepness of the grade. These terraces vary in width with the type of equipment chosen and must accommodate the excavation activity as well as supply access and maneuvering room for the overburden haulage vehicles. Overburden is excavated while tramming diagonally from one terrace to the next lower one.

To maintain access from both ends of each terrace when loading shovels or front-end loaders excavate the overburden, the lateral excavations must be made in narrow strips along the length of the terrace face. On each terrace, these excavations must progress into the highwall at about the same rate. Since the terrace heights will vary in a multiple seam mine because of varying interburden thicknesses and coal seam thicknesses, work scheduled on a given terrace must be coordinated with scheduled work progress on the other terraces. The required same rate of advancement but differing terrace heights implies different production volume rates on individual terraces. Coal removal and haulage has to keep up the same daily pace as overburden removal.

Overburden is transported over the excavation terraces to roads on the sides of the pit, then to the spoil terrace where that specific material is to be deposited. The reclamation plan will normally specify the required depth and order of placement of different overburden strata.

If pan scrapers are the overburden haulage vehicles, the material is deposited on the edge of the terraces in the spoil bank by the scrapers tramming from a higher to a lower terrace in a fashion similar to the loading operation. The uppermost terrace is normally covered with topsoil and the final surface assumes the approximate original contour of the surrounding land. If trucks are used, they back up to the edge of the terrace and dump over the edge so that the terrace is widened. Topsoil is backfilled on top of the uppermost terrace surface of rocky spoil so that the trucks do not have to operate on top of the previously deposited topsoil. Grading is usually done by dozers or a motor grader.



LEVEL TERRACES ALONG ADVANCE SIDE OF PIT
AS WOULD BE USED IN A TRUCK SHOVEL OPERATION

Coal removal and haulage, aside from equipment similarities, is somewhat different from conventional mining. The face of the coal is quite wide. The consequence is that coal removal equipment must work along the coal face, rather than advancing towards the highwall, in order to maintain a safe working distance from the closest excavation. In a truck and shovel operation, part of the overburden excavation equipment works on top of the coal surface and there must be at least the same coal surface width as the highwall terraces above. The coal is removed in narrow strips and coal removal equipment moves are frequent. Coal haulage vehicles use roads on one side of the pit for access to and from the coal seam(s). These roads must be constantly maintained in order to facilitate the coal haulers' speed of movement. Because the roads are part of the pit system and are located in spoil filled areas, they are constantly built up with suitable spoil material.

Overburden excavation and coal removal are continuous, interdependent activities. Any unnecessary, extra terrace width increases haulage distances and costs. Therefore, all terraces including the exposed coal seam need to be kept at a minimum width. This minimum is established by the requirements of the working vehicles and due regard for safety. Since the pit may advance as much as thirty feet or more per day, the excavating activities on the terraces and at the coal face must be carefully coordinated by the pit supervisors on an hour by hour basis using aids such as survey stakes. Sequencing of these activities can become a matter of concern in cases where one coal loading shovel or front-end loader is all that is needed in a multi-seam mine. That is just one example out of many that are possible. Trucks and shovels of the same type working both overburden and coal can overcome many of these scheduling problems.

Pit Design

The design of a terraced pit begins with the exploratory drilling samples and the area survey. This initial information will establish the number of coal seams and their respective thicknesses, and will disclose the chemical and physical characteristics of the overburden and interburden at various elevations. The geological profile that results is the starting point for the pit design or designs depending upon how varied the geology is within the property boundaries.

Mobile, overburden haulage equipment helps to characterize this system of mining. All excavated material is hauled either by truck or pan scraper from the excavation terraces to the spoil terraces. The cost of this operation is affected primarily by the time it takes to complete a round trip cycle. The time it takes to travel to and from the loading point to the dumping point is frequently the major portion of the total cycle time. This travel time is determined by the average speed of the vehicle and this in turn is influenced by the pit design factors of road surface, distance and grades. These factors must be balanced to minimize cost and maximize production.

There are a number of other factors that will have to be taken into account before plan dimensions are established. The number of mineable coal seams and the amount of interburden between them will partly establish the number of terraces that will finally be chosen. Each coal seam will be a terrace and if it is more than about 35 feet thick, it will probably comprise two or more terraces. The same remarks apply to overburden and interburden. The reason for this is the digging height limitations of the available mobile equipment that is customarily used in surface mines.

Another factor is the safe angles of highwall and spoil materials. This is of particular importance for the sides of the pit between the unmined land and the spoil area. This is where the haulage roads will connect the overburden terraces to the spoil terraces or spoil bank. The steeper the angles are, the less material will have to be rehandled on the return pass parallel to the first pit's direction of advance.

The physical nature of the various geological strata must be evaluated for blasting requirements, if any, and for road building characteristics. Roads and terrace surfaces are important factors to consider because of the constant traffic of very heavy vehicles. The depth of penetration of tires into the road or terrace surface strongly influences rolling resistance and the resulting costs of fuel, tire wear and maintenance of the trucks and scrapers.

The slope of the land or the pitch of the coal seam may either increase or decrease the depth of overburden as the mine progresses through the property. A change in overburden depth may require the addition or deletion of the uppermost terraces and side pit haul roads. The addition of one or more side pit haul road increases the amount of material to be rehandled and this must be weighed against the negative grades that result if it is not done.

The design of the pit is also influenced by rock properties of the overburden, both physical and chemical. The model mine, described in this section of the report, has unconsolidated overburden capable of being excavated by pan scrapers. The resulting design has pitching terraces with a side haul road on each side of the pit at different elevations. This design results from the economic need to minimize negative haul grades for loaded pan scrapers.

If the overburden was predominantly consolidated rock requiring blasting, pan scrapers could not excavate it unless it was very heavily blasted. In design planning, this cost penalty for extra explosives would be weighed against the economics of using shovels or front-end loaders to excavate and trucks to haul overburden to the spoil pile. If trucks and shovels are used, the pit characteristics will include steeper road grades, and a wider pit dimension parallel to the flat, highwall terraces.

The chemical nature of the overburden affects pit design to the extent that toxic components exist in the overburden. State laws generally require that acid forming rock and other toxic materials be buried. If this material exists in sufficient quantity, a special terrace will be included in order that the material can be excavated and deposited in the most beneficial location.

The road surface material on spoil areas must also be evaluated in terms of its potential effects on land reclamation quality. Toxic rock material must be avoided at least near the land surface surrounding the mined area.

The amount of minimum and maximum coal inventory required to remain in place in the mine must be decided upon because it affects the dimensions of the pit and consequently the haulage distances of the equipment. The haulage distances, in turn, influence both the amount of capital invested for equipment and the mine operating costs of that equipment.

The length of the pit and the internal dimensions parallel to the direction of pit advance will result from the desired widths of terraces, number of terraces, the pit floor dimensions, desired amount of coal inventory in place and slope angles of the unmined terrace walls and the spoil material. When these dimensions are decided upon, the width of the pit can be derived. For example a 90 feet deep pit with a floor of 340 feet by 340 feet, and 150 foot wide terraces 30 feet high would require a pit dimension of approximately 1,500 feet long by 600 feet wide at the surface. There is a trade-off to be considered between haulage distances and their implications and the amount of rehandled spoil that will result from mining the adjacent property in a subsequent parallel pass. The resulting compromise will be made based upon cost consideration of various equipment types, sizes and capacities. To further reduce rehandle, a spoil wedge or open trench can be left adjacent to the undisturbed pit side and encountered by the next pass of the pit. This spoil wedge would be formed by not depositing spoil in the wedge area. On the final pass, it would not be necessary to leave a spoil wedge and an even contour results.

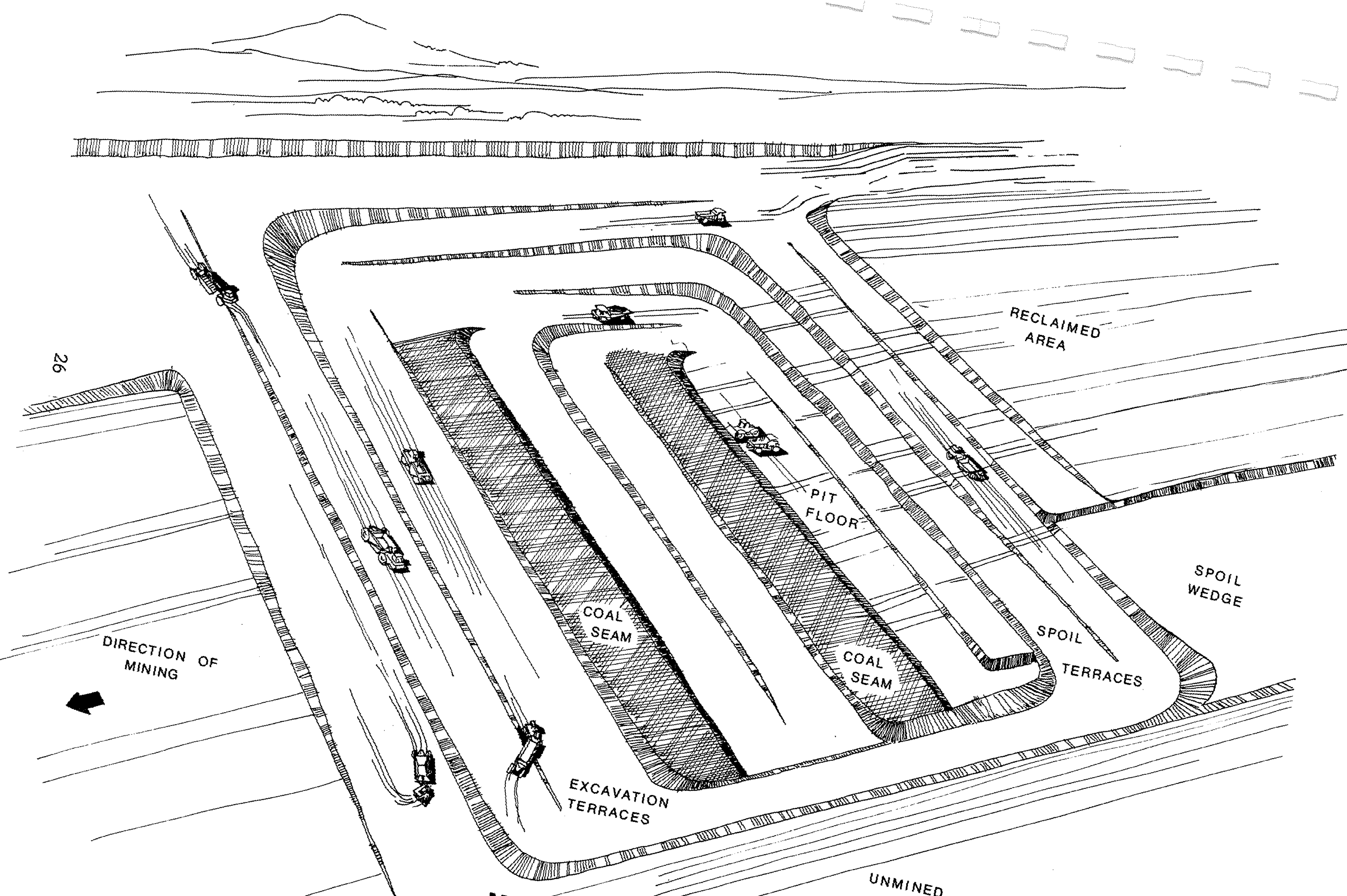
Exhibit II-2 shows a perspective view looking down into a conceptualized terrace pit operation which uses scrapers to expose two coal seams. The direction of mining is toward the left side of the page and the unmined land is that which is closest to the observer. Coal is alternately removed from one or the other of the two seams and a front-end loader can be seen on the pit floor excavating coal to be hauled by the truck waiting at its side. Two other coal haulers are climbing out of the pit in the upper center of the drawing. To the right, a scraper is spoiling on a spoil terrace, and behind him to the far right side of the picture one can see the spoil wedge which is left open temporarily to reduce rehandling costs.

Equipment Requirements

This section of the report discusses the equipment required, the job to be accomplished by each type of equipment and the logic behind selecting a particular type of equipment to accomplish a task. The terrace pit mining system utilizes equipment which is readily available and is in operation in most United State's surface coal mines.

The topsoil and subsoil removal and transport operation utilizes pan scrapers. The topsoil to be handled by the scrapers will tend to be sandy loam or unconsolidated mixtures of sand, gravel and calcareous clays. The scrapers remove the topsoil approximately 150 to 200 feet ahead of the next terrace if no blasting is required. Otherwise, they would work a sufficient distance ahead of the next terrace to allow adequate room for drilling. The material is then transported around the pit and spread on top of the roughly graded spoil on the uppermost terrace.

The loaded capacity of the scrapers and the average time that is needed to complete a round trip help determine the number of scrapers the mine will assign to this operation. The yardage of topsoil and subsoil to be removed per time period is compared to the available production time and production requirements in order to determine the number of scrapers required.



MULTI-SEAM SCRAPER TERRACE PIT MINING SYSTEM

EXHIBIT

A road grader or farm tractor completes the final grading of topsoil in preparation for the cultivation, mulching, fertilizing and seeding of the area. Seeding will most likely be done by a tractor drawn spreader although hydroseeders and aircraft are sometimes employed. The cultivating and seeding equipment is used intermittently when a fairly large area is graded and the season is right for seed germination.

If dozer ripping of the terrace surfaces is not sufficient and the overburden must be blasted, a rotary drill perforates the overburden between the topsoil removal activity and the edge of the terraced highwall to prepare for blasting. One set of conditions may facilitate drilling the entire thickness of overburden from the surface to the coal. If terrace drilling is necessary for multiple seams, it may be more economical to use a smaller drill and drill each terrace individually. The specifications of the drilling equipment such as boom length, bit diameter and electric or diesel power depend upon the thickness and the characteristics of the overburden and whether single lift or step blasting is used. The drill should have the size and power to be able to maintain an overburden penetration rate of two to three feet per minute. The diameter of the drill bit is determined such that the hole spacing is between 20 and 40 feet while maintaining a burden ratio of about 2.5 cubic yards of rock to one pound of oxidizer. This ratio varies somewhat depending on the hardness and structure of the rock that is blasted and the digging ability of overburden removal equipment. In addition to the drill, the blasting operation must be supported by bulk oxidizer storage facilities, trucks and detonating equipment.

Overburden removal and handling equipment can be of many different types. The basic functions are excavation, loading and haulage. Scrapers can be used, both push-pull and self loading types, if the geology permits. They, of course, perform the loading, transport and spoil placement functions under suitable conditions. Loading shovels either electric or diesel, front-end loaders and bucket wheel excavators can all be used in this mining system to excavate and load overburden material that is within the range of their respective capabilities. There are two proto-types of excavators called Easi-Miner and Easi-Grader, manufactured by Huron Manufacturing Corporation, which also could be applied to the terrace pit system. Trucks for hauling overburden need to be off-highway type, rear dump vehicles.

The rock trucks are loaded at the side of the excavator on the terrace and transport the material around the side of the pit and dump it over the terrace spoil bank. The capacity of the trucks and the number of units in the overburden hauling fleet should be adequate to allow the excavators to operate almost continuously. Larger numbers of smaller capacity trucks provides greater flexibility in balancing the number of units assigned to particular terraces where overburden removing capacity is required. The shift production capacity of the excavators divided by the expected production capacity of the individual rock haulers determines the required number of rock trucks in the fleet.

When rock trucks are used to backfill the spoil on terraces, a dozer, track type, steel wheel or rubber tire type is required to grade the terraces to facilitate truck travel. This equipment may also do coal seam cleanup work, road work and cable moving.

Selection of the overburden excavation and hauling equipment should give consideration to the standardization and interchangeability of equipment with the coal loading and handling operation. If it is decided to take advantage of the opportunity of interchangeability, the overburden and coal handling equipment should have similar production and physical characteristics.

The geological and physical characteristics of the various overburden strata may be substantially different from terrace to terrace and different combinations of equipment types may be indicated. For instance, unconsolidated overburden and easily fragmented rock strata, like certain shales, may be most economically excavated and hauled by pan scrapers while other material like sandstone encountered at other elevations might be best excavated by either front-end loaders or loading shovels and transported by trucks. This would especially be the case in multi-seam operations with consolidated interburden.

Shovels reportedly have a greater break out force and higher mechanical availability than front-end loaders. The larger sized front-end loaders are reported to have considerable down-time due to tire problems. On the other hand, they are more versatile and have a greater mobility than track mounted loading shovels. Whether shovels or front-end loaders are selected, the machine must have adequate height and reach to fill the large capacity, off highway type, rock trucks. The bucket must also be large enough to handle the largest sized fragments of overburden that are the planned result from the blasting operation.

Because of their high digging force, coal loading shovels will usually be the choice for coal removal and loading. Sometimes the breakout force of the shovel is not great enough to sustain its potential production capacity and it is necessary to blast the coal prior to loading. In such a case, the mine equipment will include a rotary coal drill and support equipment for blasting. The loading shovel excavates along the coal face in narrow strips, perhaps ten feet wide, rotates and dumps into a coal hauler waiting at its side.

The coal haulers can be either the end dump or bottom dump, off-highway large capacity types. End dump, integral body trucks allow for the greatest flexibility if interchangability with rock trucks is desired. The physical capabilities of the coal haulers must be adequate for the altitude, grades and surfaces conditions in the particular mine. Their number depends on their capacity, their average speed and the distance they have to travel to and from the coal hopper or tipple.

Support equipment for road work, maintenance, material handling, cable moving, compressed air, pumping, light generation, personnel transport and similar functions would depend upon the specific site and the kinds of equipment chosen for the primary operations. Most of this equipment would usually operate intermittently without a regular schedule.

This completes the description of the terrace pit equipment requirements. The following section describing a hypothetical model mine gives more specific information about equipment description, job to be accomplished and requirements.

NARRATIVE DESCRIPTION OF MODEL MINE

Overburden at the model mine consists of 40 to 145 feet of unconsolidated material with some shales found near the coal seam. The coal seam varies between 20 and 35 feet thick. For the mine life of 20 years average overburden thickness is 90 feet and average seam thickness is 25 feet. Permit reserves total approximately 75 million tons of raw coal and the mine is designed to produce 3.7 million tons per year.

The mining operation progresses at the rate of 30 feet per day in the direction of mining. The pit floor is 115 feet from the surface and the dimensions of the pit at the surface are about 600 feet by 1500 feet. The larger dimension is parallel to the direction of pit movement. The terraces are 150 feet wide and they average 35 feet in height. They are sloped along their length toward the sides of the pit at a nine percent grade and intersect level haulage roads on the sides of the pit. Exhibit II-3 illustrates a plan view and cross-section view of the model mine.

The primary elements of the operation are overburden removal, coal removal, coal haulage and land reclamation. Overburden stripping is scheduled 364 days per year, 24 hours per day. The other activities are scheduled less intensely in accordance with the requirement.

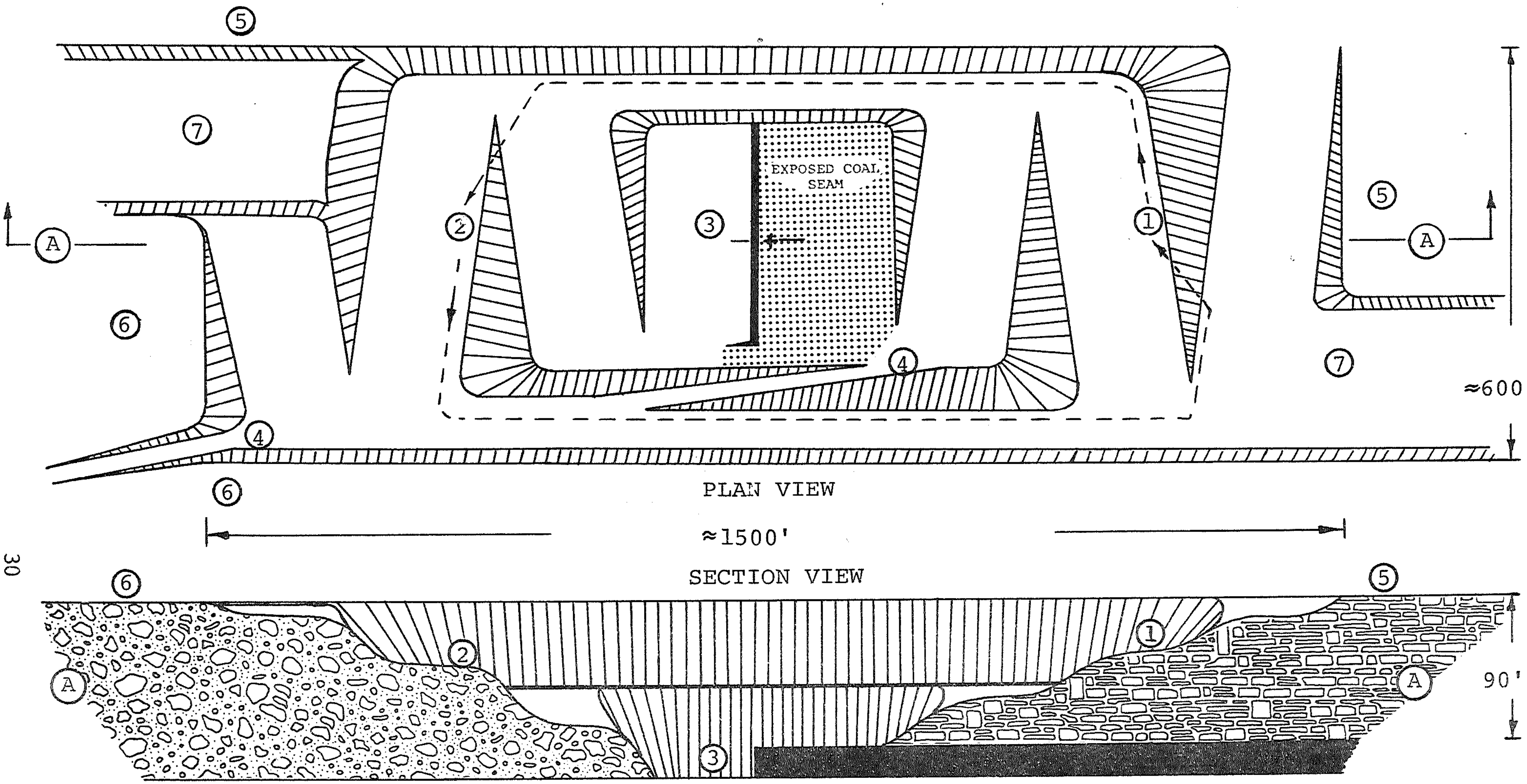
The natural angle of repose for spoil is about 37 degrees to the horizontal plane. The undesturbed material is stable up to 65 degrees. For mine planning, spoil and pit side angles are established at 30 and 60 degrees respectively.

The mine personnel consists of 17 salaried supervisory and office positions and 116 union workers. Twenty-nine percent of the total force is devoted to maintenance.

Overburden Removal

All overburden including topsoil is loaded into scrapers at the leading side of the pit. The scrapers start up a terrace empty and then excavate the face of the terrace operating at a diagonal to its length. This method conserves the dimensions and configurations of the pit and decreases loading and hauling time.

Loading benches or terraces are 150 feet wide to permit equipment passing, turn around, and to minimize congestion in the loading area. Scrapers haul on level roads along the sides of the pit. Haulage roads



KEY

(1)--(2) Second terrace loading point, haul route, and spoiling point (example).
(3) Coal loading point on pit floor.
(4) Coal haulage route.
(5) Undisturbed area.
(6) Mined out/reclaimed area.
(7) Open wedge to minimize rehandle.

EXHIBIT II - 3
PLAN VIEW AND CROSS SECTION VIEW OF TERRACE PIT SCRAPER SYSTEM
MODEL MINE

are advanced continually by the pit movement and their width is kept at three times the maximum vehicle width. This dimension enables two haulage vehicles to pass maintenance equipment such as a road grader without interrupting production.

The type of material being hauled determines the spoil terrace chosen for deposition of the spoil. In this case, the overburden is deposited at the same elevation it was excavated. Topsoil goes to the top of the dump area and lower strata is placed near the pit floor. There is a high degree of flexibility in the selective deposition of spoil with the terrace pit system. Dump terraces are 150 feet wide to aid selective placement and vehicle maneuverability. Scrapers return on in-pit roads to the excavation side of the pit after spoiling.

The scrapers unload while tramming over the edge of the spoil face. This maintains the dimensions and configuration of the pit. Topsoil is left in place on the uppermost terrace and leveled by a dozer or grader.

The design of the scraper terrace pit requires that more overburden be handled than actually covers the coal to be exposed. This rehandle is necessary to open haulage roads and compensate for highwall angles. This extra handling requirement is illustrated in Exhibit II-4. The extra material rehandled is 15 percent of the total overburden handled and increases the virgin strip ratio from 3.3:1 to an effective strip ratio of 3.89:1. Average one-way haul for the model mine is 1,274 feet. Expected annual production for the scraper fleet is 14.3 million bank cubic yards of overburden.

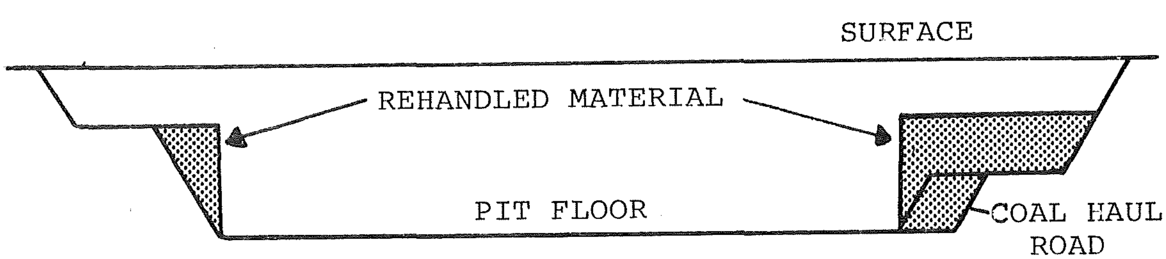


EXHIBIT II-4
CROSS SECTION ILLUSTRATION OF REHANDLED OVERBURDEN

Coal Removal

Approximately one week's supply of coal is exposed in the terrace pit at all times. Coal is drilled and blasted before loading using a nine inch truck mounted auger drill. Drilling and blasting of coal is scheduled one shift per day. The top of the coal is cleaned by a rubbertired dozer. Little effort is required to clean coal since scrapers can excavate overburden evenly very close to the coal seam. Coal is loaded into 120 ton bottom dump trucks by an electric shovel with a 16 cubic yard dipper. The area at the bottom of the terrace pit is composed of a 340 x 190 foot section of exposed coal and a 340 x 150 foot section of pit floor. The 150 feet of open pit floor provides maneuvering room for the loading shovel and auxiliary equipment, and a buffer zone between the coal and the advancing spoil.

Coal Haulage

Coal loaded into the 120 ton haulers moves up inclined haulage roads at the side of the pit. Grades of the coal haul roads are limited to a maximum of nine percent for the scraper model mine. At the surface the trucks haul the coal approximately 3 miles to the crushing and load-out facility.

Coal haulage routes and overburden haulage routes are kept separate in order to eliminate speed differential delays for the different kinds of vehicles working in the mine.

Reclamation

Reclamation is an integral part of the overburden excavation process except for final grading, mulching, adding soil amendments and seeding. The topsoil scraper builds up the surface layer of soil and then it is graded by a road grader prior to final preparation and planting.

The equipment used, its assignment and requirements are summarized in Exhibit II-5 on the following page.

ANALYSES OF THE SYSTEM

This section of the report includes an evaluation of the terrace pit mining system, and covers its engineering feasibility, implementation potential, environmental benefits, and cost benefits.

Engineering Feasibility

In order to increase national coal production in the near future, quickly acquired equipment must be utilized which can economically increase a mine's capacity to remove overburden. Field observations and interviews with industry personnel point out that draglines will continue to be the primary stripping equipment used at western mines. It is not reasonable to assume, however, that draglines will be able to meet our increasing national demand for coal if delivery lead times continue to exceed five years. Mining systems which utilize readily available equipment to increase coal production and meet reclamation requirements will have to fill the gap.

EXHIBIT II-5
SCRAPER TERRACE PIT MINING SYSTEM
EQUIPMENT DESCRIPTION AND OPERATION REQUIREMENTS

ITEM:	NO.	DESCRIPTION	OPERATION ASSIGNMENT	REQUIRED PRODUCTION	PHYSICAL REQUIREMENTS
Powder Truck and Tools	1	Flatbed	Loading Blast Holes		
Scrapers	6	657-B (P-P)	Excavate Overburden	14.3 Million bcy. per year	Push-Pull Type 1274 ft. per load (Average)
Road Graders	2	16-G	Road Maintenance, Clean Coal, Finish Grade Spoil	Not Applicable	10 ft. Blade
Dozers (D-9)	4	W/U-Blade & Ripper	Assist Stripping & Road Maintenance	" "	Support Activity
Coal Loading-Shovel	1	16 cy 195-B	Load Coal	3.7 Million Tons Per Year	25 ft. Lift
Coal Drill	1	9" Auger	Drills Coal for Blasting	2 ft./min.	25 ft. Holes (Avg.)
Coal Haulage Trucks	3	120 Ton Bottom Dump	Haul Coal to Tipple	3.7 Million Tons Per Year	3 Mile Haul
Reseeding Equipment	1	Tractor, Seeder & Accessories	Final Reclamation	100 Acres Per Year	Plant & Fertilize
Road Roller	1	W/Vibration	Road Maintenance	Not Applicable	Support Activity
Water Truck	1	8000 Gallons	" "	" "	" "
End Dump Truck	1	10 Ton	" "	" "	" "
Pumps & Piping	1		Pit Dewatering	" "	" "
Truck Crane	1	110 Ton	Miscellaneous Maintenance	" "	" "
Lowboy Trailer & Tractor	1	50 Ton, Rear Loading	Miscellaneous Maintenance	" "	" "
Fuel & Lube Truck	1		Fuel & Lube Equipment	" "	" "
Portable Compressor & Light Plant	1	30 KW	Miscellaneous Maintenance	" "	" "
Portable Tools & Field Equip.	1		Miscellaneous Maintenance	" "	" "
Automotive Equipment	10	3/4 Ton Pickup Trucks	Miscellaneous	" "	" "
Rubber-Tired Dozer	1	834	Road Maintenance & Clean Coal	" "	" "
Radio Equipment	1	2-Way Automotive	Miscellaneous	" "	" "
Crushing & Loading Facility	1	Train Loading	Crush & Load Coal to Cars	3.7 Million Tons Per Year	" "
Forklift	1	8000 Pounds	Miscellaneous Maintenance	Not Applicable	" "

The terrace pit mining system uses scrapers, trucks, wheel loaders, dozers, road graders, drills, and loading shovels. Interviews with loading equipment manufacturers revealed that all of the above equipment types, with the exception of loading shovels, can be delivered to a mining site within one year after their order date. Loading shovels take one to two years for delivery.

The terrace pit mine is designed to recover single or multiple seams with only minor adjustments to the system. Parting material and the additional seams to be removed would appear as additional terrace operations deeper in the pit. Multiple seams do, however, imply pit enlargement with longer haul routes and more terraces to provide enough working room for the equipment in the pit. Parting or interburden material, generally harder and more consolidated, would probably utilize wheel loaders or loading shovels and haulage trucks because of this equipment's increased digging force.

The terrace pit system is applicable to gently rolling or flat terrain as well as irregular topography. The flexibility of the terrace system can be advantageous in situations such as sloping seams and surfaces, pitching seams and irregularly shaped permit areas.

In most parts of the country, there is a potential for weather related production delays in the operations of the mobile equipment.

The terrace pit system is somewhat limited physically and economically in that it cannot operate at high production levels and high strip ratios simultaneously. Generally, this is due to the following characteristics.

- As coal seams become thinner and a certain amount of exposed coal is required, pits must become larger and overburden handling costs have to increase to maintain the same production level.

- As overburden becomes thicker, more terraces and longer haul roads increase unit handling costs.

- High production levels with large numbers of equipment units causes traffic congestion in the pit.

Implementation Analysis

The terrace pit mining system requires pre-mine planning as does any other new mining installation. Coal reserve studies, production requirements and geological studies help define the mine characteristics, equipment requirements, and operation feasibility. However, the time between design start and actual production is comparatively less for a terrace system. This is due to:

- Market availability of mobile equipment
- Minimal debugging of system
- Minimal productivity loss in box cut

Mobile equipment can be obtained much easier than larger stripping equipment such as draglines, shovels, or bucket-wheel excavators. Generally, this is due to the large amount of design and fabrication time which large stripping machines require. Mobile equipment systems have the advantage of having the choice of many models and manufacturers from which to assemble a fleet of equipment.

Implementation of a terrace pit system could be accomplished without the major productivity losses and high expense frequently experienced in dragline and shovel mining systems. A wide range of equipment applications enables a high degree of flexibility which should simplify the operation.

Environmental Benefit Analysis

Terrace pit mining systems have the theoretical ability to reconstruct any stratification of spoil which is possible with material existing in the overburden. For example, toxic material can be easily buried without additional rehandle costs often required to bury pollutant material in other mining systems.

As a result of the flexible terrace system design, the spoil area can be restored to any desired contour without material rehandling. Controlled contour has the advantage of minimizing slides, siltation, and erosion. Rocks occurring in the spoil can be buried or broken up by equipment travel so that rock outcropping in the topsoil cover does not occur in reclaimed areas.

A comparison of the active area occupied by the terrace pit model mine to a sample western dragline operation reveals a 38 percent decrease in disturbed acreage (47.3 acres for terrace pit and wedge, versus 76.1 acres for 1-mile dragline pit). A minimum of disturbed area is necessary to minimize overburden handling distances.

Cost Benefit Analysis of Model Mine

One of the advantages of the scraper terrace pit, similar to that encountered in the model mine, is the financial characteristics of the system. Briefly, these include:

- Low initial capital requirement
- Low present worth value over total mine life
- Economic and practical flexibility in mine life

Mining has traditionally been a capital intensive industry. Strip mines utilizing large draglines or stripping shovels may require a 20 to 40 million dollar initial investment to start operations. A substantial portion of capital is required for large stripping equipment design/fabrication and initial non-productive mine operation before the mining systems start any return on investment.

The scraper terrace pit system could reduce the initial capital requirements while minimizing the time lag between investment and production. As a basis for comparison, the terrace pit model mine's initial capital requirement is $2.82 per annual ton. An estimated western dragline operation's initial capital requirement under similar operating conditions, is approximately $6.20 per annual ton.*

Present value analysis shows that the model scraper terrace pit system has a lower present worth lifetime capital requirement than a comparable dragline system. Deferred investment and replacement of stripping equipment, and low initial capital requirements make this possible. Exhibits II-6 to II-10 give the depreciation schedule, capital summary, estimated annual production cost, minimum sales price calculation and a production and operating cost summary for the hypothetical model mine.

In order to compare the terrace pit system to other mining systems a strip ratio sensitivity analysis was performed. The results of the analysis are shown in Exhibit II-11. The graph was developed by holding all costs constant except those associated with coal loading and hauling and varying these according to the amount of coal corresponding to the stripping ratio.

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*Referenced to the Peripheral Mining System described in Section III of this report, but excluding the costs of mine development.

EXHIBIT II-6
SCRAPER TERRACE PIT MINING SYSTEM
DEPRECIATION SCHEDULE

ITEM:	NUMBER	COST	LIFE	ANNUAL DEPRECIATION
Power Truck & Blasting Tools	1	10,000	10	1,000
657-B (P-P) Scrapers	6	1,800,000	2	900,000
Road Grader Cat-16	2	200,000	5	40,000
Coal Loading Shovel 195-B	1	1,045,000	20	52,000
Coal Drill Complete	1	50,000	10	5,000
120 Ton Bottom Dump Trucks	3	900,000	6	150,000
Reseeding Equipment	1	150,000	10	15,000
D-9 Dozer W/U-Ripper	4	792,000	4	198,000
Road Roller W/Vibration	1	10,000	10	1,000
Water Truck 8000-Gallon	1	120,000	6	20,000
End Dump Truck 10-Ton	1	18,000	5	3,000
Repair Shop, Garage & Tools	1	150,000	20	8,000
Pole Lines	1 Lot	72,000	20	4,000
Substation, 5000 KVA	1 Lot	90,000	20	5,000
Circuit Breaker	1	18,000	20	1,000
Pumps & Piping	1 Lot	85,000	6	14,000
Heavy Duty Truck Crane 110T	1	165,000	20	8,000
Lowboy Trailer & Tractor	1	120,000	10	12,000
Fuel & Lube Truck	1	31,000	6	5,000
Portable Compressor & Light Plant	1	70,000	10	7,000
Portable Tools & Field Equipment	1	130,000	8	16,000
Automotive Equipment	1 Lot	50,000	4	13,000
Rubber-Tired Dozer 834	1	150,000	4	38,000
Two-Way Radio Equipment	1 Lot	15,000	10	1,000
Forklift	1	19,000	10	2,000
Engineering, Design, Legal Purchases	1	50,000	20	3,000
Exploration Cost	1	75,000	20	4,000
Crushing & Loading Facility	1	4,000,000	20	200,000
TOTALS		$10,385,000	. . . .	$1,726,500

EXHIBIT II-7
SCRAPER TERRACE PIT MINING SYSTEM
CAPITAL SUMMARY

YEAR	CAPITAL INVESTMENT	PRESENT WORTH FACTOR @ 20%	PRESENT WORTH INVESTMENT @ 20%
0	$10,385,000	1.0000	$10,385,000
1	-0-	.8333	-0-
2	1,800,000	.6944	1,249,920
3	-0-	.5787	-0-
4	2,792,000	.4823	1,346,582
5	218,000	.4019	87,614
6	2,936,000	.3349	983,266
7	-0-	.2791	-0-
8	2,922,000	.2326	679,657
9	-0-	.1938	-0-
10	2,462,000	.1615	397,613
11	-0-	.1346	-0-
12	3,928,000	.1122	440,722
13	-0-	.0935	-0-
14	1,800,000	.0779	140,220
15	218,000	.0649	14,148
16	2,922,000	.0541	158,080
17	-0-	.0451	-0-
18	2,936,000	.0376	110,394
19	-0-	.0313	-0-
20	[806,084]	.0261	[21,039]
TOTAL			$15,972,177

EXHIBIT II-8
SCRAPER TERRACE PIT MINING SYSTEM
ESTIMATED ANNUAL PRODUCTION COST

Labor Cost:	
Direct	$ 2,181,600
Supervision	358,500
Total Labor Cost	$ 2,540,100
Supply Cost:	
Fuel, Power, Lubricants, Parts, Supplies & Repair	$ 4,775,232
Explosives	91,958
Total Supply Cost	$ 4,867,190
Auxiliary Cost:	
Contract Services	$ -0-
Communications	3,000
Welfare & Benefit Package	1,090,800
Health & Safety - $.03/ton	110,350
Royalty - 10% Sales	1,311,790
License and Fees	1,103,500
Total Auxiliary Cost	$ 3,619,440
Indirect Cost:	
15% of Labor, Supervision and Operating Supplies	$ 1,111,094
Fixed Cost:	
Insurance and Taxes	$ 207,700
Depreciation	1,726,500
TOTAL PRODUCTION COST	$14,072,024

EXHIBIT II-9
SCRAPER TERRACE PIT MINING SYSTEM
MINIMUM SALES PRICE COMPUTATION

Sales = Cost of Production plus Depletion* plus 2 Times Net Profit
Depletion plus Net Profit = Present Value of Capital Due Less Depreciation

Also,

Sales = Cost of Production plus 2 Times (present value due, minus depreciation) Minus Depletion

Present Value of Capital Requirements Due in 20 Years @ 20% Compound Interest	
$15,972,177 X .205356	= $ 3,279,982
Less: Annual Depreciation	- 1,726,500
Depletion plus Net Profit	= $ 1,553,482
Sales = $14,072,024 plus 4/3 (1,553,482)	= $16,143,333
Gross Profit = Sales minus Cost of Production	
= 16,143,333 minus 14,072,024	= $ 2,071,309
Less Depletion Allowance	- 1,035,655
Taxable Income	= $ 1,035,654
Less Federal Income Tax at 50%	- 517,827
Net Profit	= $ 517,827
Annual Cash Flow = Net Profit plus Depreciation plus Depletion	= $ 3,279,982
Selling Price Per Ton = Sales divided by Production (16,143,333 divided by 3,678,332)	= $4.39

*10% of Sales not to exceed 50% of Gross Profit

EXHIBIT II-10
SCRAPER TERRACE PIT MINING SYSTEM
PRODUCTION AND OPERATING COST SUMMARY
(DEPRECIATION, LABOR AND SUPPLIES)

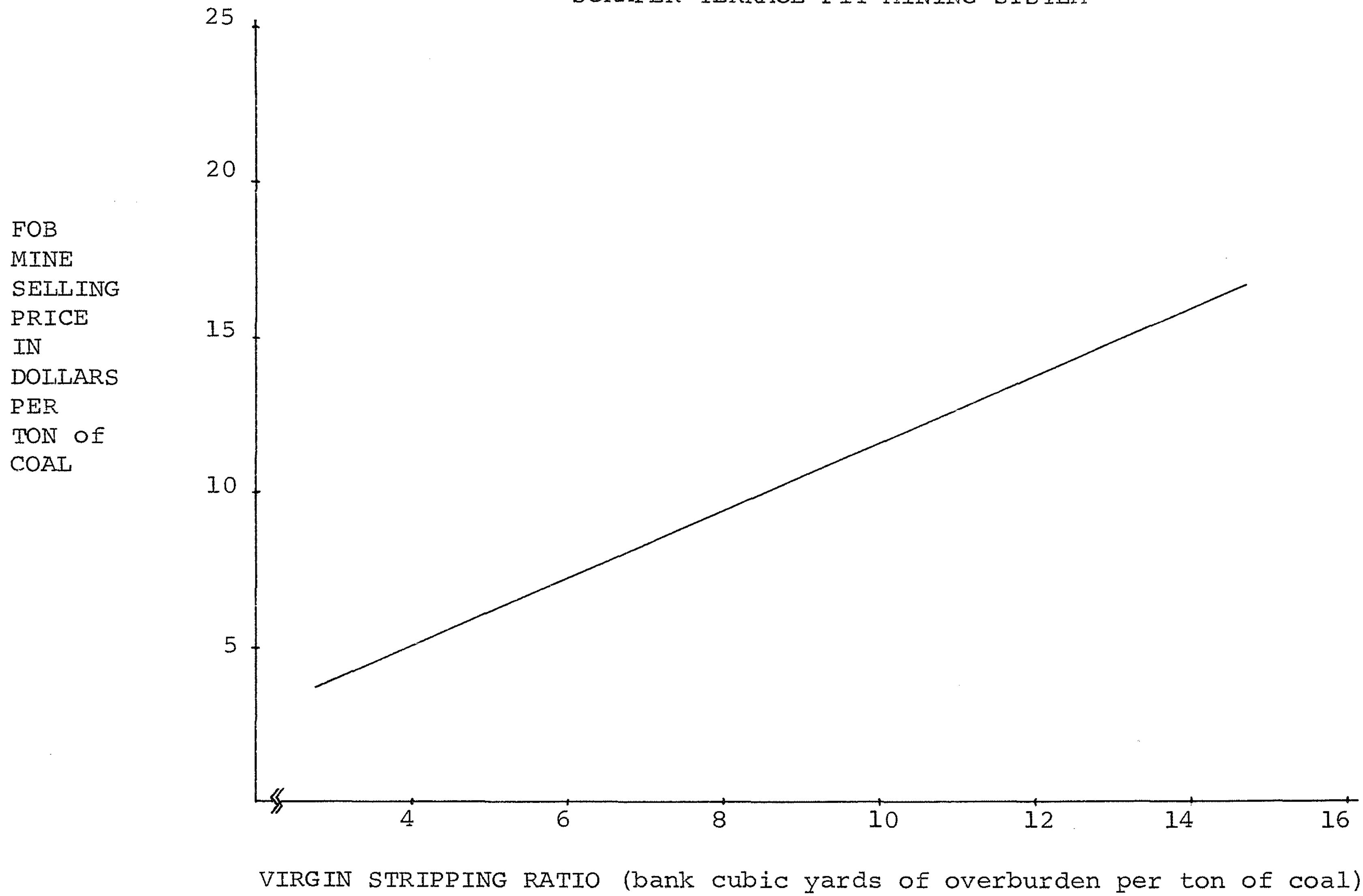
ELEMENT *	UNITS	ANNUAL PRODUCTION	FIXED COST	VARIABLE COST	TOTAL COST	COST PER UNIT OF PRODUCTION	COST PER TON OF RAW COAL
Overburden Removal	Cubic Yards	14,318,643	1,068,500	4,277,696	5,346,196	.373	1.453
Coal Removal	Tons	3,678,332	58,000	519,118	577,118	.157	.157
Coal Haulage	Ton-Miles	11,034,996	150,000	860,200	1,010,200	.092	.275
Reclamation	Acres	100	15,000	27,948	42,948	4,295	.012
Mine Administration & Production Support	---	---	435,000	1,722,328	2,157,328	---	.588
TOTAL	---	---	$1,726,500	$7,407,290	$9,133,790	--	$ 2.48

* Minor amount of ground preparation included in overburden removal.

EXHIBIT II-11

SENSITIVITY ANALYSIS OF MINE PRICE TO STRIPPING RATIO

SCRAPER TERRACE PIT MINING SYSTEM



INTRODUCTION AND SUMMARY

Area haulback mining was devised as a means to increase existing dragline productivity by reducing rehandle work and decreasing the machine's cycle time. It also allows a dragline mine to selectively place excavated overburden in the spoil pile to appreciably improve reclamation practices.

Compared to a traditional dragline mine, the pit is shorter and wider. Ground preparation is the same except for the haulage of topsoil around the ends of the pit and its deposition on the spoil pile by mobile equipment. Drilling and blasting occurs close to the overburden excavation activities and requires closer control.

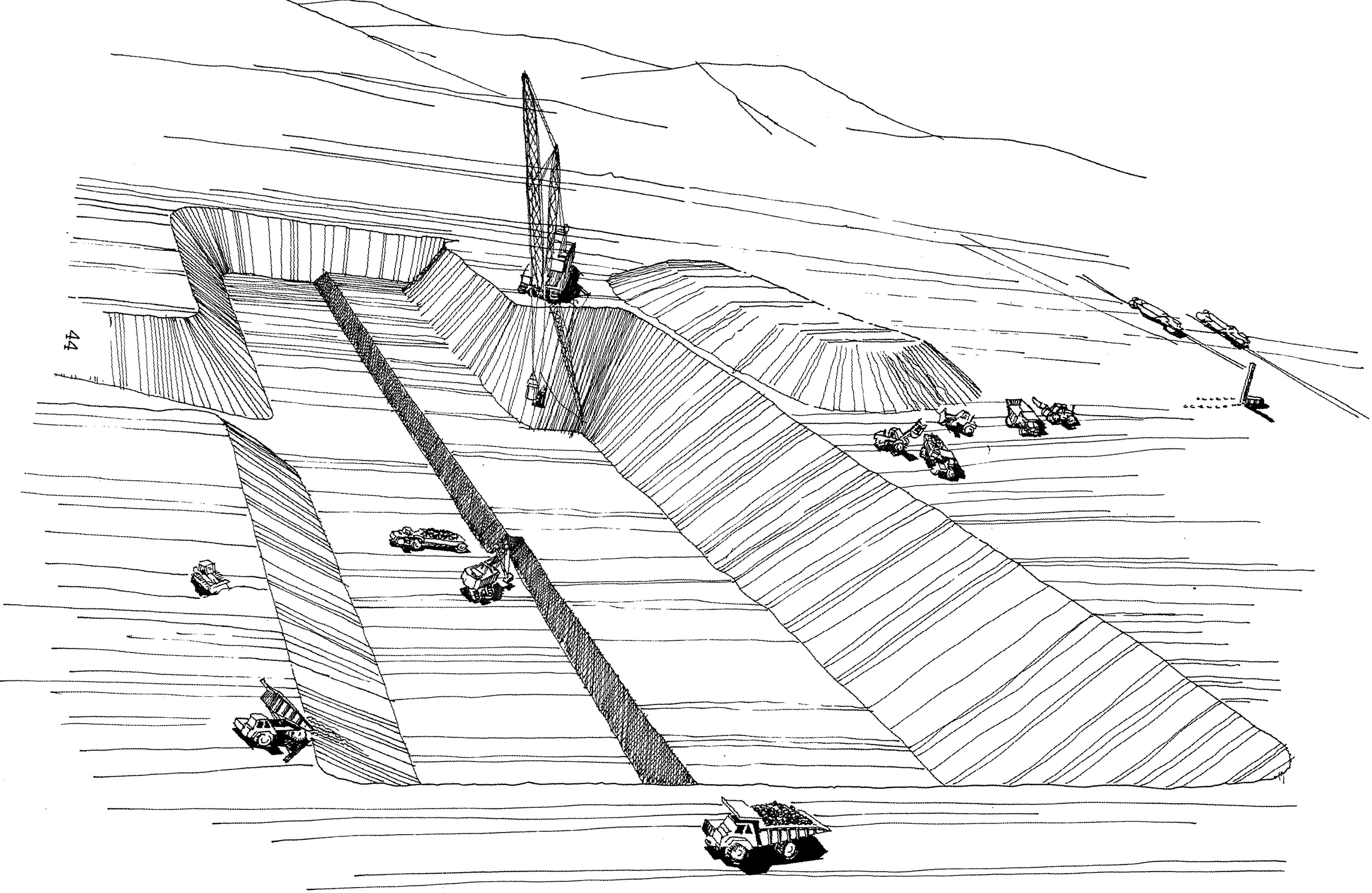
The dragline digs in a conventional manner but spoil on the highwall instead of into the mined out pit. It moves in a straight line without zig-zagging along the highwall bench. The width of the cut face is relatively narrow to control the height and size of the spoil piled on the highwall. Keyway cutting is very much reduced and so is scaling of the highwall face.

Mobile equipment loads and hauls the spoil from the highwall bench around either end of the pit to the final location. The spoil pile is kept level without ridges and topsoil is replaced to its original position without being mixed with the rocky foundation materials.

Coal removal and haulage is sequenced with overburden excavation and spoiling to maintain safe distances. The coal trucks enter and exit from the pit on a single road through the spoil.

The equipment requirements are essentially the same as those required for the traditional area mining operation, except for the mobile equipment which reloads and hauls the spoil around the pit. Scrapers may be used for ground preparation and haulage to the land reclamation area. Farm type equipment completes the surface reclamation requirements. Vertical rotary drills provide the blast holes in the overburden. A walking dragline of medium size completes the overburden excavation. Shovels or front-end loaders and trucks may be used for reloading and hauling the spoil at the surface elevation. A wheel-type dozer maintains a level, suitable surface on the spoil dump area for the overburden haulage vehicles. Coal blasting, loading and haulage equipment and support equipment for the primary activities is typical of that used in other dragline mining systems.

The estimated total cost of operation for a hypothetical mine with a stripping ratio of five to one is 14 percent higher than it would be if the haulback technique were not used. It is anticipated that industry acceptance of the area haulback mining system will be slow because of increased production cost. However, as the recovery of coal from deeper seams is required or as environmental pressures increase, area haulback mining may become very competive with traditional side-cast dragline operations with add-on reclamation. Exhibit III-1 shows a perspective sketch of the Area Haulback Mining System.



AREA HAULBACK MINING SYSTEM

EXHIBIT III-

DESCRIPTION OF THE MINING SYSTEM

The area haulback mining is a modification to the traditional area mining technique utilized throughout the midwestern and western coal fields. Because of the similarities between traditional area mining and area haulback, the new system may be used in any location where geologic and stratigraphic conditions permit area mining. The area haulback system requires extensive rehandling of overburden, therefore, the system is more economically suited to those deposits in the western coal fields with lower stripping ratios characterized by thick overburden and thick coal seams. A detailed description of the operating methodology, equipment requirements and description of a hypothetical mine using the area haulback mining system is included in this section of the report.

Operating Methodology

In the area haulback mining system, overburden excavation consists of three primary steps:

- Ground preparation
- Drilling and blasting overburden
- Overburden excavation, reloading and hauling

These will be discussed below in detail.

The ground preparation activity involves the removal of topsoil and subsoil from the virgin land. In general, the depth of the material to be removed by ground preparation ranges from 18 inches to over 20 feet, however, in certain areas of the country where topsoil thickness is insufficient to substain vegetation growth, it may be necessary to borrow or transport topsoil material from off-site locations.

Where soil conditions permit, the ground preparation operation is conducted with pan scrapers. The scrapers are used to scalp the topsoil and rooted material in advance of the other overburden removal operations. After removing the topsoil, the scrapers travel around the pit, deposit the material behind the rock spoiling operation and return to the highwall side of the pit for another load. The area haulback system eliminates spoil ridges, traditionally found in area mining. This system allows the scrapers to deposit topsoil in its final location, thus reducing greatly the need for stockpiling or rehandling of topsoil.

Overburden drilling and blasting in the area haulback mining method is greatly complicated by the system's utilization of a short pit. Close control of the drilling and blasting operation must be maintained to prevent production interferences or safety hazards from developing between the drilling and blasting operation and the other overburden removal operations. In order to achieve these objectives and allow sufficient operating room, the drilling and blasting operation takes place a minimum of two bench widths from the highwall. Careful planning of the drilling operation is necessary to make it possible to shoot into previously blasted overburden material. Shooting into unblasted or consolidated material requires closer spacing of holes and more oxidizers to obtain the same breakage and is thus less efficient. Exhibit III-2 shows a progression of blasting sequences which will minimize interferences with other overburden removal operations and obtain good oxidizer efficiency.

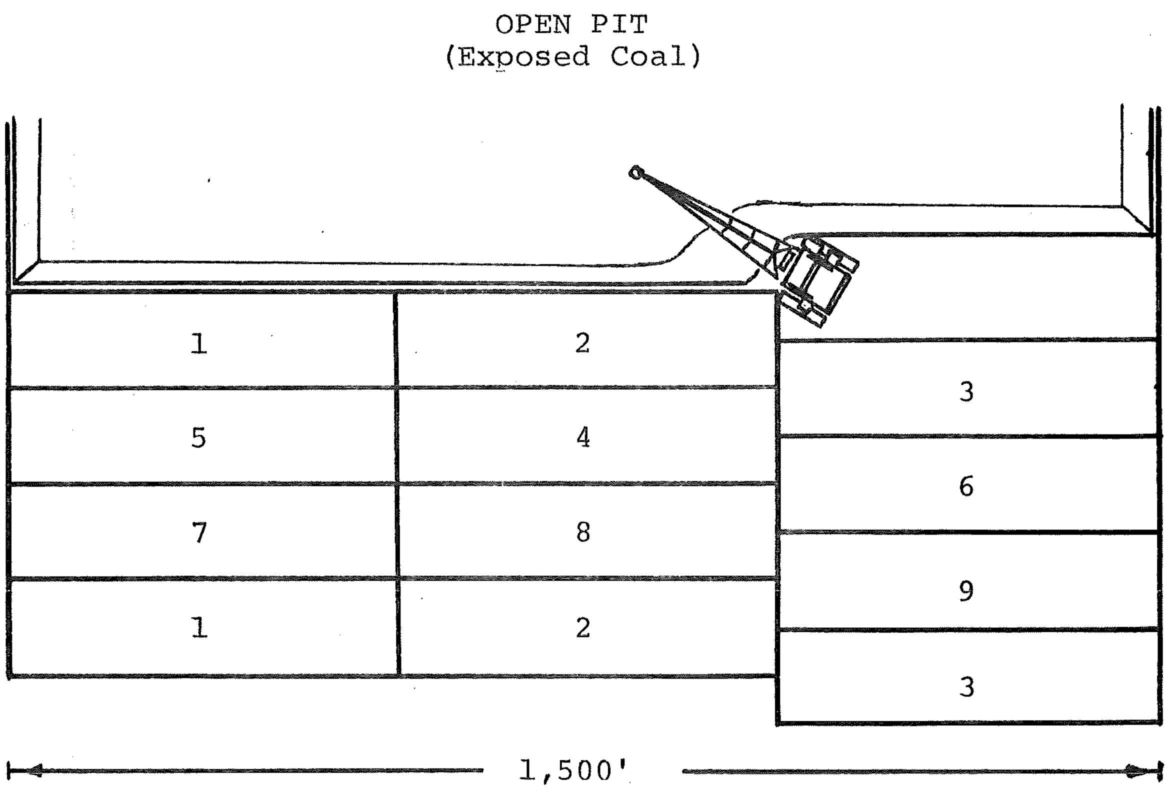
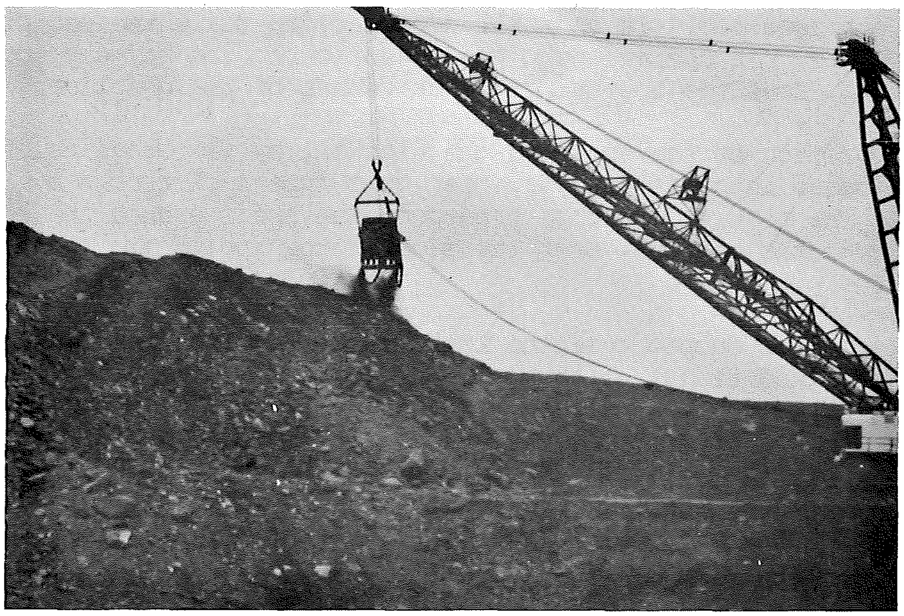


EXHIBIT III-2
AREA HAULBACK BLASTING SEQUENCE

The overburden drilling operation is conducted with vertical drills working on top of the consolidated overburden which was previously uncovered by the ground preparation operation. The actual hole spacing and charge per hole will vary depending upon overburden thickness and hardness. Under normal conditions, hole spacing should be established which will obtain a burden ratio of 2.5 cubic yards of rock per pound of oxidizer. It may be necessary to reduce the burden ratio in the area haulback mining system to insure that breakage is sufficient to facilitate reloading of material with the front-end loaders.

The area haulback system utilizes a dragline as the primary piece of overburden excavating equipment. The dragline is positioned on top of the highwall, excavating the material from a cut face which is at a 45 degree to 90 degree angle to the main highwall. Excavation takes place in the conventional manner, by dragging the bucket across the cut face until it is full and then hoisting the bucket to the height of the highwall spoil pile while the boom is being rotated into the dumping position. Once the bucket is positioned, the material is slewed or cast on top of the pile in order to obtain a relatively flat surface, the boom is then repositioned to begin another excavation cycle. The dragline continues excavating from the cut face and depositing material on the highwall until it approaches the other end of the pit. When the dragline comes within spoiling range of the end of the pit, the excavated material is deposited on the end-pit highwall. End of pit spoiling is necessary to allow the reloading operation sufficient time to remove the highwall spoil pile in order that the dragline can immediately cut a new bench and begin excavating in the opposite direction. This practice eliminates deadheading, thus increasing the productive time of the dragline.



DRAGLINE SPOILING ON THE HIGHWALL

Two additional aspects of the draglines operation are unique to the area haulback mining system. First, the need for tramming the dragline back and forth in a zig-zag fashion across the work bench is eliminated because it is not necessary to spoil across the pit. Second, the dragline power cable is run along the top of the highwall in the direction of excavation advance; that is, the dragline continually reels in the cable as it advances. This is necessary to prevent the cable from interfering with the highwall spoiling and reloading operation.

Several factors are involved in determining the width of the cut face. The desire to maximize the digging time of the dragline by reducing tram time encourages wide excavating benches or cut faces. However, as the width of the cut face increases, the amount of material spoiled on the highwall for each individual pass increases. Because of height limitations on the highwall spoil pile, it is necessary to increase the width of the pile to accomodate additional material.

As the spoil pile becomes wider, the swing time and spoiling time for the dragline is increased. In addition a wider spoil pile creates a potential interference with the drilling and blasting operation and the overburden reloading and haulage operation. The maximum width of the spoil pile would be equal to the maximum spoiling radius of the dragline. In summary, the optimum cut face width for a particular site is a balance between overburden thickness, efficient operation of the dragline and minimal interference with other highwall operations.

The area haulback system reduces the need for keyway cutting performed by the dragline in traditional area mining operations. The width of the floor of the pit and the distance between the highwall and the coal loading operation sufficiently reduces the hazards of falling objects entering the in-pit working areas so that key-way cutting and highwall scaling are not required. It is still necessary to scale the end-pit highwall for safe, pit operations. The reduction in the key-way cutting requirement increases the operating effectiveness of the dragline.

Following deposition of the spoil on the highwall by the dragline, the material is loaded into off-highway, rear dump type rock trucks by front-end loaders. The rock trucks then transport the spoil around the end of the pit and dump the material over the side of the spoil into the mined out area of the pit.

Once the material is dumped over the bank of the spoil area, it is in its final position. Additional earth moving involved in reclamation of spoil is limited to rough grading with dozers and replacement of topsoil, as previously discussed in ground preparation. The rough grading of rock spoil is necessary to facilitate rock truck access to the spoil bank. After the topsoil has been replaced by the scrapers, it is finish graded by road graders and seeded. The final grading and seeding is kept a sufficient distance from the spoil bank to prevent interferences with the rock spoiling operation.

The area haulback mining system utilizes conventional coal removal and haulage equipment. A coal loading shovel or front-end loader is used to remove coal from the seam and load it into the coal haulers. Coal is hauled from the pit via a single, two lane haulage road, exiting from the center of the pit through the spoil area.

Sequencing of the coal removal and overburden excavating and spoiling operation is critical to the safe and efficient operation of the area haulback mining system. The coal removal operation must be kept a sufficient distance from the highwall (approximately 200 feet) to prevent rocks falling from the highwall and entering the working area. Also the coal removal operation must advance fast enough to provide sufficient room for the coal haulers to turn around and maneuver between the coal removal operation and the toe of the spoil bank. Additional care must be taken that the coal removal, dragline excavation and rock dumping operations are staggered throughout the pit to further reduce the possibility of falling rocks from entering the coal removal working area.

Pit Design

The configuration of the area haulback pit is determined by balancing the desire for efficiency in all elements of the mining operation, the interface between elements of the mining operation and the need for safety.

In order to provide sufficient working room such that overburden drilling and blasting can be accomplished without interfering with the dragline and overburden reloading operations, and to maintain a safe distance between blasting and other highwall operations, a minimum pit length of 1,500 feet is required. Longer pits increase the efficiency of the dragline operation by reducing the proportion of time the machine spends on end highwall scaling, beginning new benches, and positioning to begin a new cut. But the longer the pit the further the rock trucks will have to travel. This increases their cycle time, requires more trucks to move the material and increases the cost of the overburden transportation operation. Considering these trade offs, we recommend a pit length of 1500 feet.

Pit width is again a trade off between the desire for a minimum haulage distance for the rock trucks and the requirements for in-pit maneuvering room and safety. In order to maintain a safe distance between the highwall and the coal loading operation, the pit is designed with 200 feet between the toe of the highwall and the edge of the coal. To provide adequate turning and maneuvering room for the coal haulers and to maintain a safe distance between the spoil bank and the coal loading operation, we recommend a distance of 100 feet from the edge of the coal to the toe of the spoil bank.

As a result of those considerations, we have designed the area haulback pit to be 1500 feet long by 300 feet wide at the base.

The area haulback pit design calls for a single, two lane, access road wide enough for two-way traffic and road maintenance activities. It enters from the spoil side at approximately the pit center. The short length of the pit makes it possible to service the coal haulage operation with a single road, the maximum in-pit haulage distance being 750 feet. The center line location of the pit entrance road is necessary to facilitate rock truck access to the spoil area from either end of the pit.

Equipment Requirements

This section of the report discusses the equipment required, the job to be accomplished by each type of equipment, and the logic behind selecting a particular type of equipment to accomplish a task. The area haulback mining system utilizes equipment which is currently available and is in operation in surface coal mines throughout the United States.

Pan Scrapers are used to remove the topsoil and subsoil in the ground preparation operation. The material to be handled by the scrapers is primarily unconsolidated topsoil and clays; or in some locations, an unconsolidated mixture of sand, gravel, calcareous clays and caliche. The scrapers scalp topsoil material approximately 800 feet in advance of the pit, transport it around the pit, and spread the material on top of the rough graded rock spoil approximately 200 feet behind the spoil bank. The scrapers should be of sufficient size and horsepower to enable self-loading of the unconsolidated material or to require a minimum of assistance from push dozers.

The number of scrapers required is a function of the pay load per trip and the average cycle time. The individual scraper's capacity and cycle time is compared to the available production time and production requirements to obtain the number of scrapers necessary to keep the ground preparation operation ahead of the advancing pit.

Final grading and dressing of the topsoil in preparation for seeding is accomplished through the part-time utilization of a road grader. A tractor drawn seeder, hydro-seeder, or aircraft is used to spread seeds over the reclaimed area. Utilization of the seeding equipment is sporadic or seasonal only being required when a large area is ready for revegetation or in the fall of the year.

The area haulback mining system utilizes rotary drills to drill the highwall in preparation for blasting. The physical size of the drill (boom length, bit diameter, etc.) and whether electric or diesel powered depends upon the thickness and characteristics of the overburden. The drill should be of sufficient size and horsepower to maintain an overburden penetration speed in the range of 2.5 feet per minute. The diameter of the drill bit should be determined such that a 20 to 40 foot hole spacing is possible while maintaining a burden ratio of approximately 2.5 cubic yards of rock to 1 pound of oxidizer. The blasting operation will require the traditional equipment of bulk oxidizer storage facilities, oxidizer transportation truck, powder truck, and detonating equipment.

The primary piece of overburden removal equipment and the key to obtaining the production requirements of the area haulback mining system is the walking dragline. The dragline will be used to excavate the previously blasted, consolidated overburden and deposit it on the highwall spoil pile. The bucket size and boom length of the dragline will be determined by the coal production requirements, stripping ratio, and overburden characteristics specific to each individual mine. The annual yardage requirement for the dragline is determined by multiplying the desired coal production by the raw coal stripping ratio. This information is then compared with digging cycle time and anticipated annual digging hours to obtain the required bucket size. The dragline boom must be of sufficient length, such that it is possible to reach the toe of the highwall with the bucket when digging in the deepest overburden. Another consideration in determining the boom length is the required spoiling radius. The boom should be long enough to allow the dragline to spoil all excavated rock on the highwall without rehandling material.

The overburden reloading and transportation operation utilizes loading shovels or front-end loaders and off-road type rock haulers.

Either a rigid bucket loading shovel or a large capacity front-end loader may be used to load spoiled material, previously deposited upon the highwall by the dragline, into rock trucks for transportation around pit. The capacity of the overburden reloading equipment should be sufficient to keep up with the dragline excavation so that the highwall spoil pile does not expand.

The applicability of front-end loaders or shovels to the overburden reloading operation vary according to the characteristics of the equipment and its match to the material which must be handled. The loading shovels have a greater digging force and better mechanical availability than the front-end loaders. Front-end loaders on the other hand are more mobile and versatile than loading shovels. Because of the unconsolidated nature of the highwall spoil pile (the material having already been broken up by the dragline) and their greater mobility, we favor front-end loaders for the overburden reloading task.

The primary physical requirement of the overburden reloading equipment is that the machine can reach high enough to deposit material in the rock trucks. Also, the equipment must have a bucket large enough to handle the overburden deposited on the highwall. Large capacity, off highway type, rear dump trucks are used to transport the overburden material around the pit. The rock trucks will be loaded with material at the highwall spoil pile, transport it around the end of the pit and dump the material over the spoil bank.

The capacity of individual units in the overburden hauling fleet and the number of units must be adequate to keep up with the dragline excavation. The required number of rock trucks in the fleet is determined by dividing the per shift production of the dragline by the anticipated production of the individual rock haulers.

One advantage of the area haulback mining system is that the overburden loading, transportation, and dumping operation are all conducted at the same elevation. Because of this advantage, the rock trucks can be built to achieve higher haulage speed without major concern with gradability.

The only additional equipment required in the overburden transportation are dozers used to push material over the spoil bank and to maintain the spoil area to facilitate rock truck travel. These dozers may also be used for mine support activities such as road building, pit maintenance, cable moving, etc.

Area haulback coal removal and loading requires conventional coal haulage trucks and a loading shovel or front-end loader. Because of the high digging force required to remove coal, we prefer a shovel for this operation. In some cases the break-out force of the shovel may not be great enough to maintain a sufficient level of coal production in which case it may be necessary to blast the coal prior to loading. If the specific site requires coal blasting, the mine equipment would include a coal drill and support blasting equipment.

The loading shovel excavates coal from the face, rotates, and dumps the material into the waiting coal hauler. Large, off-highway type, bottom dump haulers are used to transport the coal from the pit to the tipple. Again the coal haulage operation is similar to other surface mining operations. The physical capabilities of the coal haulers must match the conditions present at the particular mine, considering such items as grade requirements, altitude, road conditions, etc.

In addition to the primary equipment discussed above, the mine would have the usual compliment of equipment and vehicles to be used in support activities. The support equipment would include dozers for roadwork, water trucks, cranes for maintenance material handling, cable hauler, fuel and lube truck, air compressor, automotive equipment, etc. The support equipment would be used on an "as required" basis. The support equipment would be a make and model normally produced by major equipment manufacturers.

This system can be applied to two or more seams by expanding the pit in both dimensions and using conventional, cross-pit casting techniques for mining the underlying seams. Overburden haulage costs would be higher but would be partially offset by the more efficient use of the dragline or shovel which excavates interburden. In many cases, ramping the highwalls to allow truck traffic across the pit instead of around it would be more economical or would be necessary for burying toxic material.

In cases of multiple seams where the overburden is shallow, shovels can sometimes be used to both excavate overburden and load the trucks to expose the upper seams while cross-pit casting can be utilized on one of the lower seams. The principle of building a backfill with trucks is the same.

This completes the description of the area haulback systems' equipment requirements. For more specific information on equipment description, job to be accomplished and requirements, see the description of model mine section immediately following.

NARRATIVE DESCRIPTION OF MODEL MINE

The model mine is located in the northwestern coal field at an elevation of 3,000 feet. The topography is rolling hills and washes with occasional outcroppings of sandstone. Topsoil varies from zero to six feet. The major portion of overburden consists of interbedded sandstone and shale overlying 10 to 20 feet of gray shale. The average total overburden thickness is 110 feet and covers a 20 foot thick seam of coal. The strata dips less than one degree to the south. Total precipitation is about 15 inches per year.

The mining operation progresses eastward or westward at a little over ten feet per day or about a kilometer per year. The pit has a "T" shaped appearance because of the single coal haulage road from the center of the pit.

The primary elements of the operation are ground preparation, overburden removal, overburden haulage, coal removal, coal haulage and land reclamation. Overburden stripping is scheduled 364 day per year, 24 hours per day. The other activities are scheduled less intensively in accordance with the requirement.

The mine personnel consists of 16 salaried supervisory and office positions and 146 union workers. Twenty-six percent of the total force is devoted to maintenance.

Ground Preparation

A single scraper scheduled 14 hours per day, 364 days per year continuously removes the topsoil and subsoil and hauls it to the reclaimed land fill area to evenly distribute it on top of the level spoil. A D-9 dozer then levels the ground enough to permit the drill crew to begin their activities.

Overburden Removal

Blast holes of 10 5/8 inches in diameter are drilled with a track mounted rotary drill. Hole spacing averages 30 feet center to center but varies from 25 to 35 feet because of the varying hardness of the overburden. Overburden depth averages 110 feet including 5 feet of topsoil and holes are drilled at the rate of one per hour. The rotary drill is scheduled an average of 416 shifts per year, one shift, seven days per week and one overtime shift per week.

Blast holes are loaded at the rate of ten per hour. The load factor depends on the overburden hardness but averages 0.4 pounds of ANFO per yard of material. All holes are loaded, primed and blasted within 72 hours of drilling. Careful sequencing of drilling and blasting with the relative position of the dragline is necessary to avoid interferences with the overburden haulage trucks.

The mining method used does not change up to overburden depths of 150 feet or the digging depth limitation of the dragline. The 60-yard dragline operates on a working bench approximately 100 feet wide. Its loads are dumped on the highwall behind its direction of movement in a low pile. No lateral dragline movements on the bench are necessary, and no special effort need be made to dress the highwall because the activities within the pit are no less than 200 feet away. When the dragline reaches the end of the relatively short pit (once every 12 1/2 days) it turns around and excavates back in the other direction without deadheading back to the other end of the pit. At this point, the power cable which has been gradually reeled in as the dragline has been advancing is disconnected and a cable is connected from the other end of the pit.

The dragline excavates 2,460 bank cubic yards per scheduled hour and has an average cyle time of 51 seconds or 0.85 minutes. The operating statistics of the dragline are shown below.

Boom Length	325 feet
Boom Angle	37 degrees
Maximum Dumping Height	150 feet
Spoil Radius	286 feet
Maximum Digging Depth	175 feet
Rated Bucket Capacity	60 cubic yards
Connected Load	6,000 horsepower

Overburden Haulage

Following the dragline and on the opposite end of the highwall spoil pile, four large front-end loaders with bucket capacities of 15 cubic yards excavate the spoil and load it into 100-ton rear dump trucks. Six trucks are normally required to support the four front-end loaders which load the trucks from both sides at one time whenever possible. A spare truck is usually available for auxiliary or stand-by requirements. The capacity of the front-end loaders have an average cycle time of 0.7 minutes plus truck positioning delays, and average 852 BCY each per hour. A provisional loader is provided in this operation.

The six rear dump trucks haul the overburden an average of 1,600 feet and have a round trip cycle time of 7.7 minutes. Their production is between 550 and 600 BCY per hour. The roads are well maintained by grading, rolling and sprinkling equipment.

Coal Removal

The dragline does not dress the highwall, and as a result there is some danger in the pit from falling rocks, requiring that a 200 foot wide band of coal be left at all times between the toe of the highwall and the point of coal excavation. This exposed coal inventory represents approximately 24 days of production.

Periodically, a front-end loader is assigned to clean off the surface of newly exposed coal. Due to the coal's hardness, it must be fractured by blasting. The coal is drilled with nine inch holes on twenty foot spacings to an average depth of 19 feet. Forty to fifty holes are drilled and loaded per shift. Holes are loaded with ANFO prills and dynamite. A 45 hole pattern is usually blasted at the end of the first shift. The blasted coal is loaded by the 16 cubic yard coal shovel at the rate of 8,482 tons per shift into six 100 ton bottom dump coal haulers.

Coal Haulage

The trucks enter the pit from the single two-way access road which is located midway between the ends of the pit. The toe of the spoil pile is about 100 feet from the coal face so there is ample room to turn around without any need for backing up. This flow through pattern facilitates rapid loading and minimizes congestion. After being loaded the haulers transport the coal directly to a hopper about three miles away. It is then fed into a primary and secondary crusher system, belt conveyed to a tipple and loaded into unit train cars at the rate of 1,100 tons per hour.

Reclamation

Reclamation is accomplished as an integral part of the overburden excavation process except for the activities of final grading, mulching, adding soil amendments and seeding. The overburden haulage trucks expand the level surface backfill by dumping over the bank. A compactor dozer keeps the unloading area free of rocks and generally smooth. Several hundred feet back from the spoil bank's edge, the scraper builds up the surface layer of topsoil which requires a small amount of grading by a dozer or road grader prior to final soil preparation for planting.

The equipment used, its assignment and requirements are summarized in Exhibit III-3 on the following page.

ANALYSES OF THE SYSTEM

This section of the report includes an evaluation of the area haulback mining system covering its engineering feasibility, implementation potential, environmental benefits and cost benefits.

Engineering Feasibility Analysis

The design parameters sought by all the mining systems included in this report are integrated mining and reclamation activities, expanded coal production in a safe and environmentally responsive manner, competitive costs of operation with emphasis upon effectiveness, agility and flexibility and the ease with which such methods can be merged into existing coal mining procedures. Area haulback mining complies with all of these objectives in varying degrees depending upon the specific mining environment in which it might be applied. Relative to available equipment and existing dragline operating characteristics, area haulback utilizes the same techniques and equipment as traditional dragline area mines.

The additional equipment that is required to load and haul spoil around the pit includes conventional, standard makes of vehicles that are currently utilized in the mining and construction industries. Acquistion lead time for the trucks is about six months according to one leading manufacturer and the large front-end loaders could be delivered within one year.

The model mine concept described previously was presented to four major representatives of the coal mining industry and one major equipment manufacturer to obtain their evaluation of the concept. In general, no one questioned the technical feasibility of the principle. One rapidly expanding company is planning to utilize the multiple seam variation in a new venture. The concept of double handling all dragline spoil with loaders and trucks was objectionable, however, to most of those interviewed on the basis of the economics, although one stated that truck and shovel costs were becoming competitive with dragline costs because of reclamation demands. Everyone agreed that its economical application would be limited to situations otherwise requiring excessive rehandle by a dragline.

AREA HAULBACK MINING SYSTEMS
EQUIPMENT DESCRIPTION AND OPERATION REQUIREMENTS

ITEM:	No.	DESCRIPTION	ASSIGNMENT	REQUIRED PRODUCTION	PHYSICAL REQUIREMENTS
Blast Hole Drill, Track Mounted	1	10 5/8" Rotary	Drill Overburden for Blasting	2.5 Feet/Minute	150 Foot Deep Holes
Powder Truck & Tools	1	5 Ton Flatbed	Load Overburden Holes & Blast	Load 10 Holes/ Hour	.4 Pounds ANFO/ Cubic Yard
Dragline, Walking	1	60 Cubic Yards, 325 Foot Boom	Excavate 95% of Overburden	19660 BCY/Shift	200 Foot Lift
D-9 Dozer	1	385 Horsepower, Cable Reel	Bench Preparation, Cable Moving	Not Applicable	Support Activity
Pan Scraper	1	31 Cubic Yards, 415 Horsepower	Topsoil Removal & Placement	1045 BCY/Shift	Self Loading
Front End Loaders	4	15 Cubic Yards, 700 Horsepower	Load Overburden to Trucks	4146 TPH/Fleet	Reach 7.5 Feet at 15.5 Feet
Rear Dump Trucks	7	100 Ton, 63 Yards, 1000 Horsepower	Transport Over-burden, No Grades	4146 TPH/Fleet	16 Feet High, 17.7 Feet Wide
Coal Loading Shovel, Trucks	1	16 Cubic Yards, 70 Foot Boom	Excavate & Load Coal	8500 Ton/Shift	25 Foot Lift
Coal Drill & Tools	1	9" Auger	Drill Coal for Blasting	Two Feet/Minute	24 Foot Deep Holes
Coal Haulage Trucks	6	100 Ton, 550 Horsepower	Haul Coal to Hopper	8500 Tons/Shift/ Fleet	Haul 3 Miles One Way
Wheel Dozer/ Compactor	1	400 Horsepower, Steel Tires	Maintain Spoils Fill/Dump Area	Not Applicable	Support Activity
Reseeding Equipment	1	Tractor Drawn Plow & Seeder	Final Reclamation	105 Acres/Year	High Flotation
Road Grader	1	250 Horsepower	Roads & Reclama-tion	Not Applicable	Support Activity
D-9 Dozer with Ripper	1	385 Horsepower	Roads & Production Support	" "	" "
Towed Road Roller	1	25,000 Pounds Impact, Vibration	Road Construction	Not Applicable	Support Activity
Water Truck	1	8000 Gallon Tank	Road Maintenance	" "	" "
End Dump Truck	1	10 Tons	Roads & Reclama-tion	" "	" "
Crane, Tower	1	310 Horsepower Truck Mounted	Maintenance	" "	" "
Lowboy Trailer & Tractor	1	50 Ton, 3 Axle, Rear Loading	Maintenance	" "	" "
Cable Trailer, Towed	1	30 Ton, 2 Axle, Flush Deck	Cable Transport	" "	" "
Fuel & Lube Truck	1	1000 Gallon	Fuel & Lube Transport	" "	" "
PortableCompressor & Generator	1	30 KW, 150 Horsepower	Field Lighting	" "	" "
Automotive Equipment	10	1 Ton Pickups	Supervision & Maintenance	" "	" "
Forklift	1	4000 Pound, 68 Horsepower	Maintenance	" "	" "

Implementation Analysis

It would be possible to implement this system in an existing mine within one year. In such a conversion from a conventional side casting dragline operation to this system of truck hauled overburden, the box cut would be made at the end of the old pit and perpendicular to it. The box cut overburden would be deposited in the old pit and mining would progress in a direction parallel to the old pit. The time required to implement this system as a new mine would be about five years because of the delivery time for the dragline.

It is anticipated that acceptance by the surface mining industry of this system will be slow because of the increased production cost. However, as the recovery of coal from deeper seams is required or as environmental pressures increase, area haulback mining may become very competitive. In existing mines in which draglines have reached their spoiling limits, the higher productivity of the area haulback system make it a viable alternative to extensive overburden rehandling with the dragline.

Environmental Benefit Analysis

Ideally in conventional side casting with a dragline the upper horizon materials are placed either on the top of spoil peaks or, if the dragline has adequate reach, they are cast over the peak into the valley between the first and second spoil ridges. Subsequent grading buries some of this material and tends to mix what is not buried with the rocky underlying spoil. The resulting rock outcrops are not only unsightly but in some states they are illegal.

In this system of hauling spoil around the pit and depositing them on the spoil bank, the spoil area advances in the direction of mining as a level backfill. Upper horizon materials that are removed by mobile equipment to prepare the dragline bench are deposited on top of this backfill in a uniformly thick layer which precludes rock outcrops with the exception of those originally contained in the surface strata.

In some mines there are substrata in the overburden which are preferable to surface or upper horizon materials. In conventional side casting it is difficult to selectively place this material on the surface. In area haulback, in contrast, the spoil requiring segregation can be placed in a separate pile for separate loading and hauling.

The open pit area is about the same as that in a typical conventional dragline pit and will accumulate the same amount of rain water. The perimeter is much shorter, however, and the area of spoil and highwall exposed to the weather is reduced. As a consequence, there will be less acid mine drainage problems and less erosion, siltation and landslide problems. Water will have to be pumped from the pit to the surface, impounded and treated as in any other system.

The amount of unreclaimed area exposed at any time is confined to the pit, working areas on the surface of the bench, the haulage routes on the sides of the pit, one haul road in the spoil and the fill bench on the spoil where the trucks dump and make their turn around. Total area including the pit would be about 40 acres. This is approximately the same as a conventional mine with two unreclaimed spoil ridges.

Reclamation is, however, a continuous process. The spoil bank expansion is kept level and topsoil removal and placement is continuous to prepare the bench for drilling and blasting. Topsoil storage would occur only at the beginning of the project with the first 50 acres.

Compared to a conventional dragline operation, there is a greater potential for dust generation. Spoil is handled twice and truck traffic is at least doubled. Haulage routes would have to be sprinkled by a water truck frequently in dry areas.

The general appearance of the mine would be quite similar to a conventional dragline operation with the exception of the pit being much shorter and the elimination of the long spoil ridges. A pile of spoil approximately 200 feet long would always be adjacent to the dragline and this would vary in width depending on the dimensions of the cut and the angle of repose of the spoil.

Cost Benefit Analysis of Model Mine

The model mine, with a coal production of 4,240,690 tons per year, has an original cost of $24,744,930 and an annual depreciation cost of $2,031,547. Total annual production cost including depreciation is $22,876,278 and the selling price required for a 20 percent rate of return is $6.56 per ton. The annual cash flow resulting from that price is $5,744,691. See Exhibits III-4 to III-8.

To convert the model mine from a conventional side cast dragline operation to this system would cost $3,646,000 at the outset for additional equipment. To receive the same rate of return, the selling price would have to be 14 percent higher. The resulting production increase in this particular case would be 30 percent partly due to the improved performance of the dragline and partly due to the elimination of the major portion of rehandle work by the dragline.

In addition to the benefit of increased production, the other major advantage includes the improvements in reclamation and safety. Reclamation is more concurrent and selective because all overburden is truck hauled. Safety is improved because there is little need to work close to a highwall and the main highwall's slope angle does not normally have to be steep.

In order to compare the area haulback system to the other mining systems, a strip ratio sensitivity analysis was performed. The results of the analysis are shown in Exhibit III-9. The graph was developed by holding all costs constant except those associated with coal loading and hauling and varying these according to the amount of coal corresponding to the stripping ratio.

EXHIBIT III-4
AREA HAULBACK MINING SYSTEM
DEPRECIATION SCHEDULE

ITEM:	NUMBER	COST	LIFE	ANNUAL DEPRECIATION
45-R Rotary Drill	1	$ 300,000	20	$ 15,000
Powder Truck & Tools	1	10,000	10	1,000
M-8050 Dragline	1	8,800,000	20	440,000
D-9 Dozer	1	185,000	4	46,250
631-C Scraper	1	189,000	6	31,500
L-700 Front-End Loaders	4	1,546,000	6	258,000
U.R. M-100 Rear Dump Trucks	7	2,100,000	6	350,000
195-B Loading Shovel	1	1,045,000	20	52,250
Coal Drill & Tools	1	50,000	10	5,000
Cat. 660 Haulage Trucks	6	1,800,000	6	300,000
Cat. 834 Wheel Dozer	1	150,000	6	25,000
Reseeding Equipment	1	55,000	10	5,500
Cat. 16 Road Grader	1	100,000	5	20,000
D-9 Dozer with Ripper	1	198,000	8	24,750
Towed Road Roller	1	10,000	10	1,000
Water Truck, 8000 Gallon	1	10,000	8	1,250
End Dump Truck, 10-Ton	1	18,000	10	1,800
Heavy Duty Crane L-1400	1	165,000	20	8,250
Lowboy Trailer & Tractor	1	120,000	10	12,000
Cable Trailer, Towed	1	6,000	10	600
Fuel & Lube Truck	1	31,000	10	3,100
Portable Compressor & Generator	1	70,000	7	10,000
Automotive Equipment	1 Lot	50,000	5	10,000
Forklift	1	15,000	5	3,000
Pumps & Piping	1 Lot	85,000	6	14,200
Crushing & Loading	1	4,000,000	20	200,000
High Voltage Pole Line	1	72,000	20	3,600
Substation for 195-B	1	90,000	20	4,500
Substation for Drill	1	42,000	20	2,100
Circuit Breaker	2	36,000	20	1,800
Repair Shop & Truck Garage	1	200,000	20	10,000
Portable Tools & Field Equipment	1	130,000	8	16,250
Two-Way Radio Equipment	1	15,000	10	1,500
Engineering, Legal, & Purchasing	1	50,000	20	2,500
Exploration	1	75,000	20	3,500
Mine Development	1	500,000	20	25,000
Interest During Construction	1	2,426,930	20	121,347
TOTALS		$24,744,930	. . . . . .	$2,031,547

EXHIBIT III-5
AREA HAULBACK MINING SYSTEM
CAPITAL SUMMARY

YEAR	CAPITAL INVESTMENT	PRESENT WORTH FACTOR @ 20%	PRESENT WORTH INVESTMENT @ 20%
0	$24,744,930	1.0000	$24,744,930
1	-0-	.8333	-0-
2	-0-	.6944	-0-
3	-0-	.5787	-0-
4	185,000	.4823	89,226
5	165,000	.4019	66,314
6	5,870,000	.3349	1,965,863
7	70,000	.2791	19,537
8	523,000	.2326	121,650
9	-0-	.1938	-0-
10	480,000	.1615	77,520
11	-0-	.1346	-0-
12	6,055,000	.1122	679,371
13	-0-	.0935	-0-
14	70,000	.0779	5,453
15	165,000	.0649	10,709
16	523,000	.0541	28,294
17	-0-	.0451	-0-
18	5,870,000	.0376	220,712
19	-0-	.0313	-0-
20	[2,126,000]	.0260	$ [55,276]
TOTAL			$27,974,303

EXHIBIT III-6
AREA HAULBACK MINING SYSTEM
ESTIMATED ANNUAL PRODUCTION COST

Labor Cost:	
Direct	$ 2,831,500
Supervision	339,600
Total Labor Cost	$ 3,171,100
Supply Cost:	
Fuel, Power, Lubricants, Parts, Supplies & Repair	$ 8,550,723
Explosives	1,120,431
Total Supply Cost	$ 9,671,154
Auxiliary Cost:	
Contract Services	$ -0-
Communications	3,000
Welfare & Benefit Package	1,415,750
Health & Safety - $.03/ton	127,221
Royalty - 10% Sales	2,784,227
License & Fees	1,272,207
Total Auxiliary Cost	$ 5,602,405
Indirect Cost:	
15% of Labor, Supervision and Operating Supplies	$ 1,926,338
Fixed Cost:	
Insurance and Taxes	$ 473,734
Depreciation	2,031,547
TOTAL PRODUCTION COST	$22,876,278

EXHIBIT III-7
AREA HAULBACK MINING SYSTEM
MINIMUM SALES PRICE COMPUTATION

Sales = Cost of Production plus Depletion* plus
2 Times Net Profit
Depletion plus Net Profit = Present Value of Capital
Due Less Depreciation

Also,

Sales = Cost of Production plus 2 Times (present value
due, minus depreciation) Minus Depletion

Present Value of Capital Requirements Due in 20 Years at 20% Compound Interest =	
27,974,303 X .205356	= $ 5,744,691
Less: Annual Depreciation	- 2,031,547
Depletion plus Net Profit	= $ 3,713,144
Sales = 22,876,278 plus 2 (3,713,144) minus Depletion	= $27,827,137
Gross Profit = Sales minus Cost of Production = 27,827,137 minus 22,876,278	= $ 4,950,859
Less Depletion Allowance	- 2,475,429
Taxable Income	= $ 2,475,430
Less Federal Income Tax at 50%	- 1,237,715
Net Profit	= $ 1,237,715
Annual Cash Flow = Net Profit plus Depreciation plus Depletion	= $ 5,744,691
Selling Price Per Ton = Sales divided by Production (27,547,787 divided by 4,240,690)	= $6.56

*10% of Sales not to exceed 50% of Gross Profit

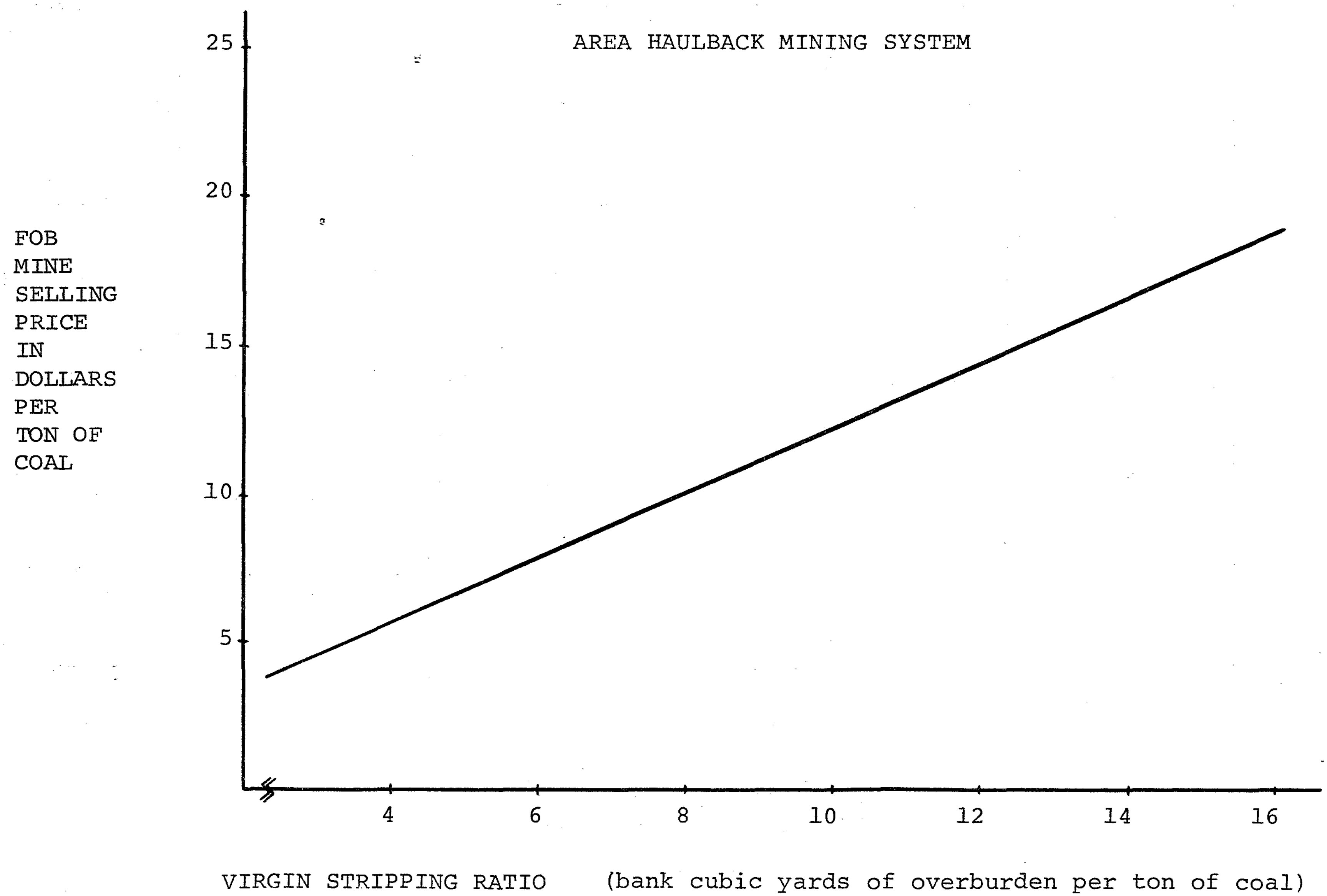
EXHIBIT III-8

AREA HAULBACK MINING SYSTEM
PRODUCTION AND OPERATING COST SUMMARY
(DEPRECIATION, LABOR AND SUPPLIES)

ELEMENT	UNITS	ANNUAL PRODUCTION	FIXED COST	VARIABLE COST	TOTAL COST	COST PER UNIT OF PRODUCTION	COST PER TON OF RAW COAL
Overburden Preparation	Acres	97	$ 16,000	$ 1,672,660	$ 1,688,660	$17,409	$ .398
Overburden Removal	Cubic Yards	22,117,750	1,125,750	6,806,363	7,932,113	.359	1.870
Coal Removal	Tons	4,240,690	57,250	641,536	698,786	.165	.165
Coal Haulage	Ton Miles	12,722,070	300,000	1,448,140	1,748,140	.137	.412
Reclamation	Acres	104	30,500	479,320	509,820	4,902	.120
Mine Administration	---	---	146,347	222,000	368,347	---	.087
Production Support	---	---	355,700	1,572,235	1,927,935	---	.455
TOTAL	---	---	$2,031,547	$12,842,254	$14,873,801	---	$3.507

EXHIBIT III-9

SENSITIVITY ANALYSIS OF MINE PRICE TO STRIPPING RATIO



INTRODUCTION AND SUMMARY

The periphery mining system is not new in concept although it has been practiced very little. The reason for this is that it requires very special circumstances to be practical. If the geological and other conditions of a site favor its application, it offers numerous advantages.

The equipment used in all operations is essentially the same as what it would be if the pit were straight. The primary excavator would most likely be a dragline although other kinds of equipment could conceivably be used instead for this work.

The things that make the system distinctive are all derived from the mining stategy and not from the specific methods used in the various operations. These strategies will in turn be determined by the nature of the property and the climatic conditions at the site.

The initial box cut is comparatively long and costly. Highwall ramps for coal haulage are conducive to lower costs and better reclamation. Careful control of surface water drainage on the center island of unmined land has to be practiced to keep the pit dry.

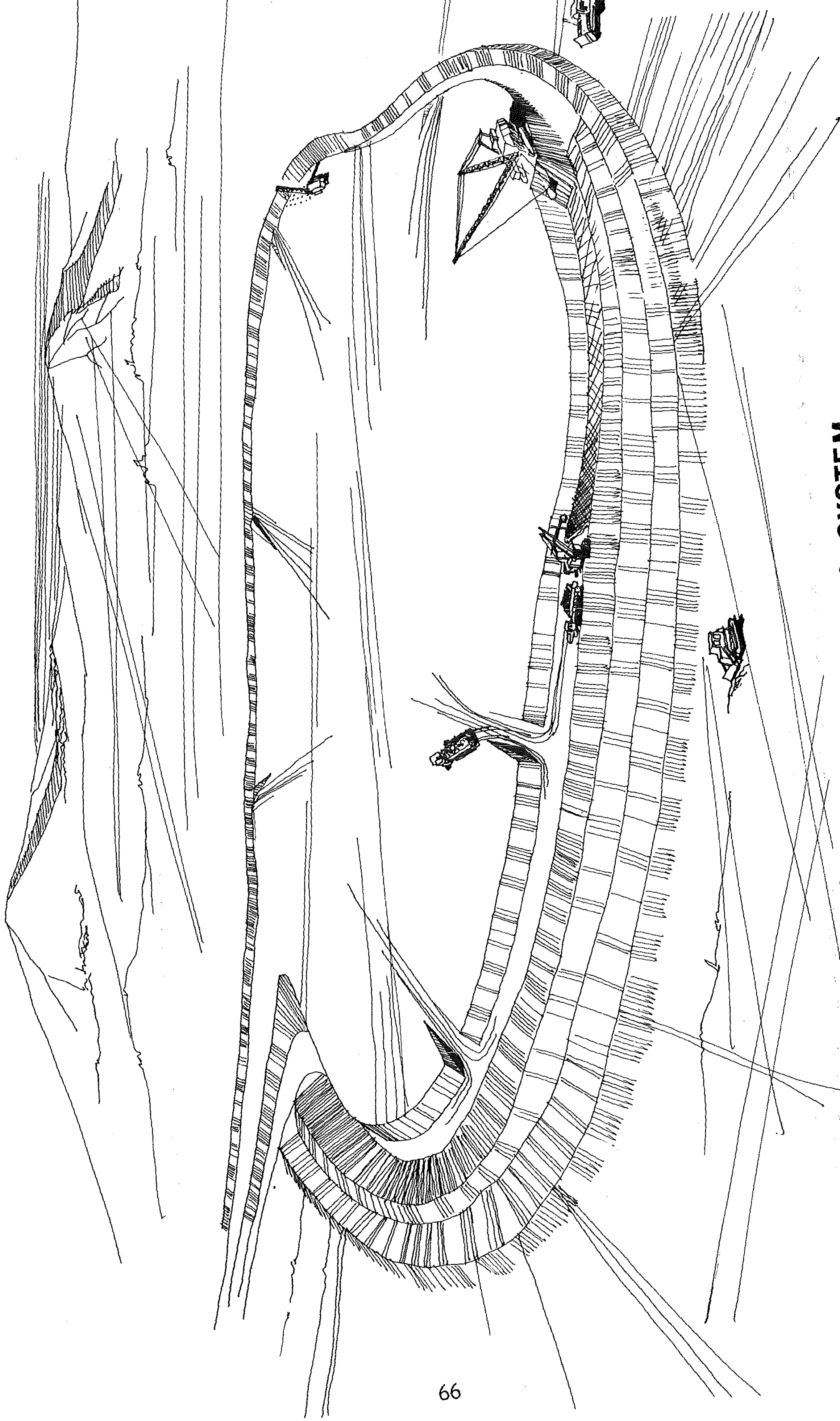
The coal haulage trucks drive up the highwall ramps and across this central island. An option exists whether to have coal haulers drive back down off the highwall, across the pit floor, and up the spoil side to get to the coal hopper or to leave via an access peninsula.

The pit configuration is determined primarily by the topography, geography and geology of the reserve. Many trade-offs such as property area versus box cut length have to be identified, quantified and integrated into a total plan of system optimization when the mine is being designed.

The minimum area of land to be economically mined this way is about 1,000 acres and it should be free of inclusions of unmineable land. The mine plan should include the provision of opening the box cut in one direction for about one-fourth the perimeter and returning the dragline to the starting point to open it in the other direction. This is done in order to minimize the box cut stripping ratio in the beginning, and consequently the mining plan development is more complex than that for a straight pit operation.

The system offers the opportunity for retreat mining with its advantages of more concurrent reclamation and the elimination of spoil haulage roads while averaging the stripping ratio over the life of the pit. Its cost of operation is competitive with other area mining systems. Exhibit IV-1 shows a perspective sketch of the Periphery Mining System.

EXHIBIT IV·1



PERIPHERY MINING SYSTEM

DESCRIPTION OF MINING SYSTEM

Periphery or circular mining is a modification of straight pit area mining where the pit at first circumscribes an area and continues in a spiral fashion to mine toward the center of the property. The equipment requirements are the same as traditional area mines, although there are some advantages to using a dragline in preference to a stripping shovel.

The advantages of periphery mining include the following:

- There is no final highwall.
- It can be adapted to the retreat mining concept.
- The mine is less visible from the surrounding area.
- Blasting noise is less outside the perimeter.
- Dragline deadheading is eliminated.
- Outside curves reduce spoil peak heights and reduce rehandle requirements.
- Haulage road maintenance may be less.
- It averages overburden handling costs.
- There is less moisture in blast holes.

A detailed description of the operating methodology, equipment requirements and description of a hypothetical mine using the peripheral mining system is included in this section of the report.

Operating Methodology

In the periphery mining system, overburden excavation is composed of three essential phases:

- Ground preparation
- Drilling and blasting overburden
- Overburden excavation and spoiling

These will be discussed below in detail.

Ground preparation consists of the removal of obstacles such as trees and buildings if they exist and the removal of topsoil and subsoil. The thickness of these surface layers vary from nothing to over twenty feet. Sometimes it is necessary to transport material from other locations or to use large quantities of mulch and other soil amendments to foster growth of vegetation on the reclaimed spoil.

The nature of the site will determine the type of equipment to be used in ground preparation operation. Pan scrapers are frequently used to remove the unconsolidated surface strata ahead of the other overburden removal operations. After removing the topsoil, the scrapers travel to stockpiles and deposit it there or they travel down highwall ramps, across the pit floor and up spoil access roads to spread it on graded spoil. Returing the way they came, the cycle is repeated. In some cases where the overburden is shallow, the topsoil material can be cast by the dragline onto leveled spoil. In that event the soil is stockpiled on the highwall working bench. This reduces equipment requirements for ground preparation and eliminates the need for access roads in the spoil.

The drilling and blasting operation in the periphery mining system is the same as that used in straight pit area mining. Depending on the geology of the overburden, either vertical or horizontal drills can be used. The vertical drills work on top of the consolidated overburden which has been stripped by the ground preparation operation. The horizontal drills work on the pit floor. In either case, hole spacing and the quantity of explosive per hole will vary depending upon overburden hardness and thickness. A typical burden ratio is 2.5 cubic yards of rock per pound of oxidizer.

In the periphery mining system, a dragline is the principal piece of excavating equipment. It works in a typical fashion on top of the highwall and excavates by dragging the bucket across the cut face until it is full. It then hoists the bucket to the height of the spoil pile while it rotates about 90 degrees to the dumping position. The drag cable is then slackened and broken rock is dropped onto the spoil pile.

The initial box cut eventually circumscribes the area to be mined. It is opened in the shallowest overburden and extends toward the deeper overburden until enough coal has been exposed to meet current production requirements. The primary excavator then returns to an area of shallow overburden and continues around the loop in the opposite direction until the peripheral boxcut is completed.

The outer half of the box cut spoil is graded to a gentle slope concurrent with mining. After the box cut is completed, mining advances toward the center of the area in a spiral layout eliminating the need for a final cut highwall.

Haulage roads are located, where possible, on areas to be mined with ramps entering the pit from the highwall side. This eliminates the need for traffic and ramp roads through the spoil and helps to expedite earlier land reclamation.

The minimum distance between these ramps may be established by operating efficiencies, reclamation regulations, or state reclamation agency rulings. The closer the ramps are together, the shorter the haul distance for the coal trucks. The penalties are the production time lost while the dragline trams around the ramp and the extra road maintenance that is required.

The initial perimeter box cut provides for the impoundment and control of water originating outside the mining area. Precipitation which falls on the island within the box cut perimeter must be diverted with interceptor dams which should be constructed and maintained so as to minimize the collection of surface water in the pit. Water from rainfall or sub-surface seepage is collected in pit sumps so that it can be tested to determine the necessity of water treatment prior to discharge into natural drainageways.

Coal is removed with an electric loading shovel or front-end loader into trucks which drive on the coal surface. The coal is hauled up a highwall ramp and across the center island to minimize haulage distances.

At the edge of the center island nearest to the coal hopper, the coal haul trucks have to drive down the highwall ramp across the pit and up through the spoil unless the mine plan specifies the leaving of an access peninsula or unmined strip of land extending radially from the perimeter nearest the coal hopper to the center island. If this option is used, then this peninsula is the last part of the area to be mined.

The decision to leave an access peninsula is partly determined by the coal reserve's characteristics. Shallow overburden means short ramps and a minor grade penalty for the coal haulers discouraging the penisula. A peninsula gives the advantage of a semi-permanent access road and feeder cable installation. Some of its disadvantages include the tramming time crossing it and the possibility of having to rehandle some spoil at the junction of the pit and the peninsula.

Pit Design

The periphery mine pit configuration is determined primarily by the topography, geography and geology of the reserve to be mined. The closer the box cut can approach a circle, the greater is the opportunity for outside curves that reduce spoil peak height. In addition, the larger the area to be mined, the lesser is the cost portion of the total mine cost that is attributable to the box cut. This, however, is counteracted to some degree by the increased initial cost of the project and the time it takes to complete a full circle. If the time is very great, special consideration must be given to erosion of the highwall and the amount of precipitation that will fall within the perimeter.

The topography of the property determines the depth and cost of the box cut. If the overburden is thicker in the center than it is at the edge of the area under consideration, the box cut cost will be less than it would cost with level coal seams or a property with an increasing stripping ratio from one side to the other. The topography also determines the drainage patterns and the resulting requirements for diversion ditches and dams that will collect runoff before it can drain into the pit where it would interfer with production and become contaminated. This need for ditches and dams has to be integrated with the haulage road layout of the center island. The determination of optimum road locations will be affected by the topography and its consequences more than any other factor.

The geography or size and shape of the reserve within the permit area is a vital consideration. If there are unmineable areas included within the boundaries, the pit will be interupted and production efficiency will be reduced because of having to tram the equipment around the obstacle. If the shape of the mineable area is highly irregular, then various trade offs may have to be evaluated. Pit sections with inside curves may be tolerable in shallower overburden. Otherwise, the cost of rehandling a portion of the spoil in those areas must be weighed against other alternatives such as sacrificing some of the coal, straight pit mining a portion of the property or using some other mining method for those particular areas. The shape of the center island will also be affected by the choice of highwall ramp locations. They should intersect at a bend or outside curve in the pit to facilitate spoiling by the dragline. Perhaps of greatest importance is the size of the area. The smaller the area, the greater will be the proportionate cost of the original box cut.

Geological considerations include the depth and thickness of the coal seam(s), the physical and chemical characteristics of the various overburden strata and the degree of dip the coal seam has to the horizontal plane. These considerations are the same as they would be for a straight pit area mine except that peripheral mining has such a long box cut. Overburden permeability must be considered with reference to the amount of water that will collect in the pit and how stable the highwall is expected to be.

Seam dip and various depths of the overburden have several consequences. The most important one is the effect they have on the box cut cost, as previously mentioned. The areas of deepest overburden need the spoiling flexibility derived from outside curves in the pit while areas of shallow cover may tolerate inside curves. Pitching seams would cause steep grades on the pit floor. This could be a problem for coal loading and haulage, and might facilitate excessive water erosion in the pit.

In conclusion, there are no hard and fast rules for pit design. All influencing factors should be carefully weighed and evaluated. The trade-offs identified above, quantified and integrated into a total plan of system optimization, have to be on a site specific basis.

Equipment Requirements

This section of the report discusses the equipment required, the job to be accomplished by each type of equipment and the logic behind selecting a particular type of equipment to accomplish a task. The peripheral mining system utilizes equipment which is currently available and is in operation in surface coal mines throughout the United States.

Pan scrapers remove topsoil and subsoil in the ground preparation operation. The material handled by the scrapers is primarily unconsolidated topsoil and associated materials such as clays, sand and some gravel. The upper horizon material is removed approximately 1,000 feet ahead of the dragline and is either stockpiled on the highwall for transfer by the dragline to the spoil piles or is transported down highwall ramps across the pit and up spoil access roads and distributed on the roughly graded spoil not more than two spoil peaks away from the pit. The scrapers should be of the self loading type or large enough and powerful enough to require a minimum of assistance from push dozers. If the unconsolidated layer of topsoil and subsoil is thick enough to warrant a fairly large number of scrapers, the push-pull type may be preferred.

The number of scrapers needed depends upon the hourly production rate of one individual scraper, and this in turn depends upon its carrying capacity, average speed and distance round-trip. Comparing one scraper's rate to that of the dragline gives the number of scrapers required to keep the ground preparation operation ahead of the advancing pit.

Final grading of the topsoil may be done by a road grader or dozer working part time. Seeding, mulching and fertilizing is done by farm tractor drawn equipment. The use of this equipment is confined to certain seasons of the year when a large area is prepared for revegetation and the time is right for proper germination of the seed.

The peripheral mining system uses a rotary drill to drill the highwall bench in preparation for blasting. The physical specifications of the drill such as boom length, pit diameter, horizontal or vertical, etc., and whether diesel or electric powered depends upon the thickness and characteristics of the overburden. Drills are usually specified of such a size and power rating that they can maintain an overburden penetration speed in the range of 2 to 3 feet per minute. Drill bit diameters are specified to allow for 20 to 40 foot hole spacing and the achievement of a burden to explosive ratio of 2.5 yards of rock to one pound of oxidizer. In addition to the rotary drill, the blasting operation requires the typical support equipment of bulk storage facilities, oxidizer transportation truck, power truck and detonating equipment.

A walking dragline is the basic item of overburden removal equipment, and it is specified to be of such a capacity that the coal production requirements are met. The dragline excavates the previously blasted, consolidated overburden and deposits it in the empty, mined out pit adjacent to the highwall forming a spoil pile ridge. The size of the bucket, the length of the boom and the drag and hoist motor horsepower are set by the average coal removal rate required, the stripping ratios, the combined thickness of the overburden and coal seam and the overburden characteristics which are specific to each mine location. The product of the scheduled coal production in tons per year and the raw coal stripping ratio gives the annual bank cubic yard requirement for the dragline. This figure in addition to the swell factor of the overburden, the desired average cycle time of the machine and the planned digging hours are used to calculate the required bucket size. The length of the dragline boom is a function of the spoiling radius required, and it is usually desirable to be of such a length that the dragline can cast all excavated rock on the spoil pile without rehandling material.

The dragline requires a reasonably level bench to work on and one or more bulldozers are normally required to do this grading work after the topsoil has been removed and the overburden has been blasted. This equipment can also be used for other activities such as assisting the scrapers and road building. Maintenance of the highwall ramp roads would be done by these dozers and a road grader.

Removing and loading the coal in a peripheral mine requires either a coal loading shovel or a large front-end loader. Loading shovels are preferred because they have a greater break-out force and better mechanical availibility. If the coal is consolidated enough, it must be blasted in order to sustain coal production requirements. The equipment needed is a rotary coal drill and supporting equipment.

The coal loading shovel works on the pit floor, excavating the coal from the face of the seam, rotating as required and dumps the coal into a waiting coal hauler which may either be stationed on the coal seam's surface above the shovel or on the pit floor. Usually the coal haulers are large, off-highway type, bottom dump trucks but sometimes end dumps are used. The trucks transport the coal from the pit up the highwall ramp and across the central island to the tipple or coal hopper. For a given truck capacity, the number of coal haulers is determined from distances, grades, road condition, altitude and any other factor which affects the average round trip time of the vehicle.

Additional equipment needed in the operation includes dozers for reclamation grading, a road grader, dozer and roller for road building, a water truck for dust control and other support equipment such as trucks, a crane, cable handling equipment, a fuel and lube truck and other maintenance support equipment. The support equipment is available for use when required but is not scheduled for a fixed number of operating hours.

This completes the discussion of the peripheral area mining system's equipment needs. The description of a hypothetical model mine which follows in the next section of this report details more specifically the equipment, the job to be done and the requirements at a given mine site.

NARRATIVE DESCRIPTION OF MODEL MINE

The model mine is located in the northwestern coal field at an elevation of 3,000 feet. The topography is rolling hills and washes with an occasional outcropping of sandstone. Topsoil varies from zero to six feet. The major portion of overburden consists of interbedded sandstone and shale overlying 10 to 20 feet of gray shale. The average total overburden thickness is 110 feet and covers a 20-foot thick seam of coal. The strata dips less than one degree to the south. Total precipitation is about 15 inches per year.

The shape of the property is approximately oval and the coal hopper is located north of the center of the property. The original area included 1,150 acres and the box cut circumference was 28,800 feet long. The box cut development work is estimated to require about five months to complete and cost approximately $2.6 million dollars. Coal production during this period is projected to be about 25 percent of what it is working under normal conditions.

The primary elements of the operation are ground preparation, overburden removal, coal removal, coal haulage and land reclamation. Overburden stripping is scheduled 364 days per year, 24 hours per day. The other activities are scheduled less intensively in accordance with the requirement.

The mine personnel consists of 15 salaried supervisory and office positions and 97 union workers. Twenty-nine percent of the total force is devoted to maintenance.

Ground Preparation

One scraper scheduled 14 hours per day, 364 days per year removes the topsoil and subsoil ahead of the drilling and blasting crew. Where the overburden is shallow, this unconsolidated material is stockpiled on the highwall for later removal and transfer to the spoil by the dragline. In all other locations around the periphery except near the access peninsula, the scraper hauls it down a highwall ramp, crosses the pit floor and carries it up onto the spoil pile. This scraper haulage to the spoil pile constitutes about 3% of the total material handled. A second scraper, working on the spoil pile, evenly distributes the topsoil transferred by the dragline and assists the other scraper when required. Following the topsoil removal, a D-9 dozer levels the highwall bench surface by pushing overburden into the pit to allow the drill crew to begin their activities. This and two more D-9 dozers excavate the highwall ramps by pushing the overburden down the ramp slope and into the open pit. These three dozers account for 10 percent of the total overburden handling.

Overburden Removal

Blast holes of 10 5/8 inches in diameter are drilled with a track mounted rotary drill. Hole spacing averages 32 feet center to center but varies from 25 to 35 feet because of the varying hardness of the overburden. Overburden depth reaches 125 feet and averages 110 feet including 5 feet of topsoil. Holes are drilled at the rate of one per hour. The rotary drill is scheduled an average of 364 shifts per year.

Blast holes are loaded at the rate of 10 per hour. The load factor depends on the overburden hardness but averages 0.4 pounds of ANFO per cubic yard of material. All holes are loaded, primed and blasted within 72 hours of drilling.

The dragline removes the upper two thirds of the overburden from the highwall position depositing it in the pit mined out on the previous pass. The dragline is then moved across the pit onto the bench created by the spoil, and removes remaining one-third of the overburden down to the coal seam. The spoil from this second cut will be placed on the spoil from the first cut as the dragline advances to produce roughly leveled spoil. In areas of deeper overburden up to 20 percent of the spoil from the first cut must be rehandled by the dragline during the second cut.

The dragline position on the spoil bench allows enough reach to cast the spoil without making typical spoil ridges and leaves the spoils in a level, semi-graded condition. The dragline continues to operate in a spiral pattern with all deadheadings eliminated.

The dragline excavates 2,082 bank cubic yards per scheduled hour and has an average cycle time of 58 seconds or 0.97 minute. The operating statistics of the dragline are shown below.

Boom Length	275 feet
Boom Angle	33 degrees
Maximum Dumping Height	115 feet
Spoil Radius	262 feet
Maximum Digging Depth	165 feet
Rated Bucket Capacity	70 cubic yards
Connected Load	7,000 horsepower

Coal Removal

Due to the coal's hardness it must be fractured by blasting. The coal is drilled with nine inch holes on twenty foot spacings an average depth of 20 feet. Forty to fifty holes are drilled and loaded per shift. Holes are loaded with ANFO prills and dynamite. A forty-five hole pattern is usually blasted at the end of the first shift. The blasted coal is loaded by the 16 cubic yard coal shovel at the rate of 8,962 tons per shift into six 100 ton bottom dump coal haulers.

Coal Haulage

After crossing the access peninsula and part of the center island, the trucks enter the pit on a ramp through the highwall, traverse the coal surface to the loading point and then return to the coal hopper via a highwall ramp. The ramps are about one-half mile apart. The coal haul distance averages three miles. The coal is fed from the hopper into a primary and secondary crusher system, belt conveyed to a tipple and loaded into unit train cars at the rate of 1,100 tons per hour.

Reclamation

Part of the reclamation work begins with the dragline leaving semi-level spoil instead of peaks and ridges. Two dozers working no more than two spoil piles back from the pit rough grade the surface. A scraper distributes the topsoil transferred by the dragline from the highwall and it is finish graded by one of the two reclamation dozers prior to final soil preparation for planting.

The equipment used, its assignment and requirements are summarized on the following page in Exhibit IV-2.

EXHIBIT IV-2

PERIPHERAL MINING SYSTEM
EQUIPMENT DESCRIPTION AND OPERATION REQUIREMENTS

ITEM:	NO.	DESCRIPTION	OPERATION ASSIGNMENT	REQUIRED PRODUCTION	PHYSICAL REQUIREMENTS
Blast Hole Drill, Track Mounted	1	10 5/8" Rotary	Drill Overburden for Blasting	2.5 Feet/Minute	150 Ft. Deep Holes
Powder Truck and Tools	1	5-Ton Flatbed	Load Overburden Holes & Blast	Load 10 Holes/ Hour	.4 pounds ANFO/ cubic yards
Dragline, Walking	1	70 cubic yards, 275 Foot Boom	Excavate 87% of Overburden	16,658 bcy/Shift	148 Foot Lift
D-9 Dozer	3	385 Horsepower	Bench Preparation, 10% of Overburden	1983 bcy/Shift	12 Foot of Overburden
Pan Scrapers	2	31 cubic yards, 415 Horsepower	Topsoil Removal & Placement	1045 bcy/Shift	Self Loading
Coal Loading Shovel, Trucks	1	16 cubic yards, 70 foot Boom	Excavate & Load Coal	8962 Tons/Shift	25 foot lift
Coal Drill and Tools	1	9" Auger	Drill Coal for Blasting	Two Feet/Minute	24 feet deep holes
Coal Haulage Trucks	6	100 Ton, 550 Horsepower	Haul Coal to Hopper	8962 Tons/Shift	Haul 3 Miles One Way
Wheeled Dozer	1	400 Horsepower D8H	Pit Cleanup & Roads	Not Applicable	Support Activity
Reseeding Equipment	1	Tractor Drawn Plow & Seeder	Final Reclamation	81 Acres/Year	High Flotation
Road Grader	1	250 Horsepower	Roads	Not Applicable	Support Activity
D-9 Dozer with Ripper	1	385 Horsepower	"	" "	" "
Towed Road Roller	1	25,000 Pounds Impact, Vibration	"	" "	" "
Water Truck	1	8,000 Gallon Tank	"	" "	" "
End Dump Truck	1	10 Tons	Roads & Reclamation	" "	" "
Crane, Tower	1	310 Horsepower Truck Mounted	Maintenance	Not Applicable	Support Activity
Lowboy Trailer & Tractor	1	50 Ton, 3 Axle, Rear Load	"	" "	" "
Cable Trailer, Towed	1	30 Ton, 2 Axle, Flush Deck	Cable Transport	" "	" "
Fuel & Lube Truck	1	1000 Gallon	Fuel & Lube Transport	" "	" "
Portable Compressor & Generator	1	30 KW, 150 Horsepower	Field Lighting	" "	" "
Automotive Equipment	10	3/4 Ton Pickups	Supervision & Maintenance	" "	" "
Forklift	1	4000 Pounds, 68 Horsepower	Maintenance	" "	" "

ANALYSES OF THE SYSTEM

This section of the report includes an evaluation of the peripheral mining system as to its engineering feasibility, implementation potential, environmental benefits, and cost benefits.

Engineering Feasibility Analysis

There are no unusual equipment constraints in this system. All the equipment items are conventional and the same as those normally found in a strip mine.

One technological limitation has to do with the size and shape of the reserve. It should be at least 1,000 acres unencumbered by inclusions of unmineable areas and of a shape that will minimize inside curves in the pit.

Design problems center around the geography of the reserve, the location of the outcrop and the difference between maximum and minimum overburden depths. In the original box cut which starts near the outcrop or shallowest overburden, the mine plan should include the provision of opening it in one direction for about one-fourth the perimeter and then returning the dragline to the starting point to open it in the other direction. This tactic will increase the initial supply of coal and spread the development and box cut cost over a longer period of time.

Operating characteristics which make the system different from a conventional area strip mine include hauling coal up highwall ramps and across the central island to the coal hopper, the central location of pit drainage, the reduction in dragline deadheading and the increased stabilization of coal production. The system can also include the feature of retreat mining which reduces roads on the spoils.

Industry comments on the system emphasize the inherently high mine development costs. One leading company stressed the fact that boxcuts can cost three to four times as much as a conventional highwall cut. In general, all the companies interviewed liked the concept but object to the peripheral box cut because of its length and cost.

Implementation Analysis

Leadtime to put this system into operation is minimal if it can be accomodated into an existing operation. Since no additional equipment is required, the only delays will be those resulting from the excavation of the perimeter boxcut. There are some typical production delays during this boxcut work because of slower digging. The ironing out of initial problems would continue until the perimeter box cut circumvented the property. Problems that can be anticipated are the common ones that accompany any surface mine. As the mine progresses through the property, more detailed information becomes available regarding the physical and geological attributes of the area. Because peripheral mining opens up the entire permit in the beginning, physical and geological information is obtained at an earlier stage and must be delt with during the mine development period. This reduces the time allowed to make operating adjustments.

The system is straight forward once the mine plan is complete. The development of the plan is more complex, however, and requires the trade-off of numerous alternatives. Examples include the access peninsula, highwall ramps, transporting of topsoil, pit width, tipple location and power distribution.

Constraints to implementation include the increased front-end cost of a longer boxcut and the increased amount of planning. The system is definitely limited to reserves of favorable geology where the total area is mineable on an economic basis. The size of the property determines the perimeter distance and the length of the original highwall. The size of the dragline available and the overburden height determines the rate of advance. The property and dragline capacity together determine the maximum age of the highwall. This may or may not be a constraint depending on the climate and the geology of the overburden.

The shape of the reserve may be a limitation. Ideally, it would be circular or of an angular geometry where all inside angles are less than 180 degrees. Irregular appendages to the main reserve would require special consideration and possibly increase rehandle of overburden.

There are no safety or labor constraints which are not common to a conventional dragline straight pit operation. One mining company is known to have a plan for installing this system ten years from now.

Environmental Benefit Analysis

This system offers the opportunity for retreat mining with its advantages of more concurrent reclamation and the elimination of spoil haulage roads. Reclamation can be continuous with overburden removal to within at least two spoil ridges of the pit as in a conventional mine, but the total area unreclaimed is greater. At the beginning of mining operations, the disturbed area of a peripheral mine could be as much as two to four times as large conventional area mining operations.

The berm created from the box cut spoil surrounds the property and effectively hides most of the operation from public view. It also reduces the noise from blasting outside the perimeter of the mine. All precipitation falling within the perimeter will stay there until it is pumped out to a settling pond. Water pollution can consequently be eliminated because of the total control of rainwater runoff.

If the seam of coal is tilted, water drainage from the pit will tend to converge in one low spot. This has the advantage of reducing the number of pump sump locations and the number of settling ponds. The berm from the original box cut that circumscribes the property diverts rainwater runoff and prevents it from entering the pit. These factors make it a much drier operation and reduce landslides, siltation and erosion as well as acid mine drainage.

EXHIBIT IV-3
PERIPHERAL MINING SYSTEM
DEPRECIATION SCHEDULE

ITEM:	NUMBER	COST	LIFE	ANNUAL DEPRECIATION
Crushing, Loading Facility	1	$ 3,000,000	20	$ 150,000
45-R Rotary Drill	1	300,000	20	15,000
Powder Truck & Tools	1	10,000	10	1,000
M-8050 Dragline	1	8,800,000	20	440,000
D-9 Dozer	3	555,000	4	138,750
631C Scraper	2	378,000	6	63,000
195-B Loading Shovel	1	1,045,000	20	52,250
Coal Drill & Tools	1	50,000	10	5,000
Cat 660 Haulage Trucks	6	1,800,000	6	300,000
D-8H Dozer	1	107,000	4	26,750
Reseeding Equipment	1	55,000	10	5,500
Cat 16 Road Grader	1	100,000	5	20,000
D-9 Dozer With Ripper	1	198,000	8	24,750
Towed Road Roller	1	10,000	10	1,000
Water Truck, 8000 Gal.	1	10,000	8	1,250
End Dump Truck, 10 Ton	1	18,000	10	1,800
Heavy Duty Crane L1400	1	165,000	20	8,250
Lowboy Trailer & Tractor	1	120,000	10	12,000
Cable Trailer, Towed	1	6,000	10	600
Fuel & Lube Truck	1	31,000	10	3,100
Portable Comp. & Generator	1	70,000	7	10,000
Automotive Equipment	1 Lot	50,000	5	10,000
Cat 834 Rubber Tired Dozer	1	150,000	8	18,750
Forklift	1	15,000	5	3,000
Pumps & Piping	1 Lot	85,000	6	14,200
High Voltage Pole Line	1 Lot	72,000	20	3,600
Substation for 195-B	1	90,000	20	4,500
Substation for Drill	1	42,000	20	2,100
Circuit Breaker	2	36,000	20	1,800
Repair Shop & Garage	1	150,000	20	7,500
Portable Tools & Field Equipment	1 Lot	130,000	8	16,250
Two-Way Radio Equip.	1 Lot	15,000	10	1,500
Engineering, Legal, Purch.	1	50,000	20	2,500
Exploration, Site Prep.	1	75,000	20	3,500
Mine Development, Special	1	2,644,650	20	132,232
Interest During Construction	1	2,426,930	20	121,347
TOTALS		$22,859,580		$1,622,779

EXHIBIT IV-4
PERIPHERAL MINING SYSTEM
CAPITAL SUMMARY

YEAR	CAPITAL INVESTMENT	PRESENT WORTH FACTOR @ 20%	PRESENT WORTH INVESTMENT @ 20%
0	$22,859,580	1.0000	$22,859,580
1	-0-	.8333	-0-
2	-0-	.6944	-0-
3	-0-	.5787	-0-
4	662,000	.4823	319,283
5	165,000	.4019	66,314
6	2,263,000	.3349	757,879
7	70,000	.2791	19,537
8	1,150,000	.2326	267,490
9	-0-	.1938	-0-
10	480,000	.1615	77,520
11	-0-	.1346	-0-
12	2,925,000	.1122	328,185
13	-0-	.0935	-0-
14	70,000	.0779	5,453
15	165,000	.0649	10,709
16	1,150,000	.0541	62,215
17	-0-	.0451	-0-
18	2,263,000	.0376	85,089
19	-0-	.0313	-0-
20	[998,333]	.0260	[25,957]
TOTAL			$24,833,297

EXHIBIT IV-5
PERIPHERAL MINING SYSTEM
ESTIMATED ANNUAL PRODUCTION COST

Labor Cost:	
Direct	$ 1,939,600
Supervision	320,000
Total Labor Cost	$ 2,259,600
Supply Cost:	
Fuel, Power, Lubricants, Parts, Supplies & Repair	$ 3,581,516
Explosives	908,403
Total Supply Cost	$ 4,489,919
Auxiliary Cost:	
Contract Services	$ -0-
Communications	3,000
Welfare & Benefit Package	969,800
Health and Safety - $.03/ton	97,866
Royalty - 10% Sales	1,840,642
License and Fees	978,655
Total Auxiliary Cost	$ 3,889,963
Indirect Cost:	
15% of Labor, Supervision and Operating Supplies	$ 1,122,802
Fixed Cost:	
Insurance and Taxes	$ 378,414
Depreciation	1,622,779
TOTAL PRODUCTION COST	$13,763,477

EXHIBIT IV-6
PERIPHERAL MINING SYSTEM
MINIMUM SALES PRICE COMPUTATION

Sales = Cost of Production plus Depletion* plus
2 Times Net Profit
Depletion plus Net Profit = Present Value of Capital Due
Less Depreciation

Also,

Sales = Cost of Production plus 2 Times (present value
due, minus depreciation) Minus Depletion

Present Value of Capital Requirements Due in 20 Years at 20% Compound Interest	
24,833,297 X .205356	= $ 5,099,667
Less: Annual Depreciation	- 1,622,779
Depletion plus Net Profit	$ 3,476,888
Sales = 13,763,477 plus 2 (3,476,888) minus Depletion	= 18,833,866
Gross Profit = Sales minus Cost of Production = 18,833,866 minus 13,763,477	= 5,070,389
Less Depletion Allowance	- 1,883,387
Taxable Income	= $ 3,187,002
Less Federal Income Tax at 50%	- 1,593,501
Net Profit	= $ 1,593,501
Annual Cash Flow = Net Profit plus Depreciation plus Depletion	= $ 5,099,667
Selling Price Per Ton = Sales divided by Production (18,833,866 divided by 3,262,184)	= $5.77

*10% of Sales not to exceed 50% of Gross Profit.

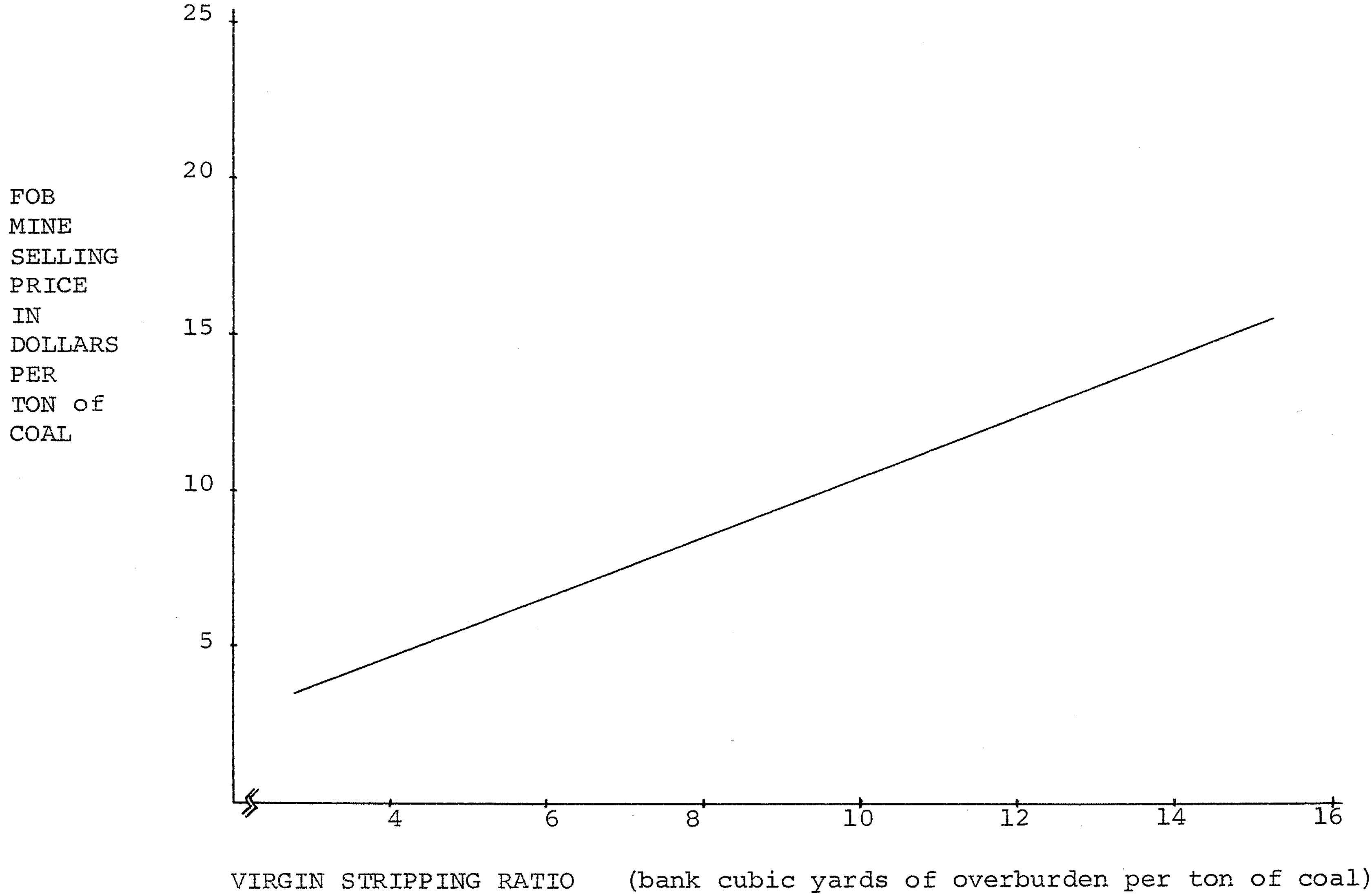
EXHIBIT IV-7
PERIPHERAL MINING SYSTEM
PRODUCTION AND OPERATING COST SUMMARY
(Depreciation, Labor, and Supplies)

ELEMENT	UNITS	ANNUAL PRODUCTION	FIXED COST	VARIABLE COST	TOTAL COST	COST PER UNIT OF PRODUCTION	COST PER TON OF RAW COAL
Overburden Preparation	Acres	75	16,000	$1,471,800	$1,487,800	19,837	$ .456
Overburden Removal	Cubic Yards	21,008,466	564,000	1,975,659	2,539,659	.121	.779
Coal Removal	Tons	3,262,184	57,250	470,595	527,845	.162	.162
Coal Haulage	Ton-Miles	9,786,552	300,000	830,576	1,130,576	.116	.347
Reclamation	Acres	80	110,000	480,198	590,198	7,377	.181
Mine Administration	—	—	253,579	222,000	475,579	—	.146
Production Support	—	—	321,950	1,298,691	1,620,641	—	.497
TOTAL	—	—	1,622,779	$6,749,519	$8,372,298	—	$2.568

EXHIBIT IV-8

SENSITIVITY ANALYSIS OF MINE PRICE TO STRIPPING RATIO

PERIPHERY MINING SYSTEM



beginning, physical and geological information is obtained at an earlier stage and must be delt with during the mine development period. This reduces the time allowed to make operating adjustments.

The system is straight forward once the mine plan is complete. The development of the plan is more complex, however, and requires the trade-off of numerous alternatives. Examples include the access peninsula, highwall ramps, transporting of topsoil, pit width, tipple location and power distribution.

Constraints to implementation include the increased front-end cost of a longer boxcut and the increased amount of planning. The system is definitely limited to reserves of favorable geology where the total area is mineable on an economic basis. The size of the property determines the perimeter distance and the length of the original highwall. The size of the dragline available and the overburden height determines the rate of advance. The property and dragline capacity together determine the maximum age of the highwall. This may or may not be a constraint depending on the climate and the geology of the overburden.

The shape of the reserve may be a limitation. Ideally, it would be circular or of an angular geometry where all inside angles are less than 180 degrees. Irregular appendages to the main reserve would require special consideration and possibly increase rehandle of overburden.

There are no safety or labor constraints which are not common to a conventional dragline straight pit operation. One mining company is known to have a plan for installing this system ten years from now.

Environmental Benefit Analysis

This system offers the opportunity for retreat mining with its advantages of more concurrent reclamation and the elimination of spoil haulage roads. Reclamation can be continuous with overburden removal to within at least two spoil ridges of the pit as in a conventional mine, but the total area unreclaimed is greater. At the beginning of mining operations, the disturbed area of a peripheral mine could be as much as two to four times as large conventional area mining operations.

The berm created from the box cut spoil surrounds the property and effectively hides most of the operation from public view. It also reduces the noise from blasting outside the perimeter of the mine. All precipitation falling within the perimeter will stay there until it is pumped out to a settling pond. Water pollution can consequently be eliminated because of the total control of rainwater runoff.

If the seam of coal is tilted, water drainage from the pit will tend to converge in one low spot. This has the advantage of reducing the number of pump sump locations and the number of settling ponds. The berm from the original box cut that circumscribes the property diverts rainwater runoff and prevents it from entering the pit. These factors make it a much drier operation and reduce landslides, siltation and erosion as well as acid mine drainage.

The system described for the model mine inverts the overburden strata below the subsoil and would be undesireable in many circumstances where toxic strata needs to be buried. If the dragline worked only from the highwall work bench, the selectivity would be the same as is typically encountered in area strip mines and the rough grading of spoil would be done entirely by dozers.

Cost Benefit Analysis of Model Mine

The model mine, with a coal production of 3,262,184 tons per year, has an original cost of $22,859,580 with an annual depreciation cost of $1,622,779. The special mine development cost attributable to the peripheral boxcut is $2,644,650. The total annual production cost including depreciation is $13,763,477, and the selling price required for a 20 percent rate of return is $5.77 per ton. The annual cash flow resulting from that price is $5,099,667. (See Exhibits IV-3 to IV-7.)

The benefits to be derived from its implementation are primarily in the area of environmental protection and land reclamation. While it averages the stripping ratio, it does not reduce mining costs. It eliminates the final highwall, it allows for retreat mining, it is less visible from surrounding areas, blasting noise is less outside the perimeter, outside curves reduce rehandling, dragline deadheading is not necessary except around highwall ramps, road maintenance may be less and there is less water in overburden blast holes.

With regard to limitations, the system is very site specific. The mining method is not confined to a dragline, but it would be the machine of preference in most cases because of the reclamation advantages of using it to reduce spoil peaks and transfer topsoil from the working bench to the spoil pile.

Topography offers no special constraint to the system. It has been used in hill top removal in some eastern mining applications according to one mining spokesman.

Climatic conditions would present problems if the precipitation was particularly high. All of the water falling within the perimeter eventually finds its way into the pump sumps or dams, and if it were substantial it would adversely affect the costs of operation.

The physical limitations, as mentioned previously, include the shape and size of the property and the presence of unmineable areas within the perimeter. The degree of dip of the coal seam could also offer obstacles to an economical operation if it were substantial.

Given compatible circumstances, the system's production limitations are controlled only by the capacity of the primary excavation equipment that is chosen or is available. The stripping ratio encountered during the development phase of a mine using this system is important because of the substantial costs of completing the perimeter box cut.

In order to compare the peripheral mining system to other mining systems, a strip ratio sensitivity analysis was performed. The results of the analysis are shown in Exhibit IV-8. The graph was developed by holding all costs constant except those associated with coal loading and hauling and varying these according to the amount of coal corresponding to the stripping ratio.

EXHIBIT IV-3
PERIPHERAL MINING SYSTEM
DEPRECIATION SCHEDULE

ITEM:	NUMBER	COST	LIFE	ANNUAL DEPRECIATION
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631C Scraper	2	378,000	6	63,000
195-B Loading Shovel	1	1,045,000	20	52,250
Coal Drill & Tools	1	50,000	10	5,000
Cat 660 Haulage Trucks	6	1,800,000	6	300,000
D-8H Dozer	1	107,000	4	26,750
Reseeding Equipment	1	55,000	10	5,500
Cat 16 Road Grader	1	100,000	5	20,000
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Water Truck, 8000 Gal.	1	10,000	8	1,250
End Dump Truck, 10 Ton	1	18,000	10	1,800
Heavy Duty Crane L1400	1	165,000	20	8,250
Lowboy Trailer & Tractor	1	120,000	10	12,000
Cable Trailer, Towed	1	6,000	10	600
Fuel & Lube Truck	1	31,000	10	3,100
Portable Comp. & Generator	1	70,000	7	10,000
Automotive Equipment	1 Lot	50,000	5	10,000
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Forklift	1	15,000	5	3,000
Pumps & Piping	1 Lot	85,000	6	14,200
High Voltage Pole Line	1 Lot	72,000	20	3,600
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Two-Way Radio Equip.	1 Lot	15,000	10	1,500
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EXHIBIT IV-4
PERIPHERAL MINING SYSTEM
CAPITAL SUMMARY

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19	-0-	.0313	-0-
20	[998,333]	.0260	[25,957]
TOTAL			$24,833,297

EXHIBIT IV-5
PERIPHERAL MINING SYSTEM
ESTIMATED ANNUAL PRODUCTION COST

Labor Cost:	
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Supply Cost:	
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Explosives	908,403
Total Supply Cost	$ 4,489,919
Auxiliary Cost:	
Contract Services	$ -0-
Communications	3,000
Welfare & Benefit Package	969,800
Health and Safety - $.03/ton	97,866
Royalty - 10% Sales	1,840,642
License and Fees	978,655
Total Auxiliary Cost	$ 3,889,963
Indirect Cost:	
15% of Labor, Supervision and Operating Supplies	$ 1,122,802
Fixed Cost:	
Insurance and Taxes	$ 378,414
Depreciation	1,622,779
TOTAL PRODUCTION COST	$13,763,477

INTRODUCTION AND SUMMARY

The block-area mining technique usually employs equipment such as dozers and front-end loaders to doze and carry overburden material that is no deeper than 40 feet. Reclamation grading and overburden removal are integrated operations.

Block-area mining using tower excavators for most of the overburden removal is an untried system although one small capacity machine has been used in a coal mine for pullback work. An open bottom bucket is drug and controlled by a set of cables running between two towers stationed on each side of the block of land that is being mined. Supplemental equipment, such as dozers and wheel loaders, is required to expose the coal seam and to rehandle spoil on the mined out side of the seam. Its application is confined to materials which are unconsolidated and works best in free caving sand or aggregate.

Compared to block-area mining with dozers and front-end loaders, the proper application of tower excavators will increase the depth of overburden that can be removed from 40 to 100 feet. Production increases that might be attained depend upon the size of machine chosen. Tower excavators with capacities up to 15 cubic yards are in use in other applications such as gravel pits and river dredging. Preliminary analysis has been done on machines with bucket sizes up to 100 cubic yards.

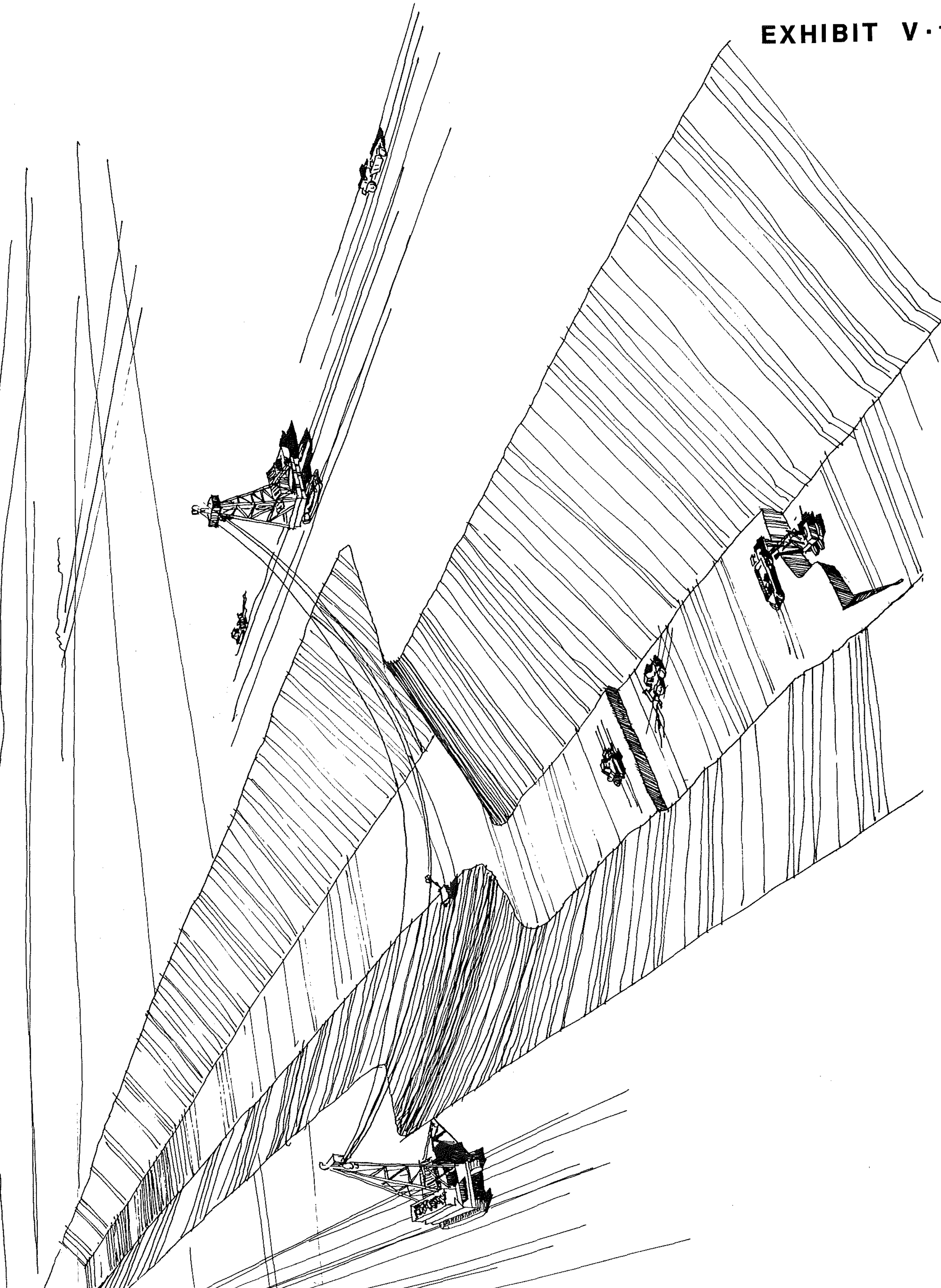
Owning and operating costs of the tower excavator including operating labor are estimated at $0.26 per bank cubic yard of overburden 73 feet thick. This cost is comparable to those anticipated in block-area mining with dozers and front-end loaders.

Reclamation grading is an integral part of the overburden removal process as the tower machine leaves no ridges. Grading must be done in advance of the towers to prepare a level bench for the headtower to rest on. The width of the cut can be more than ten times the depth of the overburden, and as a result the amount of disturbed area can be rather large. This tendency is somewhat diminished, however, by the need to have a fairly short pit to minimize coal haulage and topsoil haulage costs. Two access/haul roads through the spoil are used, one at each end of the pit.

The need for selective placement of overburden is accomplished by the complimentary mobile equipment working in the pit and on the surface. Scrapers haul topsoil around the pit and deposit it on graded spoil behind the head tower machine.

The system has the advantage of being able to dig deeper overburden at about the same cost as dozers and front-end loaders generate in fairly shallow overburden. Spoil peaks are nominal compared to dragline and stripping shovel mines and reclamation grading is more concurrent. Selective excavation and placement of overburden is better than some other mining systems. It is also a very safe mine because of the gentle slopes of both the highwall and the spoil bank. Exhibit V-1 shows a perspective sketch of the Tower Excavator Mining System.

EXHIBIT V·1



TOWER EXCAVATOR MINING SYSTEM

DESCRIPTION OF THE MINING SYSTEM

The tower excavator coal mining system is a modification of the traditional block area mining method using mobile equipment. It can be employed only to a limited extent where geologic and climatic conditions permit and only in unconsolidated overburden. A detailed description of the operating methodology, equipment requirements and a description of a hypothetical mine using the tower excavator system is included in this section of the report.

Operating Methodology

In the tower excavator mining system, overburden excavation consists of two basic steps:

- Ground preparation
- Overburden excavation

These will be discussed below in detail.

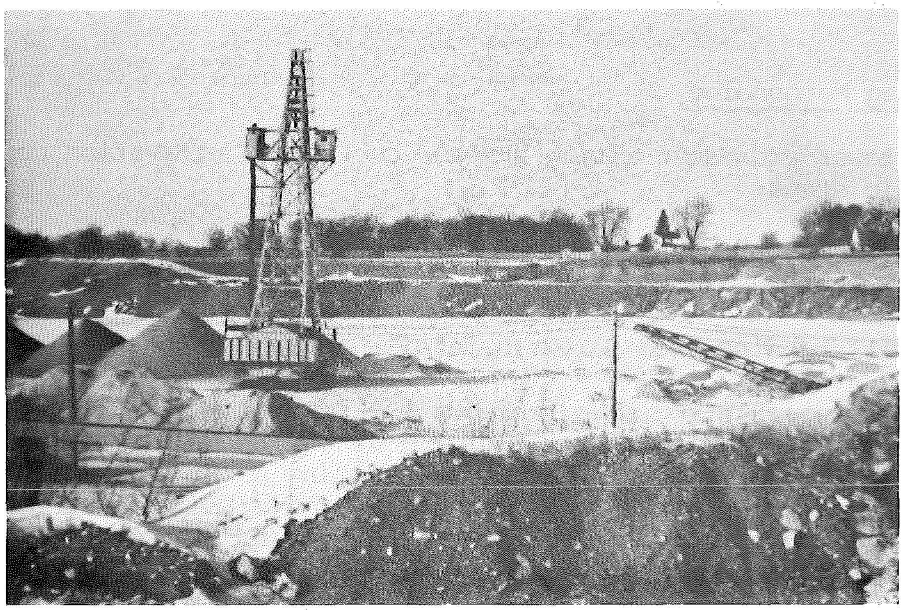
The ground preparation step includes the removal of brush, rocks and trees and the scalping of any topsoil. It may be necessary to transfer soil from some other area if the existing surface strata will not sustain vegetative growth. Pan scrapers remove the topsoil ahead of the other overburden removal operations. They travel around the ends of the the pit, deposit the material behind the head tower and return to the tail tower side of the pit for another load. The twin tower system eliminates spoil ridges like those that are typical of area mining. The scrapers, in this system, deposit the topsoil in its final location and have little need to stockpile or rehandle topsoil once the original box cut is completed.

This adaptation of block area mining utilizes a twin tower excavator to do most of the excavating work. The head tower is positioned on the leveled spoil and is connected to the tail tower by long cables. The tail tower is positioned on the undisturbed overburden side of the dish shaped pit. The excavating bucket which is suspended from these cables is bottomless. It is drug across the overburden surface by the head tower machine and when it is full, it automatically stops loading itself. The head tower continues to drag the bucket down into the pit and up over the spoil to the point where the operator wants to deposit the load. At the spoil location, the cables lift the rearend of the bucket, the spoil slides out the bottom and the bucket is returned to the overburden side of the pit, suspended in the air by the cables. The tower machine can dig down to within a few feet of the coal. The remaining excavation must be done by auxiliary equipment.

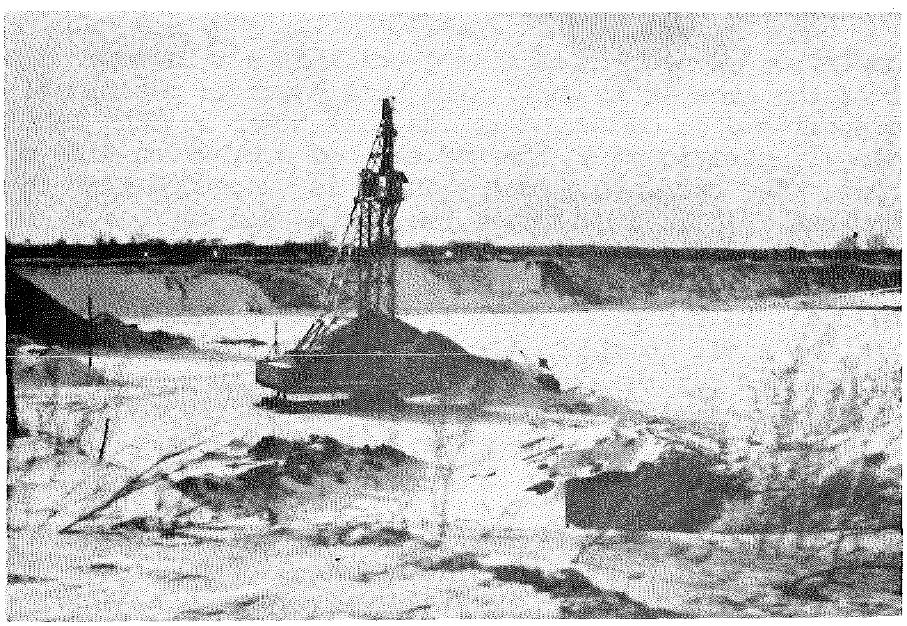
The practical limit of distance between the towers is considered by a manufacturer to be 1,000 feet. This would allow the tower excavator to excavate about 100 feet depth of soft overburden. The average bucket haul distance would approximate 600 feet and the average operating cycle time is estimated to be about four minutes for that distance.

With 50 feet of overburden, the towers would only have to be 500 feet apart. The average haul distance would be about 350 feet and the cycle time would approximate 2 1/3 minutes.

The production figures given above are only general approximations. They do show, however, the general relationship between depth of cut and cycle time and indicate the need for careful evaluation of the degree that auxiliary or tandem equipment should be used for the excavation of overburden.



HEAD AND TAIL TOWERS OF A TOWER EXCAVATOR



HEAD TOWER OF A TOWER EXCAVATOR

When the twin tower excavator reaches the end of the pit, it gradually shifts its orientation so that it digs diagonally to the center line of the pit. This is necessary to keep from blocking the access road and to maintain a uniform pit length. Once this corner work is completed, it deadheads back to the other end of the pit to begin excavating a second pass.

Auxiliary equipment located at the base of the pit must remove the remaining few feet of overburden from the coal seam's surface and rehandle the wedge of spoil located between the side of the coal seam left from the previous cut and the spoil pile. This rehandle constitutes about 14 percent of the overburden. The tower excavator cannot remove this material that has been filled into the previously mined out pit because the attached cables connected to the two towers would rub against the coal seam and prevent the bucket from digging any deeper.

The auxiliary excavating equipment includes track type dozers and front-end loaders. The dozers concentrate on removing the wedge of spoil along side the coal seam and push it up on the spoil slope. The front-end loader removes the remaining overburden from the surface of the coal seam and deposits it where the dozers can push it up on the spoil.

Coal is removed with a front-end loader or an electric loading shovel and is loaded into coal haulage trucks. Depending upon which end of the pit the tower excavator is working, the coal haul trucks will alternatively drive on the coal surface and the pit floor. In either case they enter the pit at one end, coming down one of the two ramps through the spoil, and return the same way to deliver the coal to the tipple.

The reason coal is hauled alternately up end-of-pit ramps at one end or the other is that the tower excavator bucket scrapes along the surface of the pit from one side to the other. For the same reason, the coal haulage trucks are alternately loaded on the surface of the coal seam and the surface of the mined out pit.

Pit Design

The cycle time of a tower excavator is a direct function of the distance between the towers. This distance is established by the depth of cut desired. Speaking in general, the deeper the cut, the longer the cycle time. Cable length is directly related to the distance between towers and their cost increases rapidly as their length increases.

In mine planning, a trade off exists between the depth of cut that the tower excavator might make and the amount of overburden that might be handled by auxiliary equipment. If the overburden depth that remains for auxiliary equipment handling becomes appreciable, it is necessary to consider the use of a stripping shovel. It would have to be supported by track type dozers to remove the spoil wedge at the side of the coal seam just as the front-end loader would.

The slopes of the unmined overburden side of the pit highwall, and the spoil pile are very gentle where they intersect the working pit, and as a consequence, the hazards from falling objects are reduced. This pit shape is characteristic of tower excavators and results from a combination of vectors created by the bucket's weight and the pulling force of the towing cable. The maximum angle of repose for either the spoil or the highwall is 35 degrees.

The width of the cut must be large enough to allow the coal haulage trucks room to turn around. Through pit coal haulage is not practical because the tower excavator bucket is drug across the surface of the pit. Haulage roads through the spoil, except at the ends of the pit, are not practical either because the tower excavator's head tower cannot tram around them without having excessively long cables. Consequently, the minimum pit width at the base is about 100 feet.

In contrast to the pit width, the pit length is more or less arbitrary, but generally straight. One mile is recommended to recover one section of reserves and maintain the digging efficiency of the machine. The corner work which is done when the tower excavator operates diagonally will be a little slower than when it works normal to the pit, and this potential reduction in productivity has to be weighed against in-pit haulage distances for the coal trucks. There are several basic limitations to the application of this mining system.

The twin tower excavator works best in free caving, unconsolidated overburden. It has been used to dredge river bottoms, to excavate gravel pits and to perform similar functions with considerable success. To consider it for surface coal mining, the nature and texture of the overburden must be amenable to the action of a bottomless bucket. The bucket has no breakout force except for its own weight. It can handle rock if the cables are lined up over the object and the rock is small enough to enter the bucket.

Another limitation is the topography. The towers have to work in an upright position and cannot traverse irregular ground. Frequently they are mounted on rails to facilitate lateral movement and to provide a firm, horizontal foundation.

Climatic conditions will also pose limitations. The head tower must be mounted on the spoil, and if they are soft enough to be mined by the tower excavator, they would, most probably, be so soft when wet that road ballast would have to be built on top of the spoil or some other measure taken to compensate for the soft footing.

Equipment Requirements

This section of the report covers the equipment that is required, the job that each piece of equipment accomplishes and the reasons for the selection of a particular type of equipment for a given task. This mining system requires a twin tower excavator of a size that has never been constructed. However, designers and equipment manufacturers have expressed the opinion that machines up to 50 cubic yards capacity could be constructed. The largest machine that has been built has a bucket capacity of 15 cubic yards and this size is not considered to be practical for large capacity coal mines. The other items of equipment needed are currently available and are in use in most domestic surface coal mines.

Pan scrapers do the work of removing the topsoil and subsoil in the operation of ground preparation. The material is totally unconsolidated soil, clay, sand and small rocks. The scrapers remove this upper strata ahead of the tail tower a sufficient distance that the remaining surface can be adequately leveled by a bulldozer. They transport it around the pit to the general area of the head tower and deposit it on the leveled spoil where the tower was previously located. The size and horsepower of the scrapers must be sufficient to load, haul and return fast enough to keep ahead of the tail tower's advance. Self loading or push-pull types are preferred to those that require a push dozer to load.

The quantity of scrapers needed is determined by balancing production requirements with the cubic yard capacity of each machine and the average time it takes to make a round trip. The time depends primarily on the length of the pit and the road surface condition. The yardage of topsoil to be handled in a given time to keep ahead of the tower excavator's advance is divided by the cubic yards the scraper can handle in the same time to determine the number of scrapers that are required. A road grader working part-time does the final grading. A tractor drawn seeder, hydro-seeder or an aircraft spreads the seeds, mulch and fertilizer over the reclaimed area. This work is done at certain times during the year when climatic conditions are right and when a large area is prepared for planting.

The primary excavator is unable to dig consolidated overburden. In appropriate applications, overburden blasting equipment is not required. Whether working alone or in tandem with a shovel, the tower excavator is the prime mover of overburden and coal production depends directly on its digging speed. The fact that the tower excavator drags its bucket rather than lifting it allows it to move one and one-half to two times the amount of material for the same horsepower that a dragline needs. Unfortunately, its cycle time is greater because the material is moved much longer distances. In general, the selection of a twin tower excavator is guided by the ratio of one foot of digging depth for ten feet of tower span. Currently the maximum practical distance between head and tail towers is 1,000 feet. This distance corresponds to a maximum pit depth of approximately 100 feet. The size of the bucket will be determined by the coal production requirements, the partial stripping ratio attributable to the tower machine and the characteristics of the overburden which are unique to each mining site. The annual bank cubic yard requirement of the tower excavator is found by multiplying the planned coal production by the raw coal stripping ratio times the fractional portion of the overburden that the tower machine will dig. That quantity is then compared with the digging cycle time and the predicted working hours to arrive at the bucket size.

It was mentioned previously that auxiliary equipment was needed to remove the lower portion of the overburden. If the overburden is relatively shallow, this equipment will consist of bulldozers and front-end loaders.

In deeper overburden, either a loading shovel or a stripping shovel will be needed to handle the increased volume. In the first case, the bull-dozers push the material up the gently sloping incline of the spoil pile and most of the excavation is done by a front-end loader. In the second case, the shovel would excavate overburden and build a secondary spoil pile on top of the existing one far enough away from the coal seam that the dozers can remove the wedge of spoil along side of the coal seam. The boom length of the shovel will be determined by this distance, and the distance is a function of the coal seam thickness and the angle of repose of the spoil.

The determination of what kind and capacity of auxiliary equipment is needed should be made concurrently with the specification of the tower excavator. It is the sum of the capacities of the different pieces of equipment that determines the rate of removal of the total amount of overburden.

The coal removal and loading in the tower excavator mine is accomplished by the conventional coal loading shovel or by front-end loaders. This depends in part upon the hardness of the coal and whether or not blasting is required. The electric loading shovel is preferred because of its high break out force and low down time. If coal blasting is required, the mine equipment will include an auger coal drill and the support blasting equipment.

The loading shovel works on the pit floor excavating the coal from the face of the seam, rotating and dumping it into the coal haulage truck that is waiting either on the pit floor or on top of the coal seam. During coal removal at the end of the pit, the trucks will enter the working area on the coal seam's surface and if the coal is too thick for the shovel to reach up and dump into the truck, the truck will have to ramp down to be loaded on the pit floor.

The coal haulage trucks are large, off-highway bottom dump or rear dump vehicles. The kind and size will be determined to a great extent by the driving conditions in the pit. They should have a short turning radius and adequate horsepower to maneuver any steep grades and adverse road conditions. The number of trucks is determined by the haulage capacity and the average time for a round trip haul from the pit to the tipple.

Support equipment and vehicles for the activities discussed above would be similar to those required in a conventional area mine. The equipment would include at least a dozer, motor grader and roller for road work, a water truck, a crane for maintenance activities, a cable hauler, a lowboy trailer, a fuel and lube truck, air compressor, pumps, automotive equipment and other minor items. This equipment is not scheduled like the primary operations equipment but is utilized when needed.

This completes the description of the equipment requirements for the tower excavator mining system. The following section describes a hypo-thetical model mine and it includes more specific information regarding equipment.

NARRATIVE DESCRIPTION OF MODEL MINE

The tower excavator model mine is located in the western coal region and has the following physical characteristics:

- Mineral rights have been obtained for a one square mile section with land access rights to adjacent property.
- Three feet of suitable topsoil material is available.
- Overburden below the topsoil consists of 70 feet of unconsolidated, sandy material.
- The single coal seam is fairly flat and averages 20 feet in thickness.
- Average stripping ratio for the mine's life of 20 years is 3.4:1.

Ground Preparation

Ground preparation consists of topsoil excavation and highwall bench leveling. Two 20 cubic yard pushpull scrapers are used to remove the three feet of topsoil. This is done two shifts per day, five days per week. The scrapers load topsoil ahead of the pit excavation and transport the material around the pit and deposit it on the spoil. One dozer assists in ground preparation by maintaining an even loading zone for the scrapers and by leveling the overburden for the tail tower to work on.

Ground preparation capacity is 1,102 loose cubic yards of topsoil per shift hauled a one-way distance of 4,500 feet to the spoil area.

Overburden Excavation

Primary overburden excavation is performed by a hypothetical 50 cubic yard twin tower excavator. All other equipment requirements are designed to support the tower excavator's stripping capacity.

The tower excavator scrapes overburden from the highwall side to the spoil side of the pit in front of the head tower and traverses the mile-long pit in approximately 61 days working around the clock. Reaching the end of the pit, the towers deadhead back to the opposite end and begin the excavation of next pit. The tower machine is scheduled to dig 21,060 bank cubic yards of overburden per 24 hour days, 364 days per year.

Following the primary excavation, a seven cubic yard wheel loader and two 180 horsepower dozers remove the overburden near the coal seam and clean the exposed surface of the coal. This remaining overburden is pushed onto the nearby spoil pile by the dozers and taken behind the coal loading operation and deposited on the pit floor by the wheel loader. The two in-pit dozers and a wheel loader are operated two shifts per day, five days per week. The in-pit overburden handling and coal cleaning operation is scheduled to move 4,331 loose cubic yards of material per shift.

Following this operation, the coal is drilled and blasted. A nine inch truck mounted auger drill is used for coal drilling. ANFO prills and dynamite are used for blasting. Coal drilling and shooting are performed one shift per day, five days per week. Blasting is done at the end of the day shift.

Coal Removal and Haulage

A 14 cubic yard electric shovel loads coal into a fleet of three 120 ton bottom dump trucks for the three-mile haul to the tipple. Coal loading and haulage is done two shifts per day, five days per week. Planned coal production for the model mine is 2,337,264 tons per year.

Reclamation

Reclamation is an integrated part of the overburden excavation and ground preparation. One dozer levels the spoil piles created by the tower to make a working bench for the next pass. After the head tower proceeds to a new position, the scrapers spread topsoil over the spoil area. In this way, approximate original contour is achieved and continuous reclamation is integrated with stripping. A road grader finish grades the topsoil to effect the final contour.

A summary of the tower excavator model mine equipment is shown in Exhibit V-2 on the following page. Operating equipment is detailed by description, assignment, required production, and physical requirements.

ANALYSES OF THE SYSTEM

Engineering Feasibility Analysis

With the exception of the tower excavator machine, all required mining and mine support equipment is proven and on the market. Lead time for equipment delivery of mobile units is less than one year. Loading shovels require one to two years for delivery. Tower excavators up to 15 cubic yard capacity are on the market and preliminary analysis with respect to large capacity (50-100 c.y.) mobile tower systems has been done. It is estimated, however, that a four to five year lead time is required to complete design and fabrication of a large capacity machine.

The tower excavator mining system is limited to areas where the overburden is unconsolidated and where the terrain is relatively flat. Even towers designed with a very low center of gravity would not be able to operate on, or traverse an uneven ground surface.

EXHIBIT V-2

TOWER EXCAVATOR MINING SYSTEMS

EQUIPMENT DESCRIPTION AND OPERATION REQUIREMENTS

ITEM:	NO.	DESCRIPTION	OPERATION ASSIGNMENT	REQUIRED PRODUCTION	PHYSICAL REQUIREMENTS
Push-Pull Scraper	2	950 Horsepower	Remove/Replace Topsoil	961 LCY/Shift	4500 Foot Travel One Way
Dozer	2	385 Horsepower	Bench Preparation for Head & Tail Towers	Not Applicable	Not Applicable
Tower Excavator	1	50 Cubic Yards, Scraper Bucket	Overburden Removal & Movement	7020 BCY/Shift	1000 Foot Span
Dozer	2	180 Horsepower, U Blade	Clean Coal	3198 LCY/Shift	Not Applicable
Wheel Loader	1	7 Cubic Yards, 325 Horsepower	Clean Coal	2288 LCY/Shift	20 Foot Reach
Powder Truck	1	5 Ton Flatbed	Load Coal Holes	Not Applicable	Not Applicable
Coal Drill	1	9" Auger	Drill Coal	Two Feet/Minute	20 Foot Deep Holes
Coal Shovel	1	14 Cubic Yards, Bucket	Excavate & Load Coal	4816 Tons/Shift	25 Foot Lift
Bottom Dump Trucks	3	120 Ton	Haul Coal to Tipple	4816 Tons/Shift	Haul 3 Miles One Way
Road Grader	1	250 Horsepower	Roads & Reclamation	Not Applicable	Reclamation & Support
Seeding Equipment	1	Tractor Drawn Plow & Seeder	Final Reclamation	68.4 Acres/Year	High Flotation
Road Roller	1	25,000 Pounds Impact, Vibration	Roads	Not Applicable	Support Activity
Water Truck	1	8000 Gallon	Roads	" "	" "
Dump Truck	1	10 Ton	Roads & Miscellaneous	" "	" "
Heavy Duty Truck Crane	1	310 Horsepower	Maintenance	" "	" "
Lowboy Tractor & Trailer	1	50 Ton, 3 Axle, Rear Loading	Maintenance	" "	" "
Towed Cable Trailer	1	30 Ton, 2 Axle, Flush Deck	Cable Transport	Not Applicable	Support Activity
Fuel & Lube Truck	1	1000 Gallon	Fuel & Lube Transport	" "	" "
Rubber Tired Dozer	1	400 Horsepower	Roads & Miscellaneous	" "	" "
Forklift	1	4000 Pound, 68 Horsepower	Maintenance	" "	" "
Portable Compressor & Generator	1	30 KW, 150 Horsepower	Field Lighting	" "	" "
Automotive Equipment	10	3/4 Ton Pickups	Supervision & Maintenance	" "	" "

Because of the large span between the head and tail towers, land rights must be obtained on adjacent properties in order to fully extract the total permit reserves. This is especially relevant in the West where reserves are often owned and controlled in alternate sections.

The towers require design and fabrication of walking/crawler mechanisms which have a low bearing pressure for stability on soft spoil areas.

Legal requirements relative to reclamation can be met. The system enables some selective deposition of spoil, and reclamation is concurrent with mining although it does disturb a relatively large area.

The tower machine has a productive capacity roughly half that of a comparably sized dragline because of long bucket haul distances. Field evaluation of the mining system included interviews with two manufacturers of tower excavators, inspection of a tower excavator gravel pit operation, and discussions with a strip mine operator who had used a tower excavator to rehandle stripping shovel spoil.

The estimated cost of a 50 cubic yard tower excavator is 1.5 to 2 times the cost of a comparable dragline and the slow cycle time increases the cost of operation substantially.

Although the manufacturer felt that the tower excavator would handle overburden under freezing conditions, the mine operator doubts that the scraper bucket would dig frozen material effectively.

Implementation Analysis

The anticipated lead time to implement a large capacity tower excavator mining system is about six years. The system implementation would be straight forward given the availability of equipment, mine site and adequate planning, and would be similar to the requirements of a conventional dragline system.

Environmental Benefits

The relative environmental impact of the tower mining system is favorable: some selective placement of spoil, concurrent reclamation with mining, ability to bury rocks, reclaimed land profiled to approximate original contour, and moderate highwall and spoil slopes. The one visual liability to the mining method is the relatively large area which is disturbed during mining.

Cost Benefit Analysis

An economic analysis of the tower excavator model mine was performed in order to compare the system with other mining systems.

Exhibit V-3 gives the depreciation schedule and Exhibit V-4 shows the estimated capital requirements for the tower system discounted over a 20-year mine life. A large majority of the capital investment is at the beginning of the project. This is mostly due to the cost of the tower excavator. An indication of the relative capital requirements can be made by comparing initial capital investment of a system to annual tonnage. For the tower system model mine, initial capital required per annual ton is 9.2. A comparable dragline system's initial capital per annual ton is only 6.2.

Analysis of the model mine operating costs was made by compiling direct labor, mine administration costs, power costs, operating supplies, maintenance costs, and ammortization. The results of this analysis are shown in Figure V-5. For simplification, annual costs are summarized by fixed and variable components. Annual production levels are listed by specific operation element.

Exhibit V-7 shows the estimated production cost summary for the tower excavator model mine. Based on the total estimated annual production cost and annual output, the estimated sales price for the tower system model mine is $6.56 per ton F.O.B. mine as shown in Exhibit V-6.

Evaluation of the tower excavator mining system in terms of the system's sensitivity to stripping ratio was made. Exhibit V-8 illustrates the results of this strip ratio sensitivity analysis. The graph was developed by holding all costs constant except those associated with coal loading and hauling and varying these according to the amount of coal corresponding to the stripping ratio.

The tower excavator mining system is a unique mining method and has some limitations with respect to its potential application.

- It would require unconsolidated overburden with a practical depth limit of 100 feet.
- The system would be confined to flat or gently rolling topography.
- Wet unstable spoil would impede the head tower's ability to move, and it is doubtfull that the bucket would dig frozen ground.
- The system permits total recovery of reserves only if adjoining surface rights are acquired for temporary equipment operation.

EXHIBIT V-3
TOWER EXCAVATOR MINING SYSTEMS
DEPRECIATION SCHEDULE

ITEM:	NUMBER	COST	LIFE	ANNUAL DEPRECIATION
627-B (P-P) Scraper	2	$ 600,000	6	$ 100,000
D-9 Dozer	2	370,000	4	92,500
50 Cubic Yard Tower Excavator	1	14,875,000	20	744,000
D-7 Dozer	2	194,000	4	48,500
988 Wheel Loader	1	124,000	4	31,000
Powder Truck	1	10,000	10	1,000
Coal Drill Complete	1	50,000	10	5,000
14 Cubic Yard Coal Shovel	1	1,004,000	20	50,200
120 Ton Bottom Dump Trucks	3	900,000	6	150,000
Road Grader	1	100,000	5	20,000
Reseeding Equipment	1	150,000	10	15,000
Road Roller	1	10,000	10	1,000
Water Truck	1	120,000	6	20,000
Dump Truck	1	18,000	5	3,600
Heavy Duty Crane	1	165,000	20	8,250
Lowboy Tractor & Trailer	1	120,000	10	12,000
Towed Cable Trailer	1	5,000	10	500
Fuel & Lube Truck	1	31,000	6	5,200
834 Dozer	1	150,000	4	37,500
Forklift	1	19,000	10	1,900
Repair Shop, Garage, Tools	1 Lot	150,000	20	7,500
High Voltage Power Lines	1 Lot	72,000	20	3,600
Sub-Station	2	180,000	20	9,000
Circuit Breaker	2	18,000	20	900
Pumps/Piping	1 Lot	85,000	6	14,200
Portable Compressor/ Light Plant	1	70,000	10	7,000
Portable Tools/Field Equipment	1 Lot	130,000	8	16,250
Automotive Equipment	1 Lot	50,000	4	12,500
Two-Way Radio Equipment	1 Lot	15,000	10	1,500
Engineering/Design/ Legal	1 Lot	50,000	20	2,500
Exploration Cost	1 Lot	75,000	20	3,750
Crusher/Loader	1 Lot	3,000,000	20	150,000
TOTALS		$22,910,000	. . . .	$1,575,850

EXHIBIT V-4
TOWER EXCAVATOR MINING SYSTEM
CAPITAL SUMMARY

YEAR	CAPITAL INVESTMENT	PRESENT WORTH FACTOR @ 20%	PRESENT WORTH INVESTMENT @ 20%
0	$22,910,000	1.0000	$22,910,000
1	-0-	.8333	-0-
2	-0-	.6944	-0-
3	-0-	.5787	-0-
4	888,000	.4823	428,282
5	118,000	.4019	47,424
6	1,736,000	.3349	581,386
7	-0-	.2791	-0-
8	1,018,000	.2326	236,787
9	-0-	.1938	-0-
10	567,000	.1615	91,570
11	-0-	.1346	-0-
12	2,624,000	.1122	294,413
13	-0-	.0935	-0-
14	-0-	.0779	-0-
15	118,000	.0649	7,658
16	1,018,000	.0541	55,074
17	-0-	.0451	-0-
18	1,736,000	.0376	65,274
19	-0-	.0313	-0-
20	[1,230,000]	.0260	[31,980]
TOTAL			$24,685,888

EXHIBIT V-5
TOWER EXCAVATOR MINING SYSTEM
ESTIMATED ANNUAL PRODUCTION COST

Labor Cost:	
Direct	$ 1,734,500
Supervision	378,100
Total Labor Cost	$ 2,112,600
Supply Cost:	
Fuel, Power, Lubricants, Parts Supplies & Repair	$ 2,136,862
Explosives	62,500
Total Supply Cost	$ 2,136,862
Auxiliary Cost:	
Contract Services	$ -0-
Communication	3,000
Welfare & Benefit Package	867,250
Health & Safety - $.03/ton	70,118
Royalty - 10% Sales	1,554,977
License & Fees	701,179
Total Auxiliary Cost	$ 3,196,524
Indirect Cost:	
15% of Labor, Supervision and Operating Supplies	$ 637,419
Fixed Cost:	
Insurance & Taxes	$ 458,200
Depreciation	1,575,850
TOTAL PRODUCTION COST	$10,117,455

EXHIBIT V-6
TOWER EXCAVATOR MINING SYSTEM
MINIMUM SALES PRICE COMPUTATION

Sales = Cost of Production plus Depletion* plus 2 Times Net Profit
Depletion plus Net Profit = Present Value of Capital Due Less Depreciation

Therefore,

Sales = Cost of Production plus 2 Times (present value due, minus depreciation) Minus Depletion

Present Value of Capital Requirements Due in 20 Years @ 20% Compound Interest	
$24,685,888 X .205356	= $ 5,069,494
Less: Annual Depreciation	- 1,575,850
Depletion plus Net Profit	= $ 3,493,644
Sales = 10,117,455 plus 2 (3,493,644) minus Depletion	= $15,549,766
Gross Profit = Sales minus Cost of Production = 15,549,766 minus 10,117,455	= $ 5,432,311
Less Depletion Allowance	- 1,554,977
Taxable Income	= $ 3,877,334
Less Federal Income Tax at 50%	- 1,938,667
Net Profit	= $ 1,938,667
Annual Cash Flow = Net Profit plus Depreciation plus Depletion	= $ 5,069,494
Selling Price Per Ton = Sales divided by Production (15,549,766 divided by 2,337,264)	= $6.65

*10% of Sales not to exceed 50% of Gross Profit

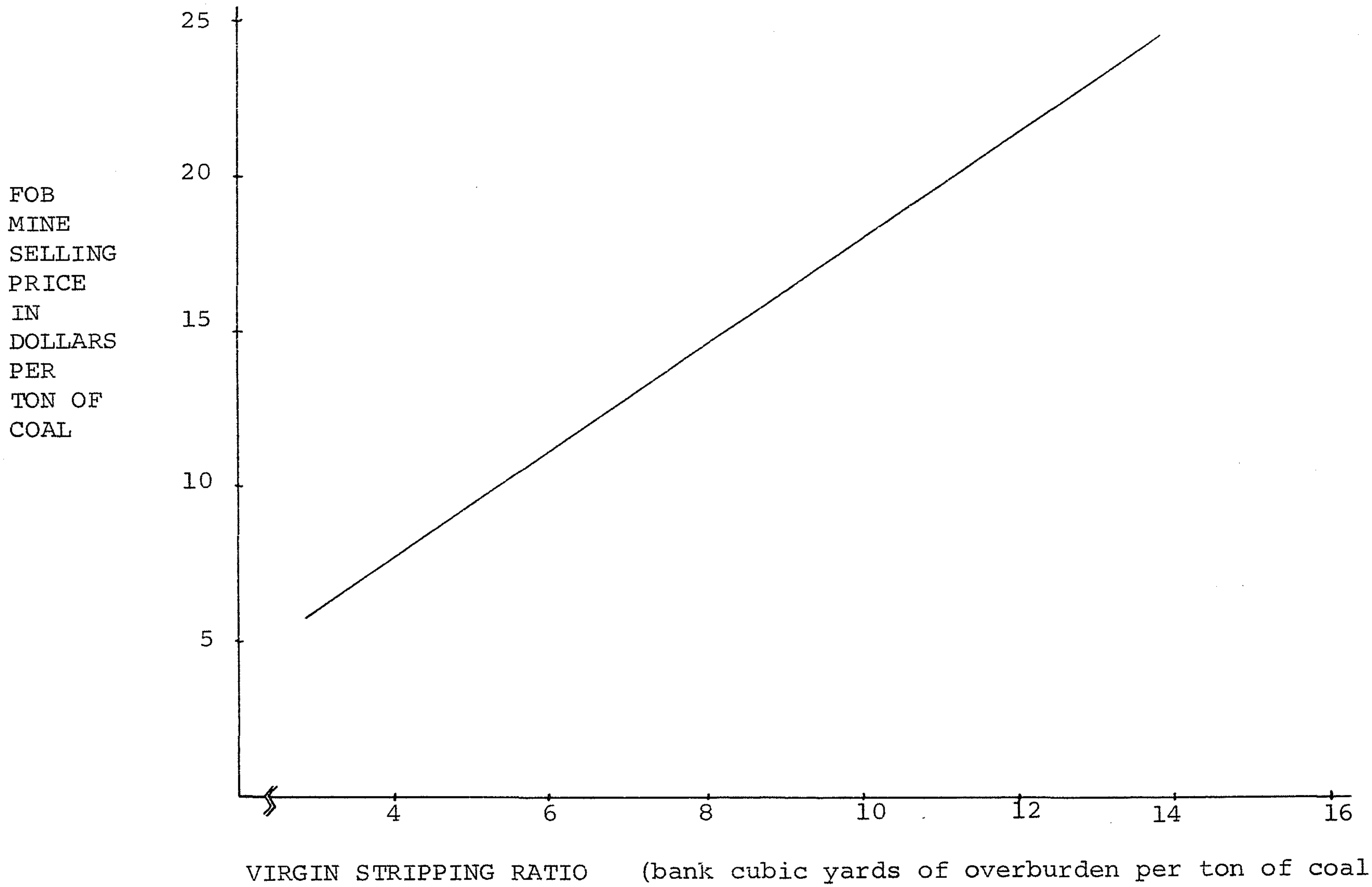
EXHIBIT V-7
TOWER EXCAVATOR MINING SYSTEM
PRODUCTION AND OPERATING COST SUMMARY
(Depreciation, Labor and Supplies)

ELEMENT	UNITS	ANNUAL PRODUCTION	FIXED COST	VARIABLE COST	TOTAL COST	COST PER UNIT OF PRODUCTION	COST PER TON OF RAW COAL
Overburden Preparation	Acres	68.4	$ 96,250	$ 406,102	$ 502,352	$7,344	$ .215
Overburden Removal	Cubic Yards	7,628,684	823,500	1,089,096	1,912,596	.251	.818
Coal Removal	Tons	2,337,264	56,200	352,016	408,216	.175	.175
Coal Haulage	Ton-Miles	7,011,792	150,000	665,040	815,040	.116	.349
Reclamation	Acres	68.4	124,650	510,508	635,158	9,286	.272
Mine Administration & Production Support	—	—	325,250	1,226,700	1,551,950	—	.664
TOTAL	—	—	$1,575,850	$4,249,462	$5,825,312	—	$2.492

EXHIBIT V-8

SENSITIVITY ANALYSIS OF MINE PRICE TO STRIPPING RATIO

TOWER EXCAVATOR MINING SYSTEM



COMPARISON ANALYSIS AND OBJECTIVE RANKING OF SYSTEMS

COMPARISON ANALYSIS OF THE FOUR SYSTEMS

Four major categories have been used to evaluate the four mining systems, viz., engineering feasibility, implementation analysis, environmental benefit analysis and cost benefit analysis. Each one of these categories will be discussed with regard to the relative merit and ranking of each of the four systems.

Under engineering feasibility, the availability of the equipment that makes the system distinctive, the degree to which the system complies with the engineering design parameters, the practicality of the system and the evaluation given it by industry representatives were considered.

- Equipment availability is greatest in a system where the change is confined to the mode of operation, and is least where a major item has to be designed prior to construction. Periphery mining requires no significant changes in mining equipment whereas the tower excavator of a size comparable to a dragline has never been designed or built. There is little difference in the equipment availability for the other two systems.

- The engineering design parameters encompass the integration of mining and reclamation activities, the expansion of coal production in a safe and environmentally responsive manner, competitive costs of operation with emphasis upon effectiveness, agility and flexibility and the ease with which such methods can be merged into existing coal mining procedures. Both the terraced pit and area haulback systems comply with these parameter requirements. Area haulback has the ability to increase production appreciably in existing mines with deep overburden, and is not limited as much by the physical characteristics of the overburden. Periphery mining has environmental advantages but does not increase production or integrate reclamation. The tower excavator complies only partially with the design parameters.

- The practicality of a system depends upon its applicability, the degree of change required to implement it, special skills and similar considerations. The terraced pit, or modifications of it, are currently in use. Area haulback is technically feasible however, there is considerable reluctance on the part of industry to rehandle all overburden. Peripheral mining is severely limited because of reserve geography and geology constraints while the tower excavator uses untried equipment, would have spare parts problems, is limited by geological characteristics and requires the greatest degree of change.

- In the field evaluation of these four systems the terrace pit and area haulback were considered the most feasible and workable, and the greatest interest was shown in the terrace pit. Periphery mining was felt to be very limited in application and the tower excavator was not considered to be a feasible surface mining system by coal industry personnel.

Under implementation analysis, we will consider the immediacy of implementation, the relative ease of implementation, the anticipated level of acceptance of the system by the surface mining industry and the major constraints to implementation. Of the four systems haulback has the greatest potential of being installed as a conversion of an existing mine. Terrace pit is the simplest and would be installed the easiest. It is also the most likely to be acceptable by the industry and has fewer constraints to implementation.

Under environmental analysis, we have the questions of solutions to reclamation problems and the concurrency of reclamation. Terrace pit and area haulback both are capable of strata segregation and selective placement of overburden. They both integrate the process of mining and reclamation. The disturbed area in both cases is about the same. Reclamation is not as current in the terrace pit system because of the spoil wedge left to reduce overburden rehandling on passes of subsequent pits. The periphery and tower excavator systems both require great amounts of unreclaimed land for efficient operation. Block area mining with tower excavators integrates overburden removal and reclamation, but this system is not capable of selective excavation or overburden placement. Land reclamation is an "add-on" operation in the periphery mining system, and a box cut spoil pile must be rehandled and spread out or it will remain after mining has terminated.

Under cost benefit analysis, we will consider capital requirements, sales price per ton, and inherent limitations on the four systems represented by the model mine.

- Scraper terrace pit has the least capital invested per annual yard of overburden moved. Area haulback is second and is 5.3 percent greater. Periphery mining is third and is 14.5 percent greater than terrace pit. The tower excavator is estimated to require 2.2 times the capital investment of the terrace pit. This comparison is based on present value invested per annual ton of virgin overburden moved.

- Comparing the minimum sales price per ton required for a 20 percent rate of return at the same virgin stripping ratio, (utilizing the stripping ratio sensitivity analysis), the periphery mine is least, terrace pit is second lowest and 7 percent more than the periphery mine, the area haulback is 14 percent higher than the periphery mine and the tower excavator is 57 percent higher than the periphery mining system. At a virgin stripping ratio of 5 to 1, the sales prices are: peripheral mining system $5.77 per ton, terrace pit mining system $6.19 per ton, area haulback mining system $6.56 per ton, and tower excavator mining system $9.04 per ton.

- The lack of flexibility of a particular mining method and its ability to be adapted to changing conditions can be considered as a limitation. In the area of mining methods such as equipment types, tandem equipment and the like, the terraced pit system allows for the greatest flexibility. Periphery mining is more limited but retains a good deal of freedom of choice as to equipment capacities; area haulback is limited to a medium capacity dragline although support equipment can vary considerably; twin tower excavators have the least flexibility in the area of mining methods because of the unique functional characteristics of the equipment.

- Stratigraphic limitations such as overburden rock hardness, friability, consistency and blockiness are handled with less constraints by the cross pit casting dragline used in the periphery system. Area haulback is limited by the front-end loaders in this respect, but has a greater degree of freedom than does the terraced pit, especially if scrapers are used. Tower excavators dig fastest in free caving material, and are not adaptable to consolidated overburdens.

- Topography and the depth of overburden that results are very critical for the periphery system because of the cost of the large box cut that starts the mine. The tower excavator must work on level ground and cannot prepare its own bench. Area haulback and terraced pit are both quite flexible in respect to their ability in varying overburden depths.

- Climatic constraints are numerous but perhaps the most critical is heavy rainfall and soft overburden. On the basis of this criterion, the tower excavator has the greatest problem because the heavy head tower must always work on the surface of the spoil. The periphery system is affected least by inclement weather because it relies least on mobile equipment. Area haul back and terraced pit systems both utilize a high degree of vehicle haulage.

- Physical limitations include the average depth of overburden and pitching or tilting coal seams. Area haulback is probably the most flexible in this regard. The terraced pit is somewhat limited with regard to overburden depth because of resulting grades and haulage distances. The peripheral mine is faced with rehandling spoil by the dragline in deep overburden and the tower excavator is limited to moderate depths because of its design.

- The limits to high production in periphery mining are set by equipment design and on a comparative basis they are the least constraining. Terraced pit mining is somewhat more limited because of traffic in the pit and on the terraces although it is potentially higher than area haulback which has even more traffic problems on the working bench. Tower excavators have lower production capacities because of the longer cycle times.

Summary of the Comparison Analysis

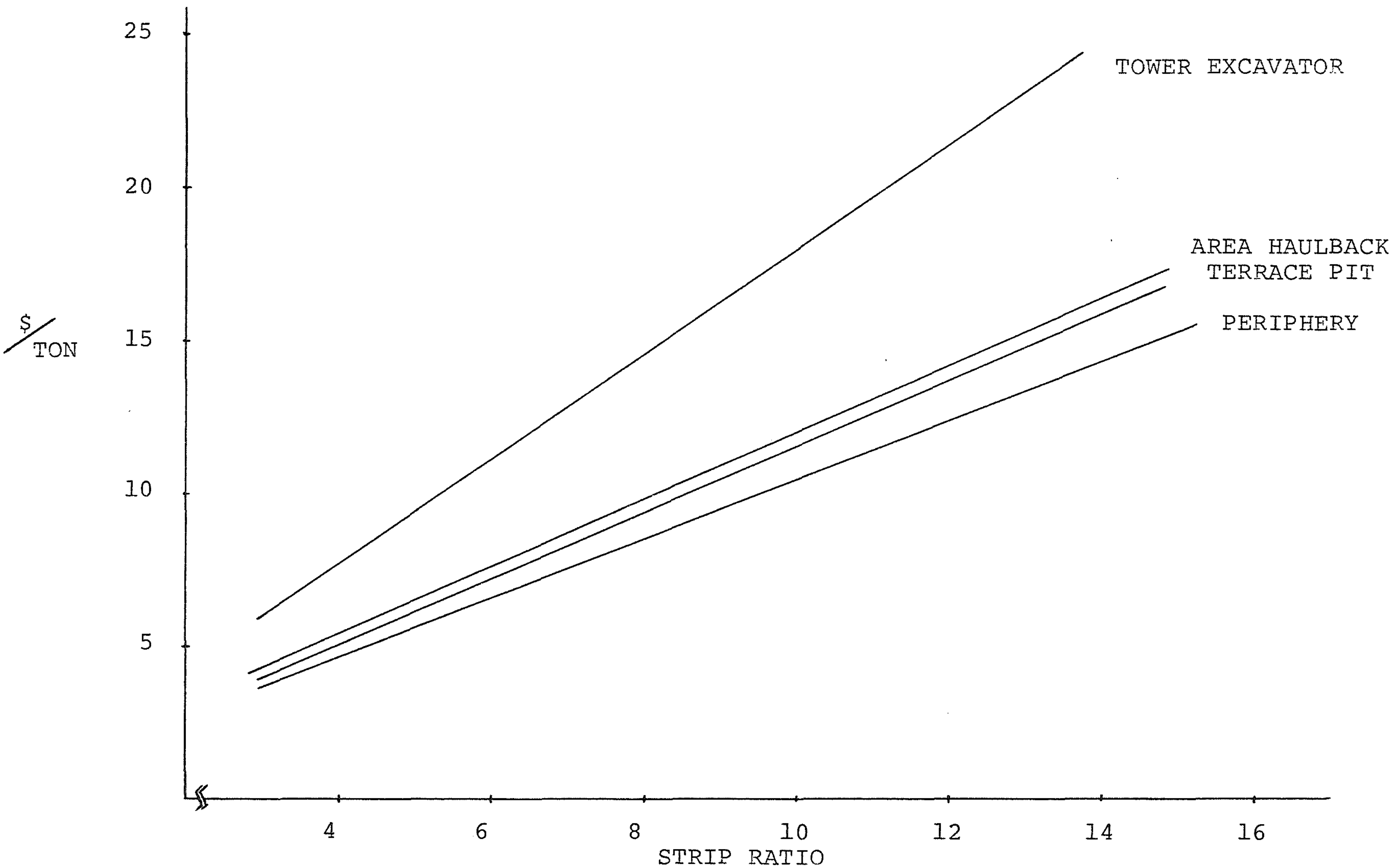
In Exhibit VI-1 the results of the foregoing analysis are summarized by ranking each system in each of the various criteria. Summarizing the scores by category we find that the terrace pit has the best average ranking in engineering feasibility and implementation analysis and shares it with area haulback in the environmental benefit analysis and with periphery mining in the cost benefit analysis. On an overall basis, the ranking is terrace pit first, area haulback second, peripheral a close third, and tower excavator last.

Exhibit VI-2 compares the relationship between the sales price and the virgin stripping ratio for the four systems, and Exhibit VI-3 compares the capital invested per annual bank cubic yard of virgin overburden excavated for the four systems. The results of this analysis indicate that the terrace pit holds the most promise for a field demonstration.

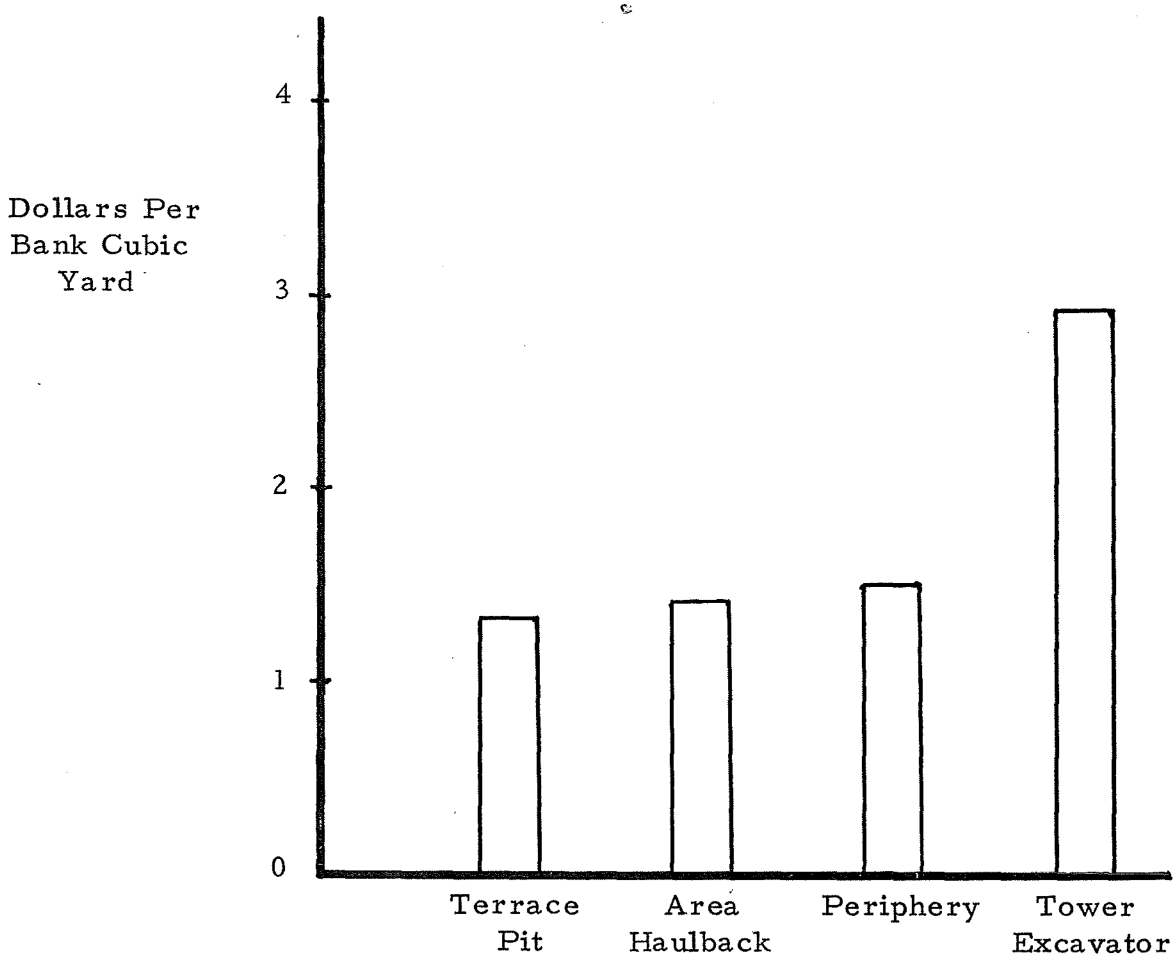
EXHIBIT VI-1
OBJECTIVE RANKING OF MINING SYSTEMS*

MINING SYSTEM CATEGORY	TERRACE PIT	AREA HAULBACK	PERIPHERY	TWIN TOWER
Engineering Feasibility				
Equipment Availability	2	3	1	4
Compliance to Design Requirements	2	1	3	4
Practicality	1	2	3	4
Industry Rating	1	2	3	4
	6	8	10	16
Implementation Analysis				
Immediacy	2	1	3	4
Ease	1	3	2	4
Acceptability	1	3	2	4
Constraints	1	2	4	3
	5	9	11	15
Environmental Analysis				
Solutions to Problems	1	2	3	4
Concurrency of Reclamation	2	1	3	4
	3	3	6	8
Cost Benefit Analysis				
Capital Requirements	1	2	3	4
Sales Price Per Ton	2	3	1	4
Limitations				
Mining Methods	1	3	2	4
Stratigraphic	3	2	1	4
Topography	1	2	4	3
Climatic	3	2	1	4
Physical	2	1	3	4
Production	2	3	1	4
	15	18	16	29
TOTAL ALL CATEGORIES	29	38	43	70

* Ranked best to worst, 1 to 4 respectively



RELATIONSHIP BETWEEN SALES PRICE (CALCULATED) AND VIRGIN STRIPPING RATIO



Comparison of Capital Invested Per Annual Bank Cubic Yard of Virgin Overburden Excavated

FIELD DEMONSTRATION AND EVALUATION PROGRAM

DEMONSTRATION AND EVALUATION PROGRAM PLAN

Implementation of a new mining system for demonstration purposes must follow an organized development plan. In order to aid the field demonstration program certain elements of pre-mine planning should be highlighted, evaluated, and certain general control procedures should be combined in three phases:

Site Selection
Data Collection and Organization
Demonstration Schedule

This chapter discusses test location criteria, documentation and organization of required data for evaluation.

In the preceeding chapter it was shown that the terrace pit was the most likely mining system for implementation. Therefore, the terrace pit mining system is used as a basis for mine demonstration analysis. This does not mean however, that the following concepts discussed are exclusive to the terrace system, only that examples and analyses are tailored to the characteristics of the terrace pit system.

Site Selection Criteria

Input from various representatives of the surface mining industry, field observations and operations analysis, etc., have been consolidated and presented in the following discussion to define general site features which would be desirable for the terrace pit demonstration mine.

- Mining Method - The terrace pit mining system in many cases would be an alternative to conventional area mining and some forms of open pit mining systems. The terrace pit could also be used as a development mining system to initiate operations at a site and at some later date reform to a conventional dragline system. Scrapers, wheel loaders and trucks, or loading shovels and trucks, could be used (combined or separate systems) in the terrace pit mining system.

- Stratigraphy - Unconsolidated overburden which does not require blasting would provide an economic and operational advantage to almost any strip mine. The terrace system has the ability to handle hard strata using truck haulage as well as unconsolidated material well suited for scraper haulage. A potential operation site should not represent conditions of either extreme (rock or loose material), but should utilize the particular equipment types in their respective applications (i.e. shovel/truck-hard, consolidated to scrapers-loose, unconsolidated). Blasting costs and requirements for a specific area should be entered into handling equipment selection.

Natural partings (or multiple coal seams) should be evident to demonstrate the systems' ability to selectively excavate and spoil overburden.

- Topography - The terrace pit system is generally applicable to flat or gently rolling areas with similar coal seam characteristics. The system could be used in a variety of topographical situations due to its flexibility. But, temporary terraces caused by frequent surface undulations would impact negatively on costs and require a higher degree of coordination.

- Climate - The system is best suited for arid or semiarid climates since heavy rain and snow would negatively affect haulage equipment. Conditions found in western coal deposits such as Montana, Wyoming and parts of Colorado would be acceptable.

- Exposed Coal - The terrace pit system is somewhat limited in the amount of exposed coal that can be maintained at the bottom of the pit. The level is determined by seam thickness, pit size, and required inventory amount. If a specific inventory is required and seam thickness decreases, pit size must increase to maintain the inventory level. Increasing pit size would also increase handling distances and cost. The interdependency of coal removal and overburden excavation means that interruption of one operation would soon affect the other. This situation is not likely to occur, however, since interchangeable units of equipment may be used and failure of any single piece would not halt production.

- Physical Characteristics - Stripping ratio for the demonstration mine should be less than 8:1, with maximum acceptable production level at 4.0 million tons per year. Greater stripping ratios could make the system less attractive; however, feasibility must be determined for a specific site and minimum acceptable rate of return for the operating company established. Production levels greater than 4 million tons per year would make the demonstration mine unwieldy.

The terrace pit system is somewhat limited physically and economically in that it cannot operate competitively at high production levels and high strip ratios simultaneously. As discussed above, decreasing seam thickness and required inventories of coal in the pit increases pit size and handling costs. Thicker overburden requires more terraces and results in increased unit handling costs for a certain seam thickness and production level. Addition of stripping equipment for a certain pit size can increase stripping capacity until increased congestion affects handling costs.

Demonstration Mine Data Collection

In order to verify the desirability of and mining costs associated with the Terrace Pit Mining System, a detailed field study of the demonstration mine will be conducted. The field demonstration study should include the following elements:

- Develop a cost model of the demonstration mine.
- Establish cost centers for all demonstration mine activities.
- Establish job numbers for all demonstration mine labor activities.
- Evaluate, modify, and supplement the selected operating companys' reporting forms and accounting procedures to coincide with cost model requirements.
- Orient the mine industrial engineer and the cost clerk in data collection methodology, mine cost model requirements, etc.
- Monitor the data collection and cost accrual activities for appropriateness and conformance to the demonstration mine's cost model requirements.
- Flow chart key mining activities: overburden prepation, overburden stripping, coal loading, coal hauling, etc.
- Time study key mining activities under varying conditions: different seam thickness, different overburden thickness, winter-summer climates, during periods of rainfall, around-the-clock operations, etc.
- Prepare monthly cost statements based on demonstration mine model.
- Prepare quarterly progress reports including: cost trends, equipment performance, general observations, problem areas, etc.
- Prepare final report which will include: a summary of mining costs presented in cost model array, study methodology, equipment performance, critique of mining method (production, engineering, economic, environmental), highlights of the system, problem areas, and recommendations.

The foregoing key data collection elements will be discussed in detail.

Develop a Cost Model of the Demonstration Mine

The selected mining company must first establish the mine site, develop a proposed mine plan, recommend mining equipment, project manpower, etc. When these mining parameters have been determined and agreed upon by all parties (USBM, mine operating company, and demonstration program coordinator), a demonstration mine cost model can be developed See Exhibit VII-1, Terrace Pit Scraper System for sample cost model on the next page. The cost model details by mining activity (overburden prep, overburden stripping, etc.) all projected costs (capital, operating, and general), manpower requirements, equipment requirements, projected tonnages, etc. This model becomes, (1) The basis for subsequent data collection activities and (2) A standard with which to measure actual mine performance.

Establish Cost Centers for All Demonstration Mine Activities

Based on the demonstration mine cost model requirements, a cost center number will be assigned to each major mining activity:

- Overburden Preparation
- Overburden Stripping
- Coal Loading
- Coal Haulage
- Reclamation
- Road Building/Maintenance
- Maintenance
- Mine Support
- Office and Supervision
- Mine General Expenses

The specific determination of cost centers will be a result of the demonstration mine cost model as it reflects the operating company's mining organization.

Establish Job Numbers for All Demonstration Mine Labor Activities

Based on the projected manning table, equipment required, and functions to be performed (all arrayed on the demonstration mine cost model), job numbers will be assigned to each activity within the previously defined cost centers. The application of job numbers in accounting for labor costs provides the basis for accurate labor distribution and cost control. For example, any labor expended in overburden preparation will be charged against the appropriate job number in the overburden preparation cost center.

Evaluate, Modify, and Supplement the Selected Operating Company's Reporting Forms and Accounting Procedures to Coincide with the Model Requirements

All cost source documents must coincide with the demonstration mine cost model in such a way that all costs (labor, supplies, etc.) are charged to the appropriate cost center activity on a timely basis (in order to

EXHIBIT VII-1
SAMPLE COST MODEL
(From Terrace Pit Scraper System Model Mine)

Element	Equipment/ Work Force Description	# of Units	Total Capital Cost Installed	Bulletin F Average Life Years	Annual Depreciation	Scheduled Shifts Per Year	Annual Usage Hours (OH + SH)	# of Men	Annual Labor Cost	Annual Maint. Labor ($/Yr.)	Explosive Maintenance Power & Operating Supplies	Subtotal
A	OVERBURDEN STRIPPING											
	Equipment:											
	657-B (P-P) Scrapers	6	1,800,000	2	900,000	6,552	38,400			782,976	1,875,072	
	Road Grader CAT-16	1	100,000	5	20,000	1,092	6,400			68,672	119,104	
	D-9 Dozer w/U Ripper	3	594,000	4	148,500	3,276	19,200			276,672	316,800	
	Subtotal		2,494,000		1,068,500							1,068,500
	Labor:											
	Foreman					1092		4	78,400			
	Scraper Operator					6552		24	456,000			
	Grader Operator					1092		4	76,000			
	Dozer Operator					3276		12	228,000			
	Maintenance					5000		20	380,000	⟨380,000⟩		
	Subtotal								1,218,400	748,320	2,310,976	5,346,196
B	COAL LOADING											
	Equipment:											
	Coal Load Shovel 195-B	1	1,045,000	20	52,000	500	3,200			18,016	74,496	
	Coal Drill Complete (9")	1	50,000	10	5,000	500	3,200			45,184	93,984	
	Powder Truck & Blasting Tools	1	10,000	10	1,000	250	800			1,264	97,774*	
	Subtotal		1,105,000		58,000							58,000
	Labor:											
	Foreman					500		2	39,200			
	195-B Shovel Operator					500		2	38,000			
	Shovel Oiler					500		2	37,000			
	Coal Driller & Helper					500		2	38,000			
	Powderman & Helper					500		2	36,200			
	Maintenance					500		2	38,000	⟨38,000⟩		
	Subtotal								226,400	26,464	266,254	577,118
C	COAL HAULAGE											
	Equipment:											
	120-Ton Bottom Dump Trucks	3	900,000	6	150,000	2,184	13,000			130,390	615,810	
	Subtotal		900,000		150,000							150,000
	Labor:											
	Coal Truck Driver					2,184		6	114,000			
	Maintenance					1,000		4	76,000	⟨76,000⟩		
	Subtotal								190,000	54,390	615,810	1,010,200

* (Includes $91,958 explosives)

Element	Equipment/ Work Force Description	# of Units	Total Capital Cost Installed	Bulletin F Average Life Years	Annual Depreciation	Scheduled Shifts Per Year	Annual Usage Hours (OH + SH)	# of Men	Annual Labor Cost	Annual Maint. Labor ($/Yr.)	Explosive Maintenance Power & Operating Supplies	Subtotal
D	RECLAMATION											
	Equipment:											
	Reseeding Equipment	1	150,000	10	15,000	250	400			1,712	8,436	
	Subtotal		150,000		15,000							15,000
	Labor:											
	Utility Man					250		1	17,800			
	Subtotal								17,800	1,712	8,436	42,948
E	MINE SUPPORT											
	Equipment:											
	Road Grader Cat-16	1	100,000	5	20,000	500	3,200			34,336	59,552	
	D-9 Dozer w/U & Ripper	1	198,000	4	50,000	500	3,200			46,112	52,800	
	Road Roller w/Vibration	1	10,000	10	1,000	500	1,600			2,704	3,456	
	Water Truck 8000 Gallons	1	120,000	6	20,000	500	1,900			13,186	39,083	
	End Dump Truck 10 Ton	1	18,000	5	3,000	500	1,900			5,814	19,304	
	Repair Shop, Garage & Tools	1	150,000	20	8,000	-	-			7,500	7,500	
	High Voltage Pole Lines, 3 Miles, 12.5KV,5conductor	1 Lot	72,000	20	4,000	-	-			-	-	
	Substation,5000 KVA 12.5/4.16 KV, For 195-B Shovel	1	90,000	20	5,000	-	-			-	-	
	Circuit Breaker	1	18,000	20	1,000	-	-			-	-	
	Pumps & Piping	1 Lot	85,000	6	14,000	-	-			-	14,167	
	Heavy Duty Truck Crane 110T	1	165,000	20	8,000	250	500			8,055	20,110*	
	Lowboy Trailer & Tractor	1	120,000	10	12,000	250	1,000			6,320	29,860**	
	Fuel & Lube Truck	1	31,000	6	5,000	1,092	6,000			18,900	89,040	
	Portable Compressor & Light Plant	1	70,000	10	7,000	-	-			-	7,000	
	Portable Tools & Field Equip.	1	130,000	8	16,000	-	-			-	-	
	Automotive Equipment	1 Lot	50,000	4	13,000	-	-			-	12,500	
	Rubber-Tired Dozer 834	1	150,000	4	38,000	1,092	6,400			49,664	160,512	
	2-Way Radio Equipment	1 Lot	15,000	10	1,000	-	-			-	1,500	
	Forklift 8000#	1	19,000	10	2,000	250	-			520	890	
	Engr, Design, Legal Purchases	1	50,000	20	3,000	-	-			-	-	
	Exploration Cost	1	75,000	20	4,000	-	-			-	-	
	Crushing & Loading Facility	1	4,000,000	20	200,000	-	-			122,611	245,222	
	Subtotal		5,736,000		435,000							435,000

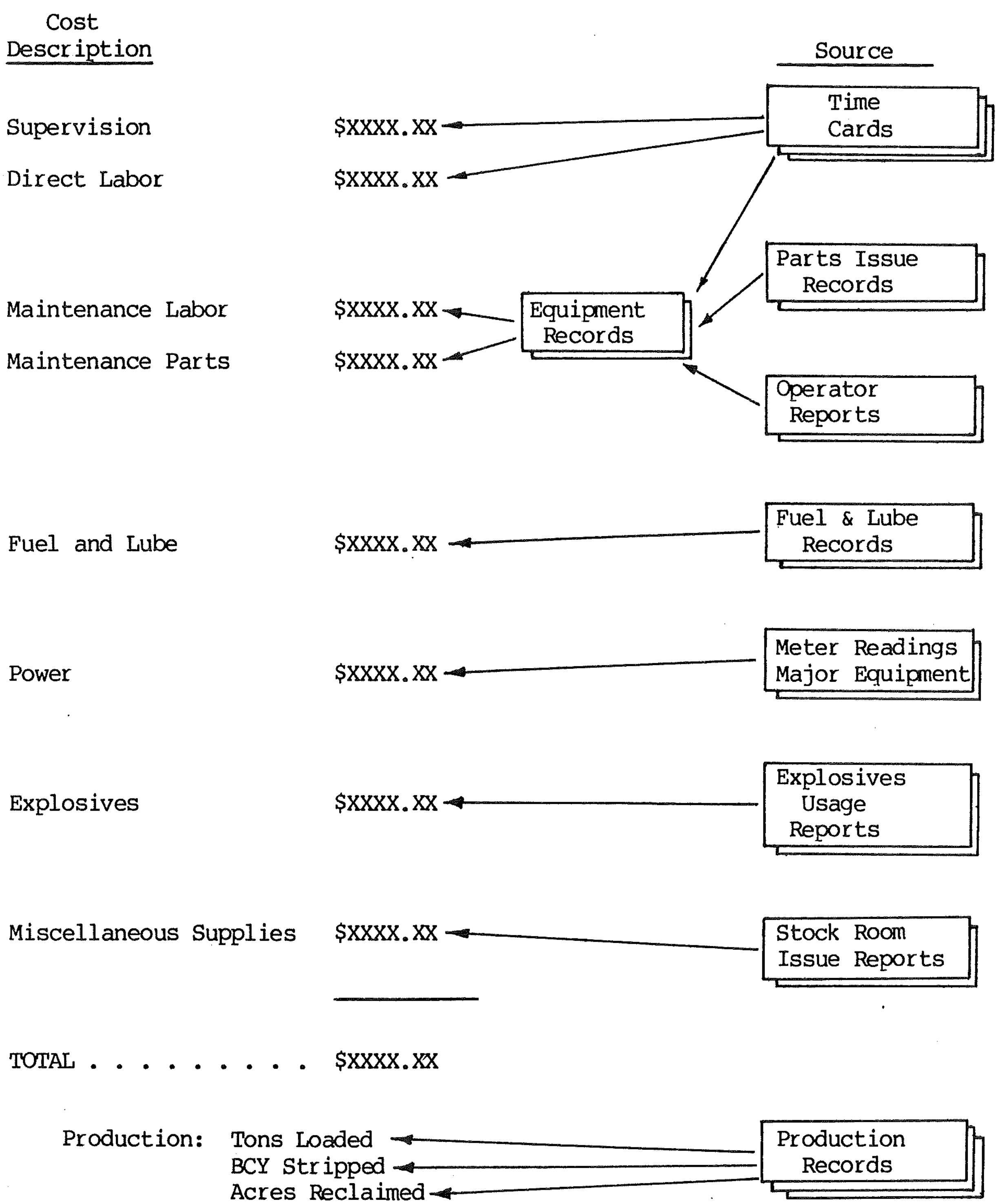
* (Operated @ 25%)
** (Operated @ 25%)

Element	Equipment/ Work Force Description	# of Units	Total Capital Cost Installed	Bulletin F Average Life Years	Annual Depreciation	Scheduled Shifts Per Year	Annual Usage Hours (OH + SH)	# of Men	Annual Labor Cost	Annual Maint. Labor ($/Yr.)	Explosive Maintenance Power & Operating Supplies	Subtotal
	MINE SUPPORT (CONTINUED)											
	Labor:											
	Grader Operator					500		2	38,000			
	Water Truck Driver					500		2	36,000			
	Dump Truck Driver					500		2	36,000			
	Road Roller Operator					500		2	38,000			
	Utility Man					500		2	35,600			
	D-9 Dozer Operator					500		2	38,000			
	Pumpman					500		2	36,000			
	Exploration Drill Crew					500		2	38,000			
	Fuel & Supply Truck Driver					1,092		4	72,000			
	Power Distribution Man					728		3	51,000			
	834 Dozer Operator					1,092		4	76,000			
	Maintenance					1,500		6	114,000	<114,000>		
	Mine Superintendent					250		1	35,000			
	Asst. Superintendent					250		1	26,000			
	Master Mechanic					250		1	25,500	<25,500>		
	Chief Electrician					250		1	25,500	<25,500>		
	Mining Engineer					250		1	16,000			
	Clerk					250		1	13,000			
	General Mine Foreman					250		1	21,500			
	Maintenance Shift Foreman					1,092		4	78,400	<78,400>		
	Tipple Operator					500		2	38,000			
	Subtotal								887,500	72,332	762,496	2,157,328
	Accumulated Subtotal		10,385,000		1,726,500				2,540,100	903,218	3,963,972	9,133,790

measure costs against current production). Exhibit VI-2 represents the cost information plan from basic cost source to cost center summary.

EXHIBIT VII-2

Basic Cost Sources - Cost Center Reporting



As much as possible, the selected operating company's records and accounting procedures will be used to provide the information required by the demonstration mine cost model. The cost center/job number cost allocation will, in all likelihood, require additional cost source documents and supplemental accounting procedures. The specific cost data source documents will be designed for the demonstration mine in conjunction with the selected operating company and cost model requirements. Some sample cost source documents are:

- Daily Maintenance Time Card
- Weekly Time Card (all labor except maintenance)
- Forman's Reports
- Maintenance Repair Record
- Parts Issue Log
- Equipment Operator's Report - Drills
- Equipment Operator's Report - Shovel
- Equipment Operator's Report - Other
- Daily Fuel/Lube Log
- Power Usage Log
- Daily Coal Blasting Report
- Daily Overburden Blasting Report

These sample documents indicate the type of information to be collected and the level of detail required in order to be effective.

<u>Orient Mine Industrial Engineer and Cost Clerk in Data Collection Methodology, Mine Cost Model Requirements, etc.</u>

To effectively monitor the demonstration mine's performance, two full-time on-site employees are required --a mine industrial engineer and a mine cost clerk. These employees will be oriented by the demonstration program coordinator in: mine cost model rationale and requirements, data collection methodology, accounting procedures, monthly report summaries, etc. Specific duties of these personnel will include:

- INDUSTRIAL ENGINEER

  Monitor accuracy of field preparation of basic cost source documents.

  Time study major mining operations.

  Interface between cost clerk and field operations.

  Be thoroughly familiar with demonstration mine cost model data requirements.

  Assist in preparing monthly cost reports, equipment utilization and capacity reports, etc.

  Detail and critique mine operations (scheduling problems, inherent delays/inefficiencies, desirable operating characteristics, etc.).

- COST CLERK

  Post source documents to appropriate accounts.

  Use operating company data when possible for posting to appropriate accounts.

  Alert industrial engineer to source document errors and ommissions.

  Summarize data monthly per mine cost model requirements.

  Prepare supplemental reports (such as machine availability) as required.

The activities of the two on-site personnel will be supplemented and supervised on a monthly basis by the demonstration program coordinator.

Monitor the Data Collection and Cost Accrual Activities for Conformance to the Demonstration Mine's Cost Model Requirements

After the cost collection system start-up, monthly visits will be made to the mine site to oversee monthly operating cost summary preparation, ascertain continuing accuracy of cost flow, and trouble-shoot any system problems.

Flow Chart Key Mining Activities

Major activities will be flow charted in order to isolate productive, nonproductive, transportation, storage, and delay activities. Completed flow charts for major operations will then be the basis for time study elements. For example, a completed flow chart for the coal loading operation will include: shovel cycles per truck, tramming distances, waiting delays, etc. See Exhibit VII-3 for a sample flow process chart.

Time Study Key Mining Activities Under Varying Conditions

Based on the previously discussed flow charts, time studies will be conducted for key operations and equipment. A wide sample of time studies will be conducted over a one-year period. These time studies must account for operations conducted under varying conditions:

- Around-the-Clock
- Seasonal
- Precipitation
- Thicknesses of Seam
- Thicknesses of Overburden

The initial time study observations should be made after the mine has been in full operation for about three months in order to permit unbiased (start-up, new operators) observations. The initial time study should take up to six man-weeks (twenty-five man days: time-study; five man-days: summarizing data).

MINE TYPE :
MINING METHOD :
SUBJECT :

EXHIBIT VII-3

SYMBOLS	ELEMENT NO.	DESCRIPTION	UNIT HANDLED	HOW HANDLED	MEN* PER UNIT	HANDLING TIME PER UNIT (M-HRS.)	ESTIMATED ELAPSED TIME (HOURS)	DISTANCE (FEET)
○ ⇨ □ D ▽								
○ ⇨ □ D ▽								
○ ⇨ □ D ▽								
○ ⇨ □ D ▽								
○ ⇨ □ D ▽								
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○ ⇨ □ D ▽								

* REQUIRED MANPOWER

FLOW PROCESS CHART

SHEET OF SHEETS

Subsequent time studies should be made periodically and on an exception basis (based on productivity variance; new equipment; new combinations of equipment, differing ground conditions, etc.) by the mine industrial engineer.

Approximately every three months (exact schedule to be determined by changing conditions described above) supplemental time studies will be made to track operation performance.

Reporting

All of the foregoing should be summarized into: monthly operating cost summaries, quarterly progress reports, equipment availability reports, etc. At the conclusion of the project, a final report and evaluation should be submitted:

Exhibit VII-4 shows the flow of mine data collection and reporting sequence.

Exhibit VII-5 shows additional time study collection forms.

A Gantt chart showing the field demonstration and evaluation program time schedule is included in Exhibit VII-6.

EXHIBIT VII-4
DEMONSTRATION MINE DATA COLLECTION - REPORT PREPARATION SEQUENCE

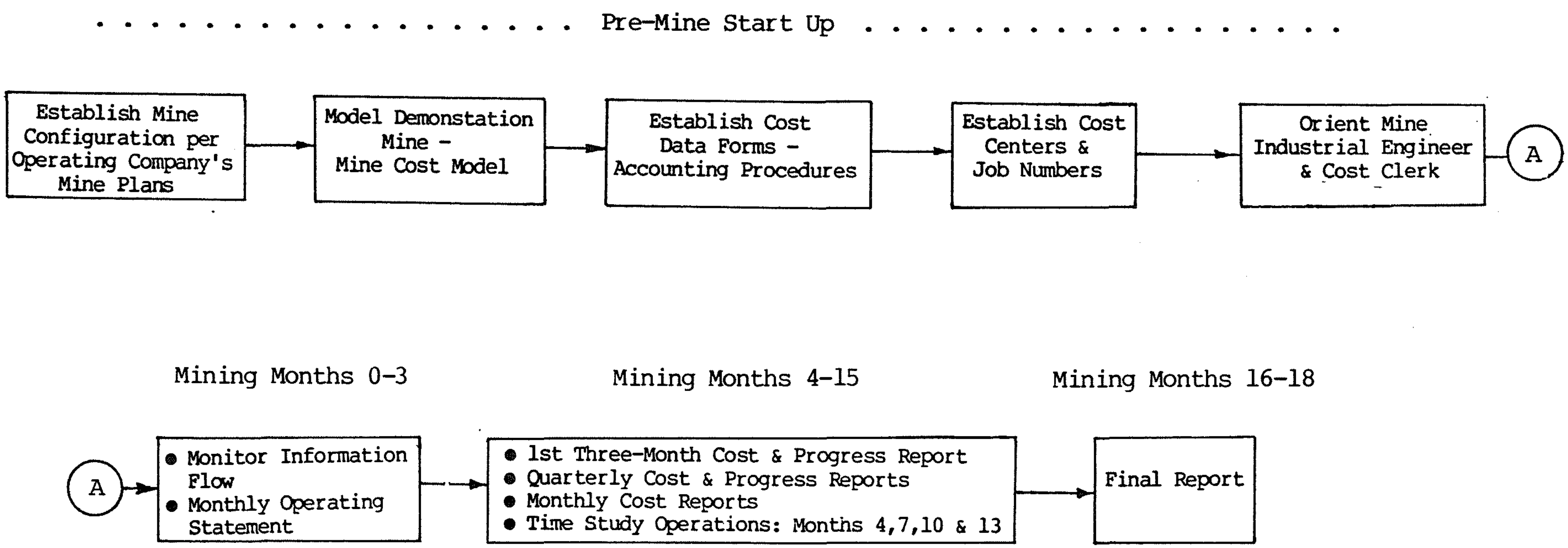


EXHIBIT VII-5

THEODORE BARRY & ASSOCIATES

TIME STUDY OBSERVATIONS

STUDY NO. ____________

DATE ____________ **PART NO.** ____________ OPER. NO. ____________ **SHEET** ______ OF ______

ELEMENT DESCRIPTION	1	2	3	4	5	6	7	8	9	10	RAT FACT	SEL. MIN. PER OCC.	NORM. MIN PER OCC.	OCC. PER PIECE	NORM. MIN. PER PIECE MAN.	NORM. MIN. PER PIECE MACH.

FOREIGN DELAYS

BRK PT	READ	ELAPS TIME	DESCRIPTION
P			
Q			
R			
S			
T			
U			
V			
W			

NON CYCLIC ELEMENTS

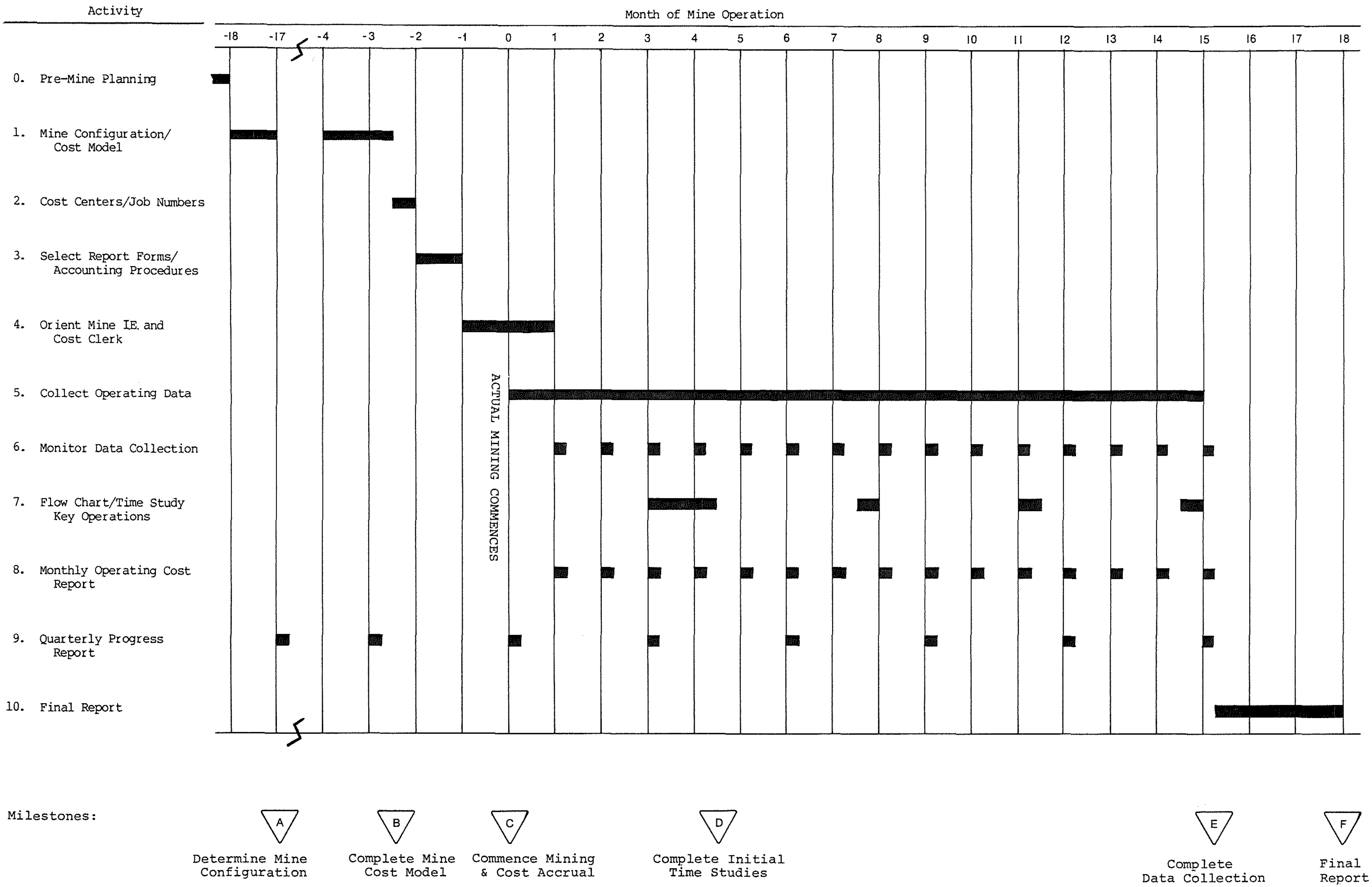
BRK PT	READ	ELAPS TIME	DESCRIPTION
A			
B			
C			
D			
E			
F			
G			
H			

		REMARKS		
STOP			NORMAL MANUAL MINUTES	
START			ALLOWANCES (MANUAL) ______ %	
ELAPSED			MACHINE MINUTES	
LOST TIME			ALLOWANCES (MACH.) ______ %	
NET TIME			TOTAL STD. MIN./PC.	
AVE./PC.			STD. HOURS/PC.	

______ OBSERVER ______ APPROVED ______ STD. HRS. PER C PCS. ______ PCS. PER HOUR ______ STANDARD MINUTES PC. ______

RATE ENTERED BY ______

EXHIBIT VII-6
DEMONSTRATION AND EVALUATION TIME SCHEDULE



DESCRIPTION OF ADDITIONAL MINING CONCEPTS

DESCRIPTION OF ADDITIONAL MINING CONCEPTS

Four mining systems were selected by representatives from the Bureau of Mines Research and Development Department and previously discussed in this report. In addition, TB&A feel that conceptual mining systems and method changes which were included in preliminary engineering analysis but were not fully developed, should be mentioned. The following items could effectively integrate reclamation and overburden handling operations:

- Narrowed dragline pits
- Scraper topsoil handling around the pit
- Topsoil handling via around-pit conveyors
- Topsoil handling via cross-pit conveyors
- Variable pitch stripping shovel dippers
- Tandem dragline operation
- Pull-back draglines on the spoil
- Tree chopper and mulching machine
- ARC or curved dragline pits
- Twin-boom draglines

A brief discussion of the primary advantages and disadvantages is included below.

Narrowed Dragline Pits

Currently used area mining dragline pit widths should be evaluated to establish their effects on productivity and their ability to selectively spoil overburden via narrowed pits.

Narrow pit widths offer relatively increased spoiling capacity and shorter cycle times by decreasing swing angles. The productive advantages are also coupled with an increased potential to integrate some reclamation with overburden stripping. Selective deposition of spoil and a more even spoil contour are possible with greater effective spoiling radius. (See Exhibit VIII-1)

Disadvantages which could result from narrowed pit widths must also be weighed. If keycuts and deadheading are done, the unproductive aspects of these two activities would be increased proportionately to the number of additional pits per a given area. For a given fleet of in-pit operating equipment, narrowing pit widths will increase pit congestion and at some point restrict maneuverability. There has also been some speculation that narrowing pits would increase highwall and spoil pile hazard exposure levels.

A preliminary systems analysis showed that the draglines' sensitivity to swing angle (productive increase) significantly outweighed proportionate increases in keycutting, deadheading, and cable moving (productive decrease). A practical minimum width for currently used in-pit operating equipment appears to be 90 feet. But, many schemes for in-pit coal handling are possible which do not require even this amount of room and

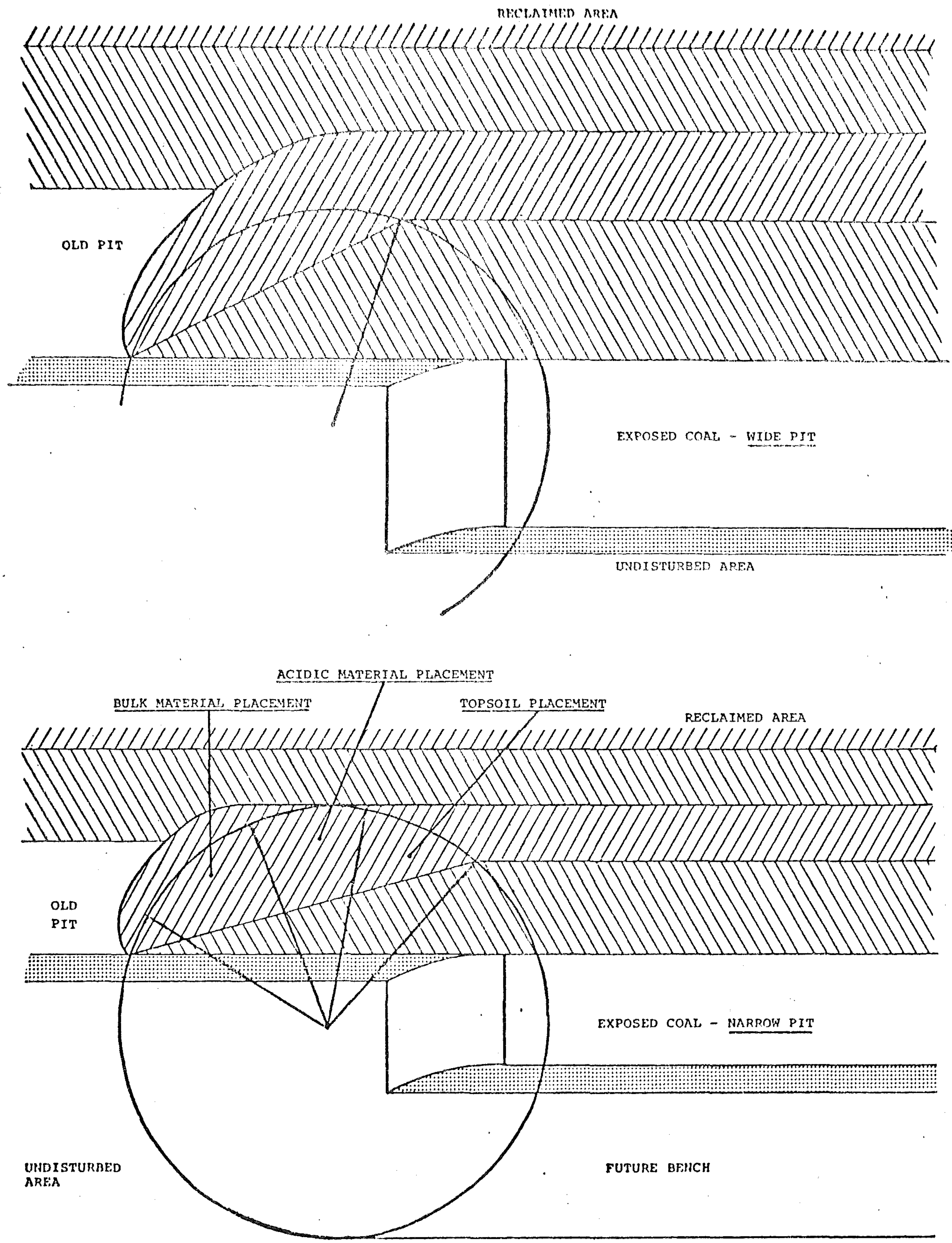


EXHIBIT VIII-1
NORMAL AND NARROWED DRAGLINE PITS

do not impede maneuverability. Preliminary analysis has given little insight as to pit width effects on hazard exposure or quantification of in-pit congestion, dragline hoisting speed limitations, coal loading requirements, ability to selectively deposit and contour spoil while dumping, potential reclamation economic effects, etc.

Scraper Topsoil Handling Around Pit

Scrapers have been used for some time in the road construction and related industries. Generally, they found that scrapers served well for cutting to grade and backfilling to close tolerances. These particular abilities are now required in strip mining to comply with topsoil replacement and approximate original contour regulations in many areas. The growing number of scrapers in coal strip mining has paralleled reclamation legislation since the demands placed on operators cannot easily be handled by major strippers such as shovels or draglines.

As the familiarity of strip mines to scrapers grows, more frequently the scrapers are used to stockpile upper material and to backfill after the pit moves (sometimes at the end of mine life). In some cases this type of rehandling might be necessary. However, in many cases scrapers can haul over a route which takes them to the spoil area and spread their load evenly. This would eliminate the cost of rehandling (temporary planting, storage, etc.) a topsoil stockpile. Reclamation would also be continuous and integrated with stripping. In some instances, continuous topsoil stripping/reclamation is being done, but the combination is infrequent.

For the strip mining industry to benefit from a system of topsoil handling such as described above, existing operations must be analyzed and various schemes displayed which develop economic and environmental advantages.

Topsoil Handling Via Around-Pit Conveyor

An "around-pit" conveyor handling system could be used to carry topsoil and upper unconsolidated overburden from the highwall side of the pit, around the end, and distribute the material evenly on rough-graded spoil. The system would be particularly advantageous when very long pits and long haul routes make vehicle haulage uneconomical.

The conveyor system would be movable such as is currently used in conjuction with bucket wheel excavators in large open cast mines (Europe, Turkey, Greece, etc.). In these applications crawler tractors work along the conveyor length and relocate the belts in short increments. This process would be necessary to keep up with pit advance.

The conveyor haulage system would be fed by scrapers, wheel loaders or various combinations of mobile equipment. The system could be used to augment existing strip capacities or utilized to integrate stripping and reclamation on a continuous basis. A casting or slewing mechanism would

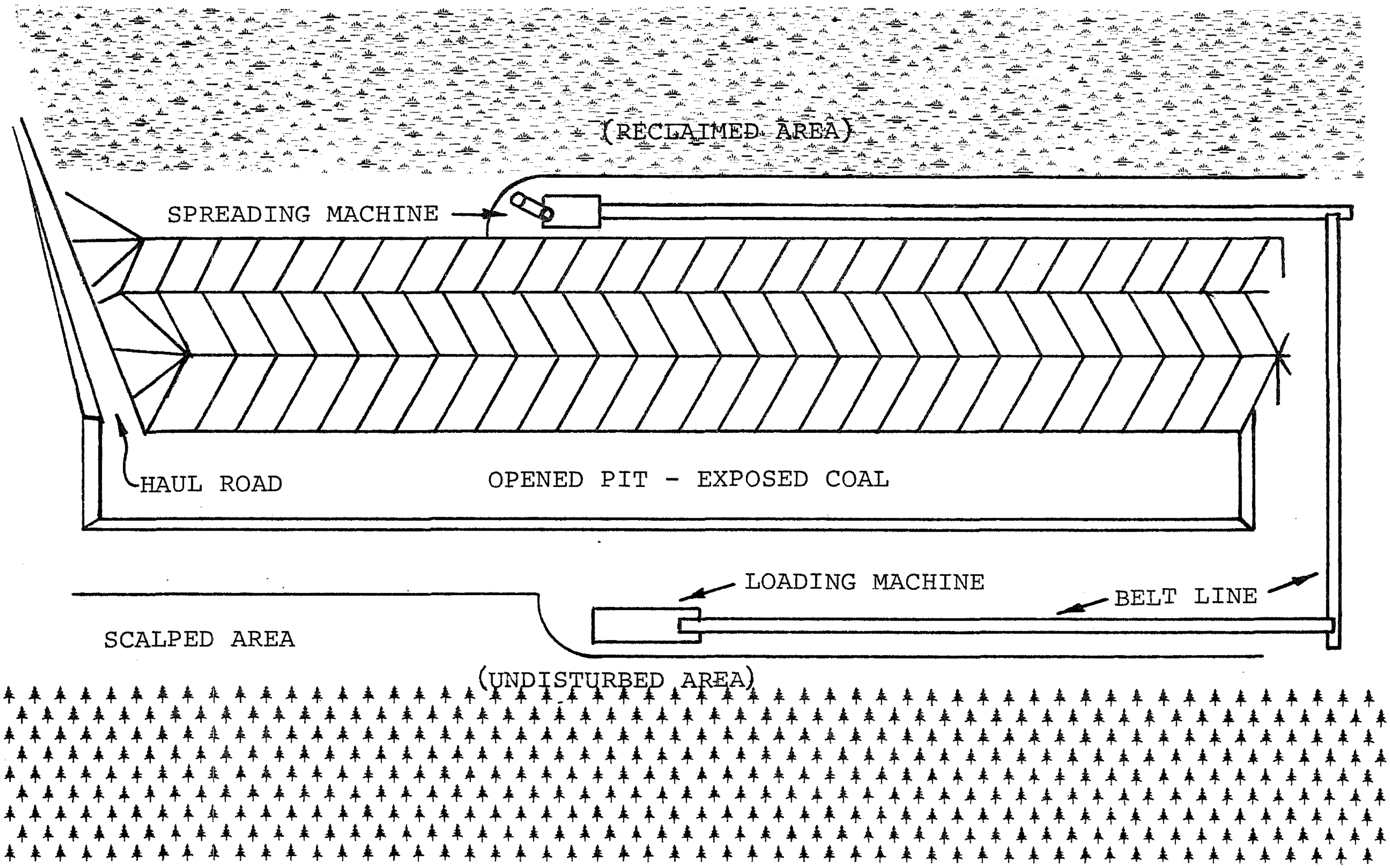


EXHIBIT VIII-2
CONCEPTUAL SKETCH OF AROUND PIT CONVEYOR SYSTEM

spread the topsoil material evenly over the spoil area or profile a specific contour without rehandling stockpiled topsoil, regrading spoil, etc. (See Exhibit VIII-2)

Conveyor material handling is generally a long term, high volume system. However, these systems are relatively inflexible and have high initial capital requirements. They could be very expensive to operate if very many crawler tractors were needed to keep conveyor movement ahead of the pit movement, and maintenance could be costly. Hauling around the pit and through spoil areas could interfere with pit access roads. The spreader/caster, conveyor structure, and crawler tractors would encounter stability problems in the spoil areas during rain or snow conditions. A mobile conveyor system would not be applicable to rough terrain or frequently undulating areas due to various horsepower/braking requirements, support structure, etc.

Topsoil Handling Via Cross-Pit Conveyor

Cross-pit conveyors could be used to transport topsoil, sandy clays, or unconsolidated overburden strata from the highwall side of the pit directly across to the spoil area and deposit the material in a manner which returns the area to AOC or a desired profile. The cross-pit conveyor system would travel the length of the pit as it handles material and advance with the pit, gradually covering the permit area. Overburden would be loaded onto the conveyor by wheel loaders, dozers, or scrapers which dump onto a hopper/feeder mechanism. The overburden transported across the pit would be spread onto rough-graded spoil to any desired contour by a slewing or casting mechanism.

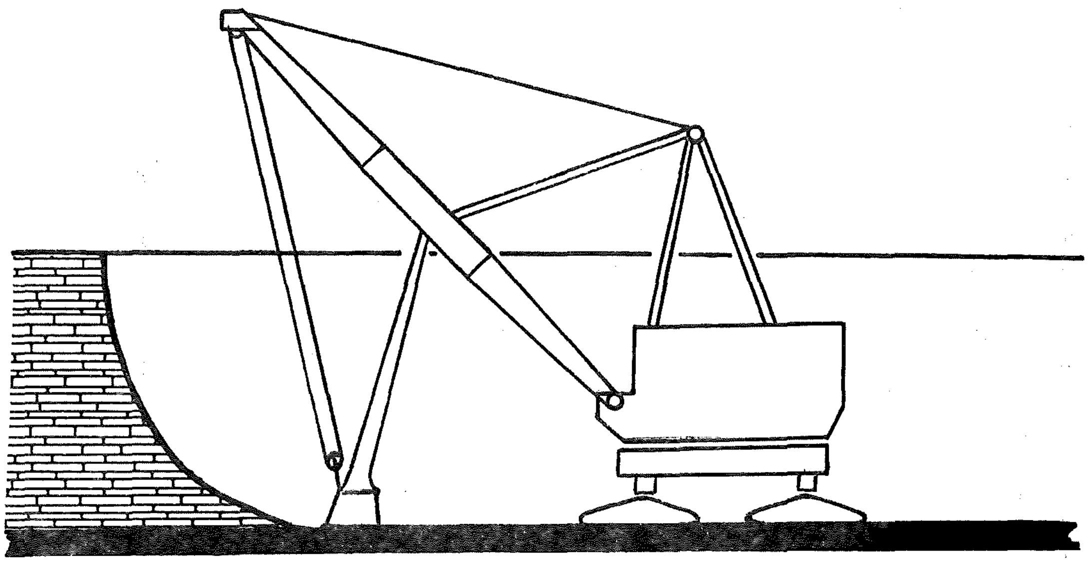
Three styles of cross-pit conveyor systems for handling topsoil and unconsolidated overburden are illustrated in Exhibit VIII-3. The system could utilize belt, bucket, or flight type conveyance as per lump size and abrasive characteristics of the material to be handled. A span of approximately 600 feet would be required to handle material from highwall bench preparation to rough-graded spoil. Additionally, the system would be required to travel around pit ends and turn in order to spread selectively and minimize interference with shovels or draglines.

The cross-pit system could also be applicable to multi-seam operations where the conveyor handled all overburden and interburden was mined in a conventional single seam manner. This application could be a viable alternative to the common productivity losses associated with draglines chopping interburden from spoil benches.

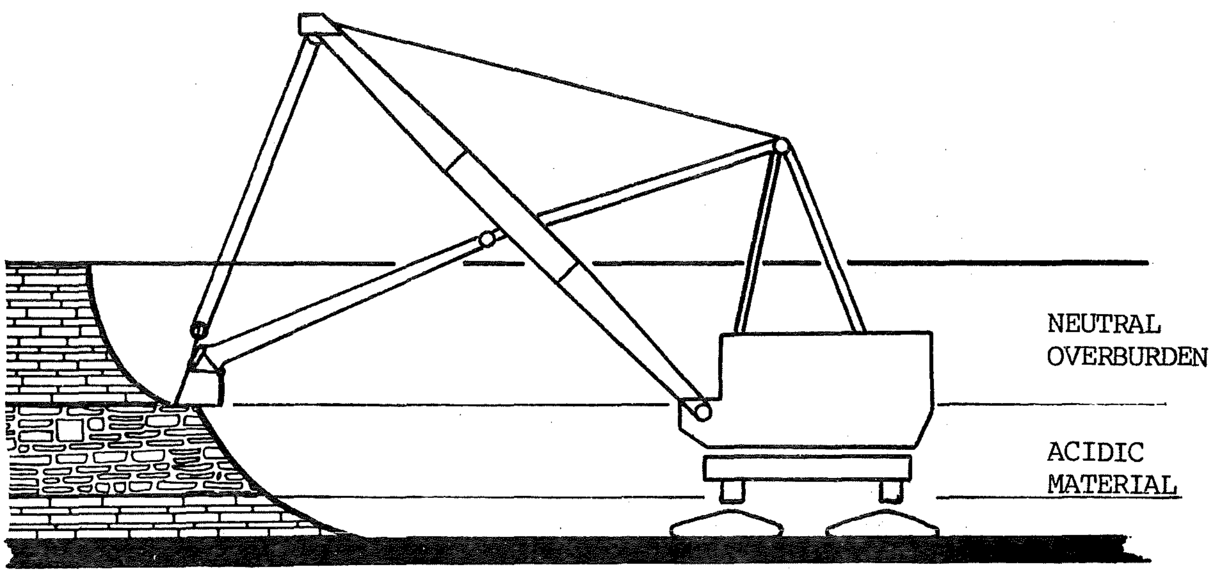
The following is a brief summary of the potential problems which must be resolved by a cross-pit conveyor system.

- Initial capital requirements for the hopper/feeder, conveyor structure, and slewing mechanism would be over a million dollars.

- Stability and flotation of the mobile units could be difficult in soft spoil, rain or snow conditions.



CONVENTIONAL STRIPPING SHOVEL



VARIABLE PITCH DIPPER STRIPPING SHOVEL

EXHIBIT VIII-4

ILLUSTRATION OF SELECTIVE SHOVEL EXCAVATION
UTILIZING A VARIABLE PITCH DIPPER

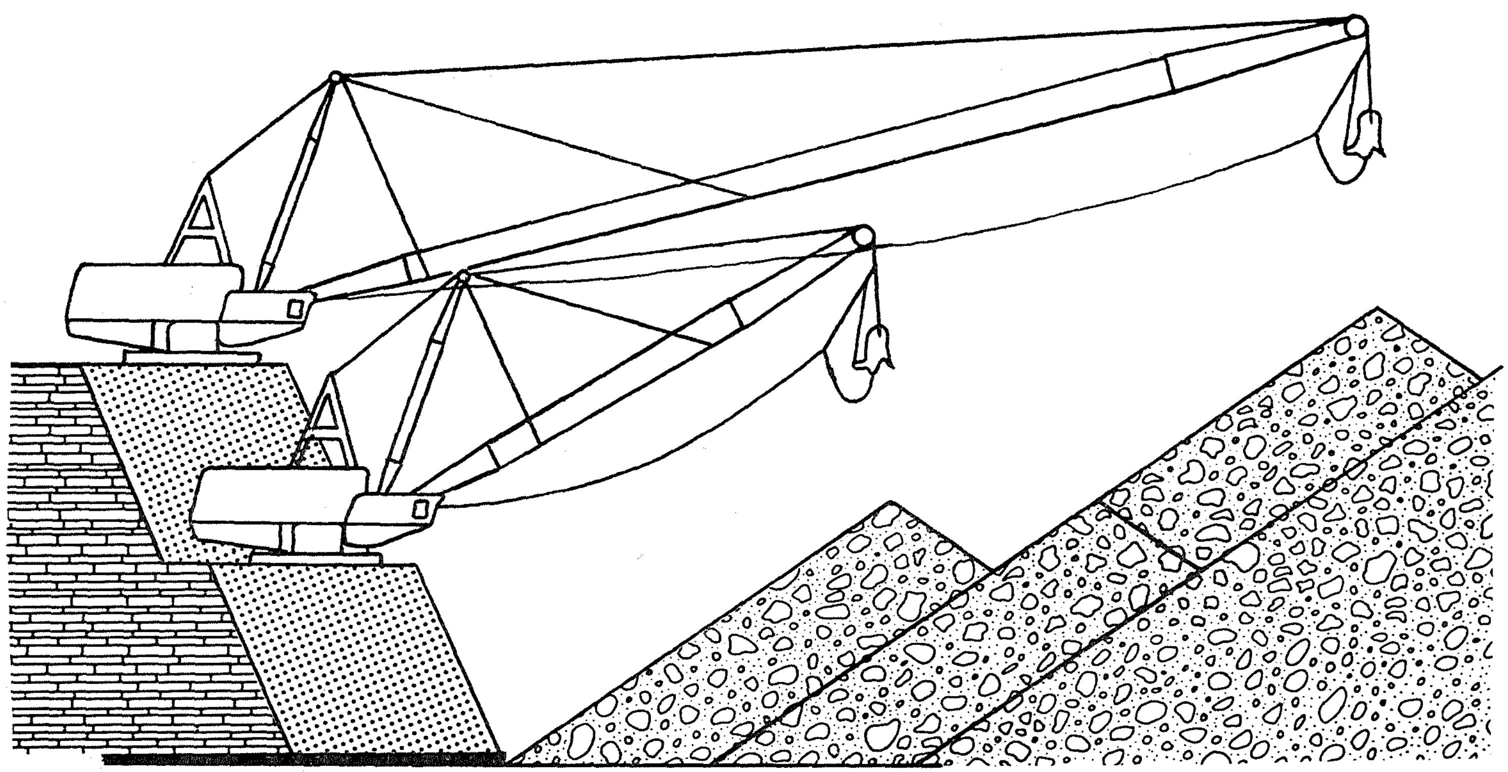


EXHIBIT VIII-5
TANDEM DRAGLINE OPERATION

dragline excavation of interburden, overburden and interburden would be removed sequentially at upper and lower levels respectively. Coal removal would take place between the draglines and following the lower level dragline. Exhibit VIII-5 shows a conceptual tandem dragline operation. Overburden and desirable upper strata is placed over the lower spoil peak to aid reclamation.

Some of the primary operating characteristics and limitations of the system which were identified during preliminary analysis are as follows:

- Operation of two medium sized draglines offer potential economic advantages over operating a very large model (mechanical availability, purchase price, debugging time, etc.).

- Sequential stripping by tandem draglines could permit a "buffer zone" such that down time of one unit would not immediately affect the other, and production could be more continuous. However, this characteristic requiries spacing between draglines which could be a disadvantage at the end of the pit when a new cut must be excavated.

- Pit access roads would probably enter the pit at each end. This could mean excessive haulage distances in long pits.

- Reclamation will be in closer conformity to legal standards requiring the strata of reclaimed areas to be basically similar to that before mining inasmuch as acidic or lower strata (overburden/interburden) will be buried under desirable overburden strata. Generally, this requires the upper level dragline to spoil over the preceeding lower spoil ridge. Preliminary analysis (for a variety of sample situations) revealed that boom length and effective spoiling radius requirements would exceed current maximum specifications.

Pull-Back Dragline on Spoil

The objective of the pull-back dragline system is to increase the primary stripping machines' capability by providing more relative spoil room, and to selectively deposit overburden. Although the pull-back dragline represents additional equipment and material rehandle, its use would eliminate some of the equipment currently required to level spoil peaks and backfill topsoil (i.e. dozers and scrapers).

The pull-back system would commence at some point subsequent to the initial box cut. The pull-back dragline would operate between the primary stripping machine and coal removal operation from a position approximately along the line of the second spoil ridge. Exhibit VIII-6 illustrates the pull-back dragline system and shows a dragline operating in the spoil area.

A summary of the potential system benefits and limitations is discussed below.

- Pull-back draglines are currently used in existing operations (as shown in Exhibit VIII-6), however, little information is available as to their reclamation potential and economic feasibility.
- A pull-back dragline would solve the problem of a "spoil-bound" primary stripping machine.
- The additional cost of a pull-back dragline could only be partially offset by the elimination of some reclamation equipment.
- An overall loss in productivity would still be characteristic of double handling spoil material.
- There appears to be less potential reclamation benefits from adding a pull-back dragline to a stripping shovel (than a stripping dragline) due to the shovel's relative inability to selectively excavate (and therefore deposit) overburden.
- Draglines could experience stability and flotation problems when operating in soft or wet spoil.

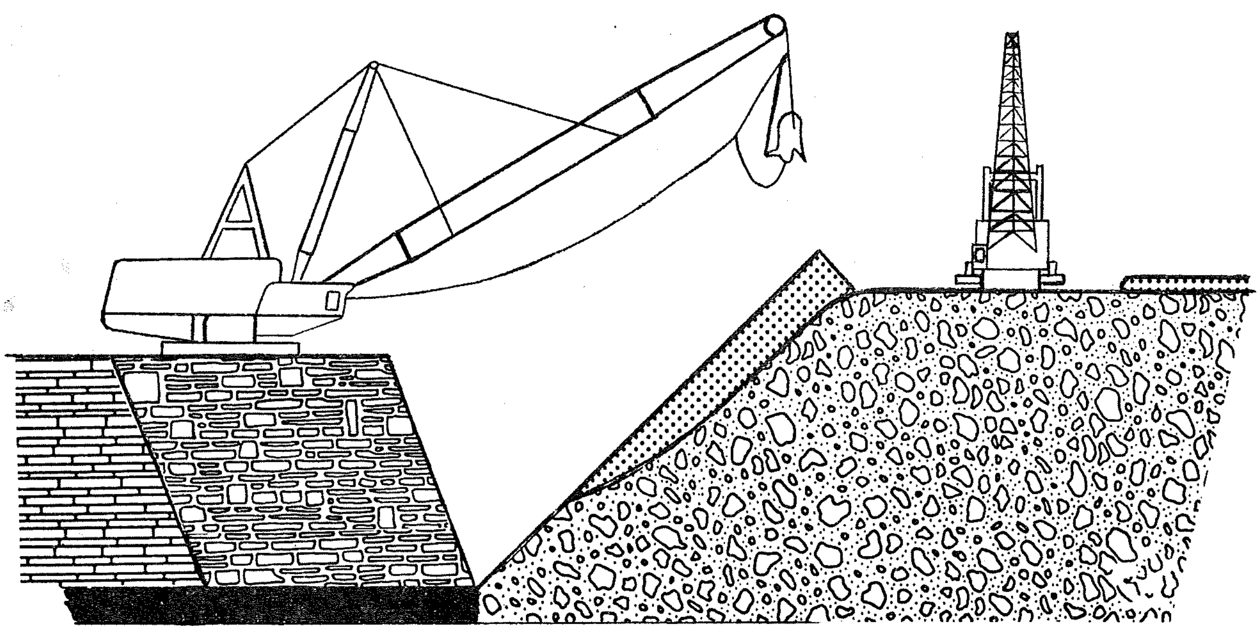


EXHIBIT VIII-6
PULL-BACK DRAGLINE OPERATING IN THE SPOIL

Tree Chopper and Mulching-Machine

A conceptual system of brush and tree removal was studied on a preliminary basis in order to eliminate the need for pushing vegetation over the outslope or burying it during pre-mining surface preparation. The system would also provide a mulching material for reclamation operations.

Conceptually, commercially attractive timber would be removed during the first phase of surface preparation. After timbering, scrub trees and brush would be taken by a self-feeding mobile tree chipper. The resultant chips would be delivered to an attached hopper trailer for subsequent use in reclamation areas. When the vegetation was totally removed, the normal mining operation would proceed with topsoil stripping, etc. (See Exhibit VIII-7).

The system requires development of a new piece of equipment for this application. The unit would be mobile, capable of self feeding, and chip trees or brush. It should be able to pull a holding trailer and operate over steep or rugged terrain. Similar equipment is currently available, however, these units do not incorporate all of the required features. And, the amount of mulch produced would probably not meet the total reclamation needs (estimated at 60 to 100 cubic yards per acre). Wood chips use nitrogen in their decaying process, and as a result, nitrogen should be added to the spoil to counter the effect (estimated at 20 pounds of nitrogen per ton of wood chips).

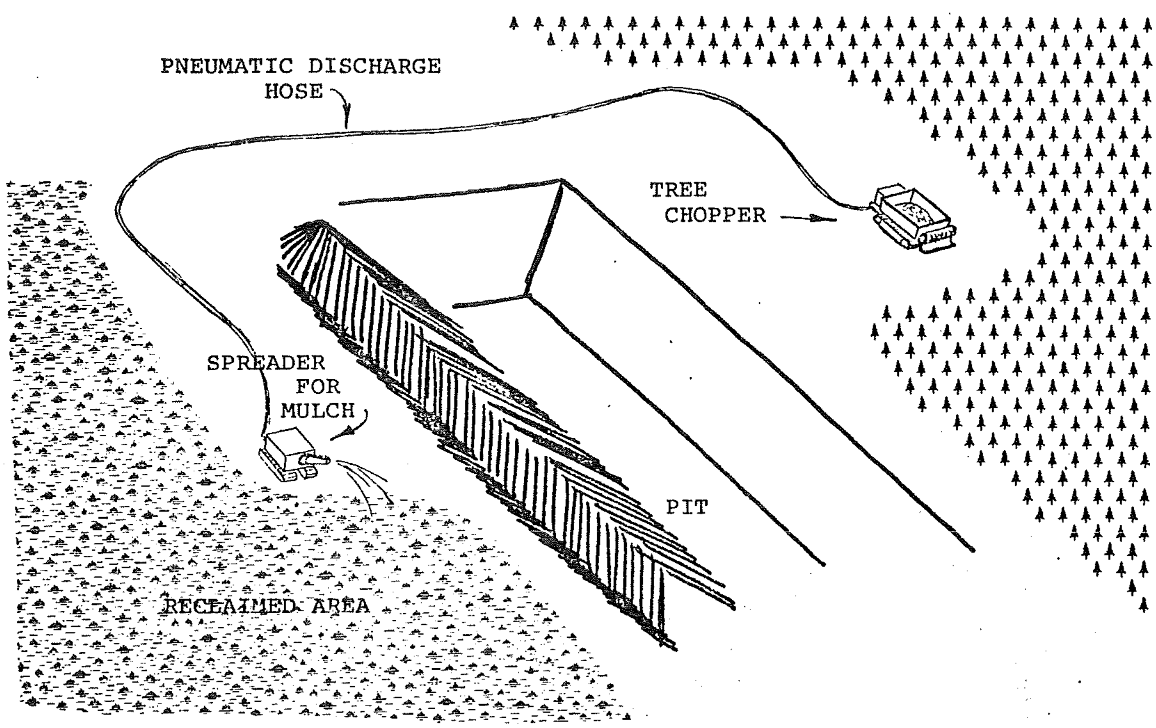


EXHIBIT VIII-7
CONCEPTUAL SKETCH OF TREE CHOPPER MULCHING OPERATION

Arc Mining

Arc mining is a modification of the common straight pit area mining system where the shape of the pit is curved and the highwall has a convex curvature (outside curve). Two basic variations of this concept are possible, viz., a system of concentric semi-circles and a system of semi-parallel curves all having the same radius. Both of these variations achieve the capacity for a relative increase in overburden depth without a corresponding increase in spoil rehandle, or conversely, a reduction in rehandle at a given overburden depth. The improvement results from an increase in unit pit area per unit of overburden surface and is least with a large arc radius.

The operation of the mine is very similar to that of a straight pit area mine. Principal excavators are the same and include bucket-wheel excavators, stripping shovels, draglines and loading shovels. If excess spoiling reach is available, the primary excavator has the advantage of having lower spoil peaks to contend with, and reclamation activities such as burying toxic spoil are simplified. If pit mounted equipment is used for excavation, deadheading continues to be a requirement. If a dragline is used and deadheading has been required in the past, the new distance is reduced to some degree depending on the radius of the arc. This assumes the pits are of equal length. If the curved pit is lengthened to mine the same property width, there is no reduction in distance although deadheading time as a fraction of the total operating time is reduced.

The principal benefit derived from this system is a reduction or avoidance of spoil rehandle and associated operating costs. Reduction of reclamation costs can be expected but the cost advantage gained would be smaller than the gain in quality of reclamation.

Among the limitations of the system is the engineering required to establish and maintain a curved pit. If haulage of topsoil around the pit is a requirement, the haulage distance will be somewhat higher again depending on the radius of the arc.

Applications that have been successful include deep overburden in Illinois where pit mounted equipment was used, and dragline operations in hilly Ohio fields. The latter operation began as a contour mine where the first cut was "U" shaped and the deepest overburden was the ridge halfway between the outcroppings. Exhibit VIII-8 illustrates the curved or arc pit mining concept.

Twin Boom Draglines

This idea was suggested in the literature and was briefly investigated for feasibility. The concept of a twin boom has much in common with the deck gear aboard a cargo ship used for hoisting items from the dock up over the deck and down into the hold. In effect, one boom begins functioning the same as that of a conventional dragline while the other assumes an increasing part of the load as the bucket moves up toward the spoil pile.

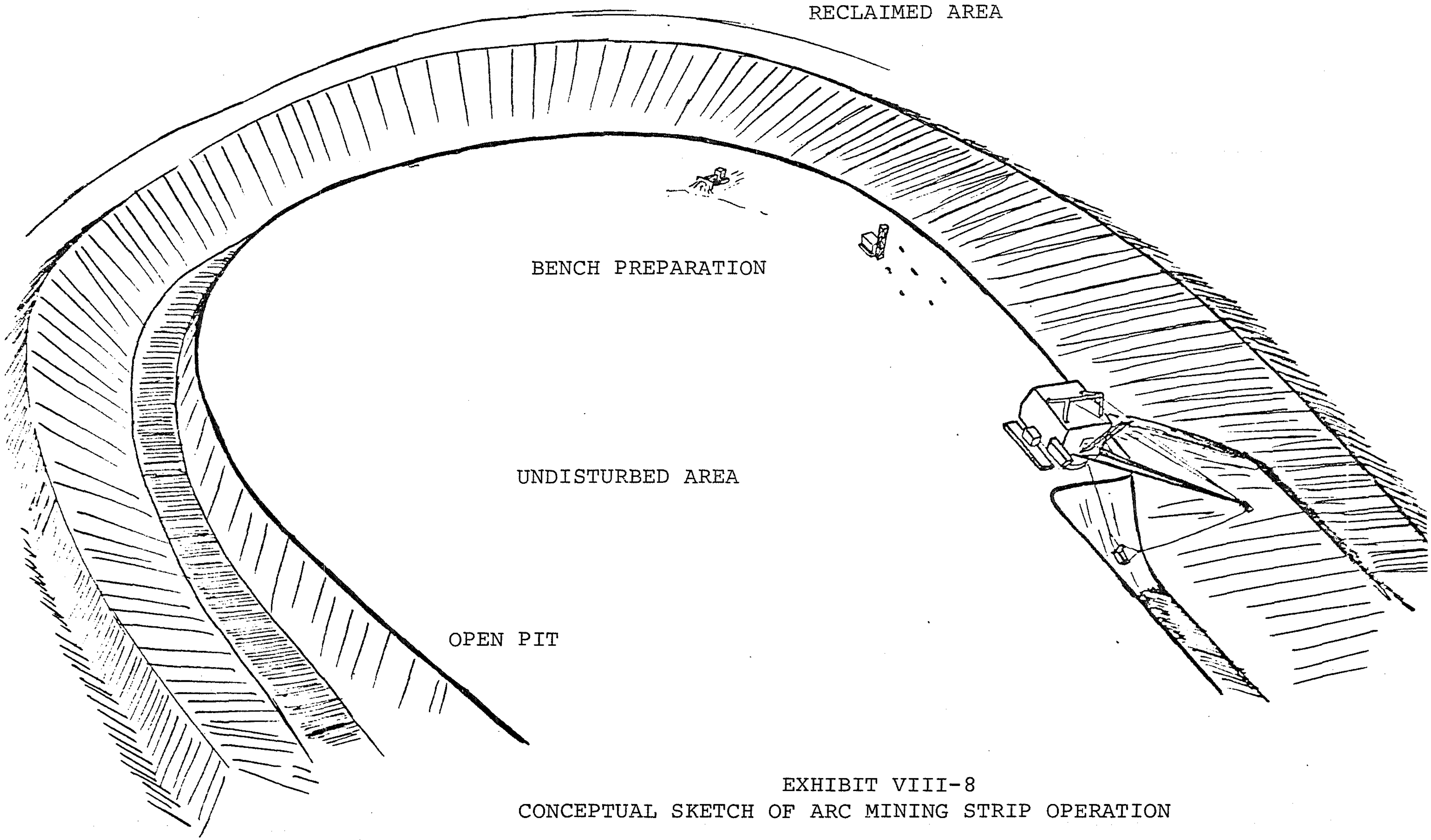


EXHIBIT VIII-8
CONCEPTUAL SKETCH OF ARC MINING STRIP OPERATION

The concept requires much greater machine weight and cost, and it would have much less lifting capability for a given size of hoisting cables. The drag cable under tension in a conventional machine holds the filled bucket in a horizontal position until dumped. Using twin booms, some other means would have to be devised to perform this function.

One benefit from such a machine would be a reduction in unit power requirements because of the reduction in the inertial forces that are encountered in an oscillating dragline. In general, it could be expected to raise operating and capital costs and do very little to improve the quality of reclamation. (See Exhibit VIII-9)

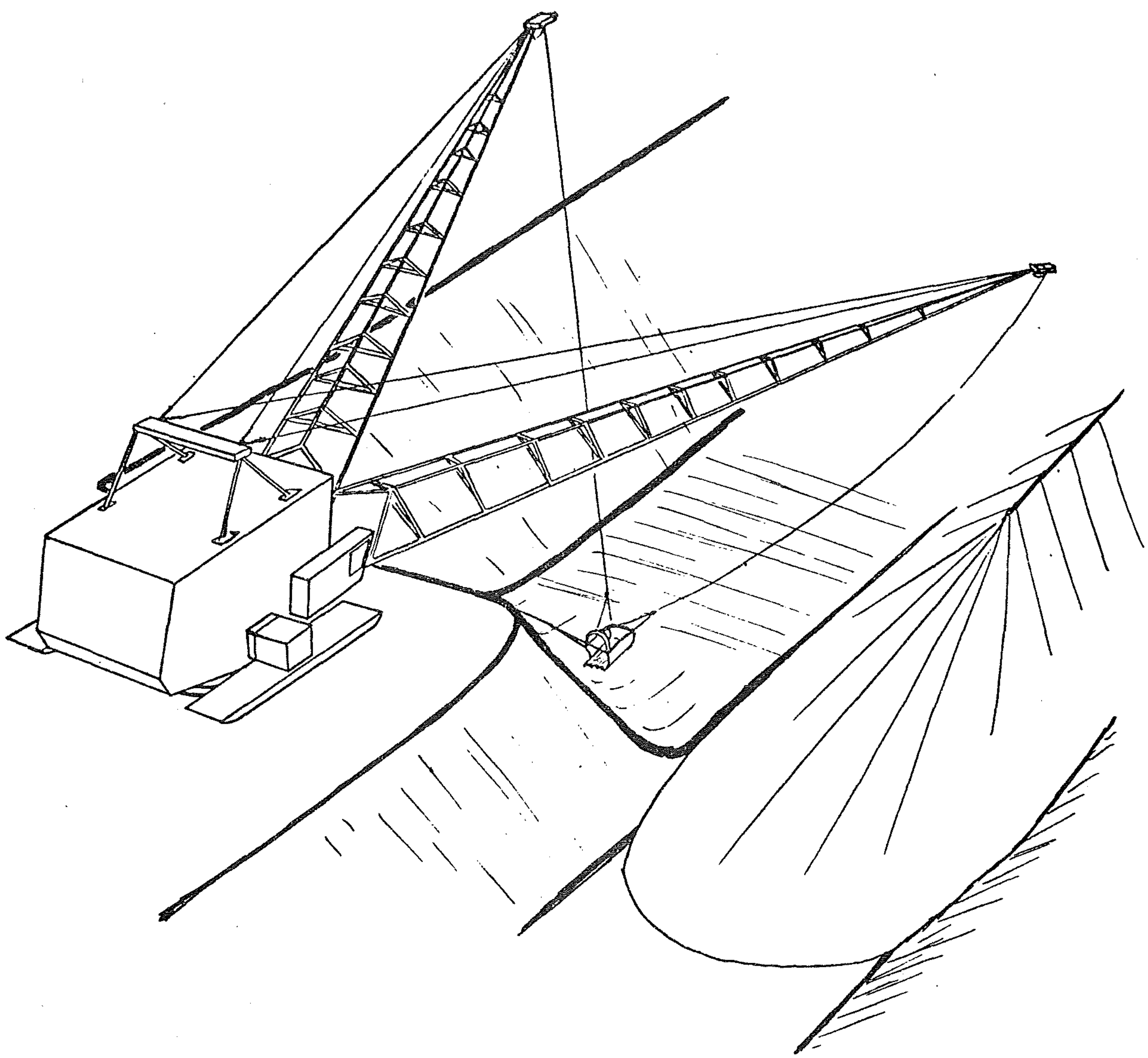


EXHIBIT VIII-9
CONCEPTUAL SKETCH OF DUAL BOOM DRAGLINE

CONCLUDING SECTIONS

RESEARCH RECOMMENDATIONS

This section of the report presents recommended ideas of future research which will benefit the coal mining industry. The expanding national need for more coal will be met from two sources:

- Expansion of production in existing coal mines and
- New coal mines.

A large portion of the new mines will be in the western states because of the large, untapped reserves that exist there. The climate and the nature of the overburden in those areas are conducive to mobile equipment operation and greater attention needs to be given to ways to make the use of that equipment more attractive functionally and economically.

1. Demonstrate the Economics and Environmental Impact of the Terrace Pit Mining System and the Area Haulback Mining System

The final objective of this study is to demonstrate promising new systems or methods for the surface mining of coal in an environmentally responsible manner. Both of these systems rely on the use of mobile equipment to handle and transport overburden, and they both backfill the spoil with stratigraphic segregation of the spoil material. In both cases, the potential choice of mobile equipment by type, manufacturer and size specifications is extensive.

2. Evaluate Additional Mining Concepts

The second recommendation involves some of the additional mining concepts mentioned in this report. Some concepts which have high potential for field evaluation include: The narrow pit dragline mining concept, curved pit, variable pitch shovel dippers, cross-pit conveyors, and around-the-pit-conveyor systems.

3. Provide Guidelines for the Choice of Final Highwall Reduction Procedures

Final highwall reduction or modification required by state reclamation laws or regulations is becomming a major expense for mining companies. There are many ways it can be done and the results in terms of cost and the effect on the environment are equally varied.

This study should include an evaluation and comparison of various methods of highwall reduction including:

- Blasting highwall and pushing material over with dozers.
- Backfill highwall using mobile equipment, trucks, scrapers.
- Use of a dragline to backfill highwall.
- Others.

4. <u>Provide Guidelines for the Establishment and Operation of a Systematic Mine Maintenance Program</u>

Surface mining in many cases uses similar, if not the same, equipment and machinery as that used in road construction. Unfortunately, most mines do not have the same organization and control over maintenance activities, nor do they have as high mechanical availability of equipment. This technology can and should be transferred. This effort should give examples of workable systems and provide the pros and cons of policies such as major component replacement and preventive maintenance. The total economics of maintenance systems including opportunity costs should be addressed so that sound mine management decisions can be easily made.

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ABSTRACT OF STATE RECLAMATION LAWS

STATE	OVERBURDEN SAMPLES	REFUSE & DRAINAGE	FINAL GRADED CONTOUR
ALABAMA (1969)	No Requirement.	Divert Stream to Reduce Damage.	Rolling Topo. 10 ft. Wide on Ridges & 15 ft. Wide on Peaks.
COLORADO (1973)	No Requirement.	Dispose of Refuse & Divert Streams to Control Damage with Ditches.	15 ft. Wide on Ridges & Peaks to Give Approximate Original Contour. Slopes According to Use.
ILLINOIS (1975)	Core Drillings Not to Exceed One Per 25 Acres If Required.	Runoff to be Impounded, Drained or Treated to Reduce Damage.	No More Than 15% Grade & 30% on Outslopes. AOC If Capable of Row Crops. Final Highwall 2:1.
INDIANA (1974)	None Required.	Drainage Grade Max. is 20% or 8% for Tillable Land. Remove or Bury All Debris.	To Conform to Land Use Objectives in Approved Plan of Recl. But Not to Exceed 33 1/3% on Final Cut.
KENTUCKY (1975)	Chemical Analysis is Required. One Sample Per Acre.	Diversion Ditches Limited to 2% Grade. All Drainage from Highwall to Outslope. No Final Drainage Less Than pH6 or More Than ph9.	AOC on Area Mines. Terrace Backfill on Contour Mines. 1:1 Slope Max. Compact Head of Hollow Fills.
MONTANA (1974)	One Hole Per 100 Acre Grid and Over-Burden & Mineral Analyses.	Remove or Bury All Refuse. Drain Both Sides of Thrucut so as Not to Affect Flow or Sediment Load of Existing Streams.	Regraded Surfaces to be Roughened in Final Grading to Assure Topsoil Stability.

ABSTRACT OF STATE RECLAMATION LAWS

STATE	TOPSOIL REMOVAL & PLACEMENT	FINAL CUTS & WATER IMPOUNDMENTS	GENERAL RECLAMATION
ALABAMA (1969)	No Requirement.	Cover Toxic Material With 2 ft. of Over-burden Material or a Permanent Water Im-poundment.	435 Trees/Acre Within One Year. No Req'mt. If Spoils Are Toxic or Rocky. Grasses to be Local Permanent.
COLORADO (1973)	Stockpile & Re-tain Topsoil. 1500 ft. Max. Between Backfill & Mine. Maximum Slope = 2:1.	Earth Dams in Final Cuts. Cover Acid Spoil to Protect Drainage with 2 ft. of Overburden or 4 ft. of Water.	Operator Proposes Ultimate Land Use With Approval of Board. All Mined Land Must be Re-claimed.
ILLINOIS (1975)	All Darkened Sur-face Soil to be Segregated and Replaced as a Final Cover. No Less Than 8". Other Suitable Strata May Be Approved.	4 ft. of Water or Other Material Over Acid Spoil. Toxic Water in Final Cut Prohi-bited.	Operator Proposes Ultimate Land Use. No Rocks Over 6" in Top 24" Nor More Than 20% Rock By Volume.
INDIANA (1974)	As Required Per Vegetative Plan.	Acid Materials. Not Covered By Impounded Water to be Under 2 ft. of Earth. Dams Subject to Approval. Highwall Grade Max. = 33 1/3%	Revegetate A.S.A.P. No Rocks Over 6" Unless Covered With 18" of Soil.
KENTUCKY (1975)	Grading & Backfill Not to Exceed 15 Day or 1000 ft.	Cover Coal Face With 4' Bury Toxic Mat'l. Under Adequate Fill. Drain, Impound or Treat All Runoff. Pools Per Specifi-cations.	Remove or Bury All Debris. Min = 5.5pH 100 lbs. P O /Acre & 60 lbs Available Nitrogen. Mulch Slopes Over 15°.
MONTANA (1974)	Remove Topsoil From the Site & Stockpile. Replace on Spoil 90 Days Prior to Seeding or Planting.	Bury All Toxic Mat'l Under Adequate Fill. Seal Off Water Break Throughs. Impound, Drain or Treat All Runnoff Water. Water Impoundments are Re-stricted.6.0 to 9.0pH	Recondition Topsoil if Necessary. A Per-manent, Diverse na-tive Cover Required. Drill Seed on Con-tour. Mulch on Lengthy Grades.

ABSTRACT OF STATE RECLAMATION LAWS

STATE	RECLAMATION TIME LIMIT	INTERIM OF LIABILITY	BONDS, FEES, FILING, REQUIREMENTS
ALABAMA (1969)	3 Years After Permit Issued.	10 Years.	$250 Filing Fee Plus Bond of $150 Per Acre Fines Between $500 & $5000.
COLORADO (1973)	3 Years After Reclamation is Begun.	10 Years.	$50 + $15/Acre Filing Fee Plus Discretionary Bond. Fines Between $50 & $1000 Per Day.
ILLINOIS (1975)	One Year After Permit Year to Grade, 3 Years For Final Recl. One Year for Gob Piles After Active Use.	Until Reclamation is Complete and Approved.	Filing Fee = $50 Plus $25 Per Acre. Bond Per Acre Between $600 & $5000 Fine for Not Filing = $50 to $1000.
INDIANA (1974)	No More Than Two Ridges Ungraded, or No More Than One Year.	Until Reclamation is Complete and Approved.	Annual Filing. Fee= $50 + $30/Acre Bond= $5000 or $600 Per Acre, Whichever is Greater. Fines Between $1000 & $5000
KENTUCKY (1975)	Seeding Within 15 Days After Grading or Apply Suitable Erosion Control. Total Reclamation By 12 Mos. After Permit.	Until Reclamation is Complete and Approved.	Basic Fee= $150 + $35/Acre/Yr. Bond= $500 to $1500/Acre With Minimum of $5000. Fines/Day From $100 to $1000.
MONTANA (1974)	Seeding At First Seasonal Opportunity.	Until Reclamation is Complete and Approved.	$50 Fee. Bond from $200 to $10,000/Acre. Minimum $5000. Failure to Comply with Plan, Fined $1K to $10K Operating W/O Approved Plan Fined from $200 to $2000 Per Day.

ABSTRACT OF STATE RECLAMATION LAWS

STATE	CONDITIONS FOR REVOCATION OR DENIAL OF PERMIT	REGULATING STATE AGENCY
ALABAMA (1969)	Failure of Substitution of Surety.	Department of Industrial Relations.
COLORADO (1973)	Violation of Any Article of State Act. Initial Permit for One Year Renewal 5 Years.	Land Reclamation Board, Division of Mines
ILLINOIS (1975)	Failure of Subs. of Surety, or Forfeiture of Bond.	Department of Mines & Minerals.
INDIANA (1974)	Violation of the Surface Mining Act.	Division of Reclamation, Natural Resources Commission.
KENTUCKY (1975)	Certain Div. of Reclamation Criteria Specified in the Regulations.	Division of Reclamation, Department of Natural Resources & Environmental Protection.
MONTANA (1974)	Inconsistent With State Policy, Non-Compliance with Time Limits, Bond Forfeiture or Repeated Violation. One Year for Plan Approval.	Department of State Lands.

ABSTRACT OF STATE RECLAMATION LAWS

STATE	OVERBURDEN SAMPLES	REFUSE & DRAINAGE	FINAL GRADED CONTOUR
N. DAKOTA	Core Drillings May Be Required. Soil Survey Will Be Required. Plus Chem. & Physical Analyses for Each Section.	Impound, Drain or Treat Runoff to Minimize Erosion & Stream Pollution. Remove or Bury Refuse.	AOC Unless Specified Otherwise.
MISSOURI	No Requirement.	Remove & Dispose of Debris.	Rolling Topography Traversable by Farm Machinery. 25° Max. for Slopes. 25% Per Year of Ridges Can be Leveled to 30 ft. Width.
W. VIRGINIA (1971)	No Requirement.	Drain Both Sides of Thrucut so as not to Affect Flow or Sediment Load of Existing Streams. Treatment Ponds & Sediment Dams Are Required.	Slope Bench Toward Highwall or Georgia Type V-Ditch. AOC Not Required. Final Surface to Permit Use of Farm Equipment.
PENNSYLVANIA (1972)	Reclamation Plan to Show Analyses of Test Borings.	Per Erosion and Sediment Control Regulations. pH Limits 6.0 to 9.0. Iron Less Than 7 MG. Per Liter. Intercept Ditching. Mine Water to be Collected, Treated.	AOC or Terracing.
TEXAS (1976)	Results of Test Borings.	Take Measures Designed to Isolate Toxic Materials and Minimize Siltation of Streams. Avoid Abandoned Underground Mines.	Reduce Highwalls to Sustain Vegetation. AOC Where Required by Federal Law. Stabilize & Protect All Surface Areas.
OHIO (1974)	Results of Test Borings.	Remove or Bury Refuse & Debris. Prevent Underground Water Contamination & Control Surface Drainage to Prevent Damage, Erosion & Pollution.	Grade, Contour or Terrace to Achieve Stability & Control Landslides & Erosion. Highwalls Are Conditionally Permitted.

ABSTRACT OF STATE RECLAMATION LAWS

STATE	TOPSOIL REMOVAL & PLACEMENT	FINAL CUTS & WATER IMPOUNDMENTS	GENERAL RECLAMATION
N. DAKOTA	Save, Segregate & Respread Suitable Plant Growth Material to a Max. of 5 ft.	All Final Cuts, Highwalls & End Walls to be Backsloped to 35% Grade or Less. Water Impoundments to be Approved.	Submit Plan For Approval Including Seeding & Planting.
MISSOURI	No Requirement.	May Build Dams For Lakes. 4 ft. of Earth Over GOB & Acid Rock or Cover With Water.	Submit Plan for Approval. Sow, Set Out or Plant. Begin A.S.A.P. Substitute Land is O.K. If Approved. Operator Determines Land Use.
W. VIRGINIA (1971)	Remove, Stockpile & Returned to Regraded Spoils.	Discharged Water Must Have pH Between 5.5 & 9.0. Bury Toxic Material in Pit Under 4 ft. Water Impoundments to be Planned & Approved.	Plant to Stabilize Grades. Detailed Conditions & Instructions. Mulch All Grades Over 20°.
PENNSYLVANIA (1972)	Alternate Layers of Refuse & Clean Fill With 10 ft. Over Uppermost Refuse. Remove, Segregate & Store Topsoil. Replace 12 Inch Cover.	No Acid Mine Drainage, Siltation or Stream Pollution.	Plant to Stabilize Grades. Return Land to its Highest Capability.
TEXAS (1976)	Remove Topsoil & Replace on Backfill Surface or Store & Protect From Erosion & Contamination. (Other Strata May be Substituted if Equivalent.)	Remove Large Siltation Structures After Reclamation. Stabilize Waste Piles. Assure That Impoundment Leachate Does Not Pollute Surface or Groundwater.	Restore Land To Same or Substantial Beneficial Condition. Establish a Diverse Native Vegetative Cover.
OHIO (1974)	Topsoil or Suitable Subsoil & Amendments in Sufficient Quantity & Depth to Sustain Growth of Stabilizing Vegetation	Water Impoundments for Recreation Require Safe Slopes & Access. Must be Safe.	Diverse Vegetative Cover Capable of Self-Regeneration & Plant Succession.

ABSTRACT OF STATE RECLAMATION LAWS

STATE	RECLAMATION TIME LIMIT	INTERIM OF LIABILITY	BONDS, FEES, FILING, REQUIREMENTS
N. DAKOTA	3 Years After Permit Termination Plus Year to Year Extension if Necessary.	Until Reclamation is Complete and Approved.	$250 + $10/Acre Fee. Bond Minimum is $1500/Acre.
MISSOURI	Complete Grading Within 6 Months. Seed, Plant Within 24 Months After Permit Expires.	Until Reclamation is Complete and Approved.	$50 + $17.50/Acre Fee. Bond of $500 Per Acre & $2000 Minimum. $50 to $1000/Day Fines for Operating Without a Permit.
W. VIRGINIA (1971)	Backfill & Grade Within 60 Days or 3000 ft. 30 Days or 1000 ft. If Augered. No More Than 2 Spoil Ridges. Max. of 3000 ft. Pit.	Until Reclamation is Complete and Approved.	Bond of $1000/Acre. $100-$300,000 PL & PD. Fee is $500. Renewal Fee is $100. Bond Minimum is $10,000. $60/Acre Tax.
PENNSYLVANIA (1972)	Max. 1500 Linear Ft. Pit. Backfill All Pits Within 6 Months After Completion of Mining. Planting Within One Year After Backfilling.	5 Years After Operation is Stopped.	$500 Fee for First Year. $300 Fee for Renewal. Fine for No Permit is $5000 Min, Plus Up to One Year Imprisonment. $100,000PL & PD $5000 Bond Minimum.
TEXAS (1976)	Proceed As Contemporaneously As Practicable.	4 Years After The First Year of Successful Revegetation.	$200 Initial Fee Plus $10/Acre. Adequate Pl & PD Insurance. Survey of Area Required Before Permit Issued. Bond Per Est. Cost. Fines Up to $10,000 and/or 1 Year Imprisonment.
OHIO (1974)	As Stated in The Approved Plan. In a Timely Manner.	Permit Valid For 10 Years. Term Established by Chief of Reclamation.	$100-$300,000 PL & PD Insurance. $150 Plus $30/Acre Up to $1000 Per Year. Bond is $500/Acre. Liability is the Actual Cost. Fines Up to $5000 + $1000/Acre & 6 Months Imprisonment.

ABSTRACT OF STATE RECLAMATION LAWS

STATE	CONDITIONS FOR REVOCATION OR DENIAL OF PERMIT	REGULATING STATE AGENCY
N. DAKOTA	Failure to Comply With Regulations or to Substitute Surety of Bond.	Public Service Commission
MISSOURI	Permit Renewed Annually. Denied if Operator Fails to Substitute Surety or Violation of Reclamation Act.	Land Reclamation Commission
W. VIRGINIA (1971)	Permit Valid for One Year. Refused if Bond Forfeited	Department of Natural Resources.
PENNSYLVANIA (1972)	Failure to Comply With Law.	Department of Environmental Resources
TEXAS (1976)	Previously Revoked Permit or Bond, or if Reclamation, Health and Safety Objectives cannot be Achieved.	Railroad Commission.
OHIO (1974)	If Reclamation cannot be Achieved Per Legal Requirement or if Code is Violated, Permit Approval in 90 Days. Denials Up to 5 Years.	Department of Natural Resources.

ABSTRACT OF STATE RECLAMATION LAWS

STATE	OVERBURDEN SAMPLES	REFUSE & DRAINAGE	FINAL GRADED CONTOUR
WYOMING (1975)	No Requirements.	Adequate Thru Drainage to Prevent Erosions, Pollution & Stagnant Water. Diversion Ditches Per Specifications.	Max. Reclaimed Slope to be no Greater Than Average in Area. No Depressions Unless Approved. Area to Blend in With Surroundings.
TENNESSEE (1974)	None Required.	Detailed Specs For Drainage to Control Erosion, Sedimentation & Pollution. 4 ft. of Spoil Over Refuse, Debris & Toxic Matl. in Pit.	AOC Except Reworked Orphan Mines. 35 Max. on Terraced Slopes. Specs. for Head-Of-Hollow Fill.
VIRGINIA (1972)	None Required.	Detailed Specs For Drainage, Dams, Ponds, Water Treatment. 4 ft. of Spoil Over Toxic Material at Back of Pit. Remove or Bury Refuse & Debris.	Graded Benches or Terrace Back Fill Permitted. Access Roads to Highwall Every 2500 ft.
NEW MEXICO (1972)	None Required.	Waste & Refuse to be Buried. Quality & Quantity of Natural Drainage to be Conserved. Waste to be Covered Immediately.	Gently Undulating Topography to Control Erosion & Siltation. Can be Deferred by Commission.

ABSTRACT OF STATE RECLAMATION LAWS

STATE	TOPSOIL REMOVAL & PLACEMENT	FINAL CUTS & WATER IMPOUNDMENTS	GENERAL RECLAMATION
WYOMING (1975)	Top Soil or Approved Substitute to be Stockpiled & Protected. Sub-soil to be Segrated & Stockpiled. Large Rocks to be Removed.	Terracing May Be Approved. 1/2 of Lake Shore May be Highwall. Base of Pit to Have Topsoil. Toxic Material to be Sealed & Buried.	Reclaim to a Use Equal to or Greater Than Highest Previous Use. Revegetate When Possible. Mechically Drilled Seeding.
TENNESSEE (1974)	Topsoil to be Separated and Stockpiled.	Coal Seam May Be Covered With Water. No Highwall Except Reworking of Orphan Mines. Specs. for Water Impoundments.	No Fill Benches on Slopes Over 28°. Spoil Limit is 50 ft. Downslope. Revegetate A.S.A.P. to Minimize Erosion. Mulch With All Seedings.
VIRGINIA (1972)	Not Specified.	Determined By Division. Reduce Highwall as Much as Possible.	Detailed Specs on Soil Amendments and Revegetation. Mulch Normally Applied.
NEW MEXICO (1972)	Proposed by Operator in Mining Plan.	Dams in Final Cut Only if Impoundment is Within Water Laws.	Revegetation to be Integral Part of Operation as Proposed by Operator in Mining Plan & in Consultation With Local Soil & Water Conservation Districts.

ABSTRACT OF STATE RECLAMATION LAWS

STATE	RECLAMATION TIME LIMIT	INTERIM OF LIABILITY	BONDS, FEES, FILING, REQUIREMENTS
WYOMING (1975)	As Soon as is Feasible. Concurrent With Mining, or at the Latest 180 Days After Mining Stops, or Written Approval For Delay.	Until Revegetation Meets Certain Criteria. Prevent Noxious Weeds for 5 Years. At Least $10,000 Bond for at Least 5 Years.	$100 + $10/Acre Not to Exceed $2000 is Fee. Bond No Less Than $10,000 or $200 Per Acre.
TENNESSEE (1974)	Backfill Within 15 Days. Ungraded Pit Length Max. is 1500 ft. All Grading Drainage to be Complete Within 180 Days.	Until Revegetation is Complete and Stable.	Fee is $250 + $25 Per Acre With Max. of $2500. Bond not Less Than $1000 Per Acre. Fines From $100 to $5000 Per Day.
VIRGINIA (1972)	Grading, Backfilling & Water Management to be Current. 60 Day Limit. Ungraded Pit Limit is 700 ft.	Within One Year if Reclamation is Approved.	Fee is $12/Acre First Year. Bonds From $200 to $1000/ Acre With Minimum of $2500. Fines Up to $1000 and/or 1 Year in Jail per Offense.
NEW MEXICO (1972)	Grading Shall be Integral Part of Operation & Completed Within Reasonably Prescribed Time Limits.	Not Specified.	Fee is $50 + $10 Per Acre First Year, $20/Acre After. Bonds are Discretionary. Fines Up to $1000/Day. Environmental Impact Hearing Required for Approval.

ABSTRACT OF STATE RECLAMATION LAWS

STATE	CONDITIONS FOR REVOCATION OR DENIAL OF PERMIT	REGULATING STATE AGENCY
WYOMING (1975)	Department to Answer in 60 Days. 12 Reasons for Denial.	Department of Environmental Quality, Land Quality Division.
TENNESSEE (1974)	Failure to Comply With Law. Failure to Reclaim Disturbed Land.	Department of Conservation, Div. of Surface Mining.
VIRGINIA (1972)	Permits Valid for One Year. Decision Given in 30 Days.	Department of Conservation & Economic Development, Div. of Mined Land Reclamation.
NEW MEXICO (1972)	Suspension or Revocation for Failure to Comply With Act.	Coal Surface-Mining Commission of Bureau of Mines & Mineral Resources.

LIST OF RECLAMATION PROBLEMS

Acid Mine Drainage (AMD)

Oxidation of certain sulfur bearing minerals including pyrite produces sulfuric acid. Abandoned deep mines usually collect a lot of water and they "breath" with changes in atmospheric pressure. The breathing introduces oxygen to the exposed pyrite and sulfuric acid results. Some AMD reaches pH values as low as 2.0. Surface coal mines occasionally expose old drifts and shafts with the result that normal operations are interrupted and special drain treatment facilities have to be constructed. This problem occurs most frequently in the Appalachian Mountains, but is encountered in the Midwest also. State reclamation inspectors in Pennsylvania claim that there is no known way to permanently seal these openings so they will not drain. Western coal mines have little trouble with AMD because there are so few abandoned underground workings and because the overburden usually contains very little if any acid forming minerals.

Acid mine drainage when it does occur should best be avoided by impounding it in ponds and treating it in some way that will raise the pH to neutral levels. The addition of lime is the most common treatment. Some experimentation has been done with distillation and dialysis as methods to neutralize acid drainage. Diversion ditches are necessary to keep as much water out of the pit as possible and divert it to collection points. In orphan mines and abandoned workings, both surface and underground, flooding with water is a common way of preventing further oxidation of exposed rock containing sulfur bearing minerals.

Sodium

Overburden strata that contain sodium create very difficult reclamation problems because it has the effect of making certain clays impermeable to water. The impermeability of surface strata increases rain water runoff and water erosion. This problem is encountered in the northwest, especially in North Dakota and to a lesser extent in Montana and Wyoming. Sodium is also very toxic to most plants and as a result, its presence hinders reclaimed land revegetation. The best way to prevent the bad effects of saline soils is to bury them by selective placement of overburden in the spoil piles.

Landslides, Siltation and Erosion

This general problem is a function of the rate and total volume of rainfall. It is most severe in Appalachia where both factors are quite high and the slope angles of the land contour are steep. The worst cases of landslides occur in those areas where spoil piles have been placed on the outslopes of contour mines, but it is occasionally a problem in box cut pits. Slides occur in the highwall as well as the spoil banks. Control measures have to be custom designed for each particular case and in general they include: terracing, diversion ditches, runoff collection basins, filtration, pumping down the water table, mining diagonally to the coal seam dip, contour plowing, mulching, planting rapidly growing cover plants and other measures designed to either remove the water in a harmless way and/or control its down hill velocity.

Rock Outcropping in Leveled Spoils

This problem occurs to a greater or lesser extent in most mines and is serious where the end use of the land is agricultural. If rock free topsoil is stockpiled and then placed on leveled spoil, there is no problem, but when the stripping equipment deposits topsoil on spoil peaks, valleys and ridges, considerable outcropping occurs when the banks are leveled. Concurrent leveling so that the stripping equipment can place topsoil on semi-leveled spoil would be desirable from a reclamation point of view, but somewhat dangerous and difficult to accomplish in actual operations. Truck and shovel operations can and do avoid this problem without rehandling topsoil, but their economic application is somewhat limited. Pan scrapers also fit in this category. Attempts have been made to apply rock picking equipment, both conventional and novel, but at best it is an expensive solution to the problem.

Leveling and Grading Soft Spoil

Areas such as central Illinois which have thick layers of topsoil and subsoil encounter the problem of equipment such as dozers sinking into wet spoil and becoming inoperable. The result is that leveling and grading can only be accomplished effectively during certain seasons of the year. Not only is equipment utilization kept at a low level, but reclamation cannot be kept concurrent with the stripping rate. The solution is either to have equipment with very low bearing pressure or eliminate the need for equipment to operate on the spoil surface.

Revegetation

Areas in the western states where rainfall is low in total volume and is concentrated in a short season have a problem reestablishing and sustaining vegetation on mine spoil. The problem is further agravated by foraging wildlife.

Hydrologic Changes

Coal seams are frequently aquifers and extensive mining in an area can sometimes interrupt ground water flow downstream from the mine. This has been a subject of controversy in certain areas which have low rainfall.

Returning Surface to Original Contour (AOC)

In certain areas and especially in many parts of Appalachia the original land contour is very steep. In order to return it to that approximate original contour, sometimes very unusual and expensive measures must be taken. Terracing is a popular means of restoring the approximate original contour and helps to reduce erosion and slides.

spread the topsoil material evenly over the spoil area or profile a specific contour without rehandling stockpiled topsoil, regrading spoil, etc. (See Exhibit VIII-2)

Conveyor material handling is generally a long term, high volume system. However, these systems are relatively inflexible and have high initial capital requirements. They could be very expensive to operate if very many crawler tractors were needed to keep conveyor movement ahead of the pit movement, and maintenance could be costly. Hauling around the pit and through spoil areas could interfere with pit access roads. The spreader/caster, conveyor structure, and crawler tractors would encounter stability problems in the spoil areas during rain or snow conditions. A mobile conveyor system would not be applicable to rough terrain or frequently undulating areas due to various horsepower/braking requirements, support structure, etc.

Topsoil Handling Via Cross-Pit Conveyor

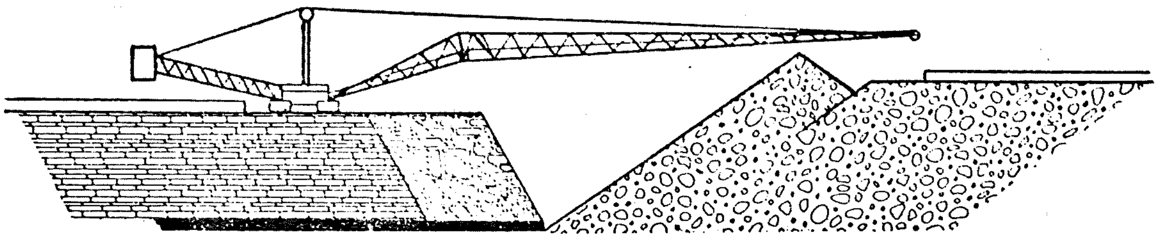
Cross-pit conveyors could be used to transport topsoil, sandy clays, or unconsolidated overburden strata from the highwall side of the pit directly across to the spoil area and deposit the material in a manner which returns the area to AOC or a desired profile. The cross-pit conveyor system would travel the length of the pit as it handles material and advance with the pit, gradually covering the permit area. Overburden would be loaded onto the conveyor by wheel loaders, dozers, or scrapers which dump onto a hopper/feeder mechanism. The overburden transported across the pit would be spread onto rough-graded spoil to any desired contour by a slewing or casting mechanism.

Three styles of cross-pit conveyor systems for handling topsoil and unconsolidated overburden are illustrated in Exhibit VIII-3. The system could utilize belt, bucket, or flight type conveyance as per lump size and abrasive characteristics of the material to be handled. A span of approximately 600 feet would be required to handle material from highwall bench preparation to rough-graded spoil. Additionally, the system would be required to travel around pit ends and turn in order to spread selectively and minimize interference with shovels or draglines.

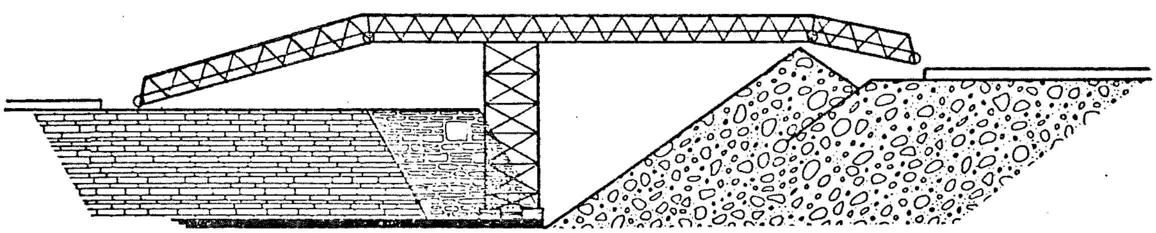
The cross-pit system could also be applicable to multi-seam operations where the conveyor handled all overburden and interburden was mined in a conventional single seam manner. This application could be a viable alternative to the common productivity losses associated with draglines chopping interburden from spoil benches.

The following is a brief summary of the potential problems which must be resolved by a cross-pit conveyor system.

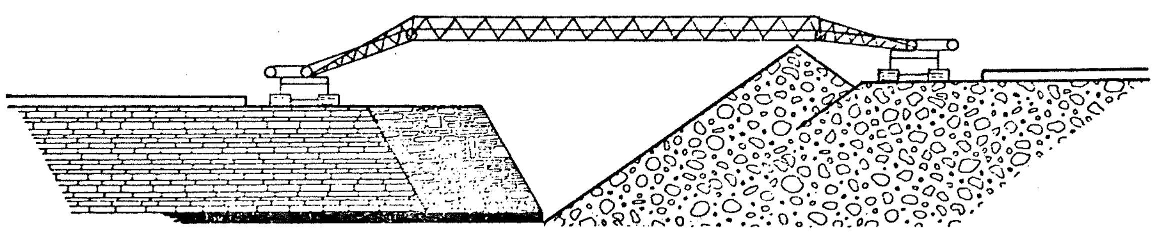
- Initial capital requirements for the hopper/feeder, conveyor structure, and slewing mechanism would be over a million dollars.
- Stability and flotation of the mobile units could be difficult in soft spoil, rain or snow conditions.



(1) Cantilever Style Conveyor



(2) In-Pit Mobile Unit Style Conveyor



(3) Dual Mobile Unit Style Conveyor

EXHIBIT VIII-3
CONCEPTUAL SKETCH OF VARIOUS CROSS-PIT
CONVEYOR SYSTEMS FOR TOPSOIL HANDLING

- Systems supported by a mobile unit in the spoil or in the pit might conflict with through-spoil haulage roads.

- Conveyor travel would be limited to flat or gently rolling terrain.

Variable Pitch Stripping Shovel Dipper

The primary objective for the use of a variable pitch dipper on stripping shovels is to selectively dig and spoil overburden or parting material. Additionally, increased yardage per stroke is possible due to improved crowding characteristics of the shovel.

The shovel operator must be able to recognize "desirable" or "undesirable" strata to be dug, adjust dipper angle, dig, and selectively place material on the spoil pile. The selective placement of the spoil occurs when the desirable material "lags" the pile and creates the top of the spoil ridge. Undesirable material "leads" the pile and is buried. (See Exhibit VIII-4) In this way reclamation will be in closer conformity to legal standards requiring the strata of the reclaimed land to be similar or better than that before mining (acidic overburden/interburden will be buried under topsoil material).

Potential limitations which were identified during preliminary systems analysis are discussed below:

- Increased operating sophistication is required since operators must differentiate between desirable/undesirable strata and lag/lead the spoil pile respectively.

- Although variable pitch dippers are being utilized in the field and can be retrofitted, they are still considered R and D by the manufacturer.

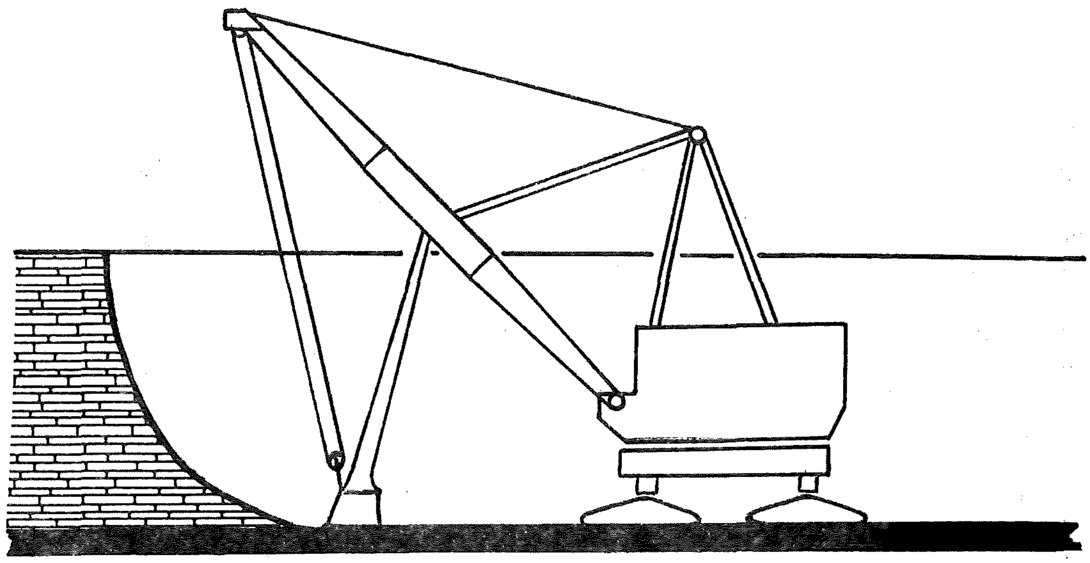
- The need to retrofit existing shovels with the variable pitch dipper presents certain installation and startup problems. Among these problems are purchase price, substantial downtime during retrofit, and debugging time.

- As the amount of desirable (topsoil) material decreases, the practicality associated with selective deposition diminishes. Therefore, the need for a variable pitch dipper decreases.

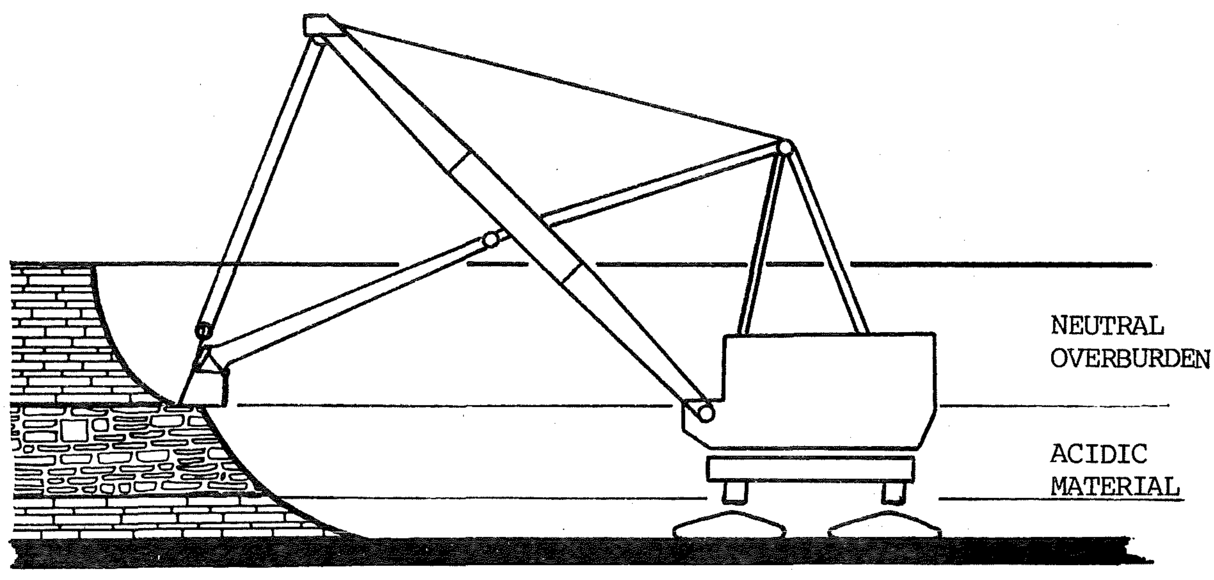
Tandem Dragline Operation

The objective of tandem draglines working on dual levels is to selectively spoil the overburden and effect economies in both reclamation and stripping activities.

For single seam mining operations overburden would be removed by both draglines at two levels along the same cut. In two-seam mines requiring



CONVENTIONAL STRIPPING SHOVEL



VARIABLE PITCH DIPPER STRIPPING SHOVEL

EXHIBIT VIII-4
ILLUSTRATION OF SELECTIVE SHOVEL EXCAVATION
UTILIZING A VARIABLE PITCH DIPPER

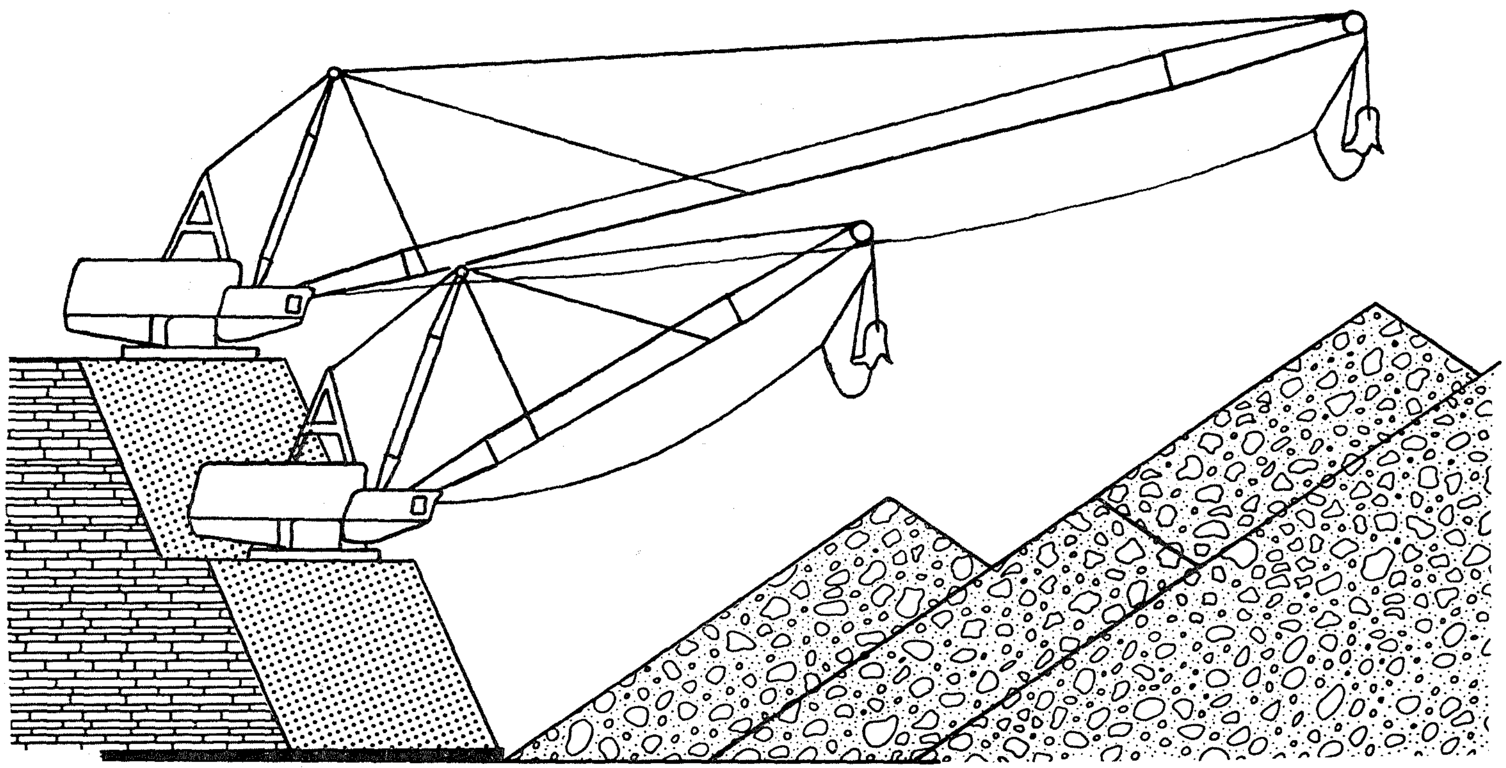


EXHIBIT VIII-5
TANDEM DRAGLINE OPERATION

dragline excavation of interburden, overburden and interburden would be removed sequentially at upper and lower levels respectively. Coal removal would take place between the draglines and following the lower level dragline. Exhibit VIII-5 shows a conceptual tandem dragline operation. Overburden and desirable upper strata is placed over the lower spoil peak to aid reclamation.

Some of the primary operating characteristics and limitations of the system which were identified during preliminary analysis are as follows:

- Operation of two medium sized draglines offer potential economic advantages over operating a very large model (mechanical availability, purchase price, debugging time, etc.).
- Sequential stripping by tandem draglines could permit a "buffer zone" such that down time of one unit would not immediately affect the other, and production could be more continuous. However, this characteristic requiries spacing between draglines which could be a disadvantage at the end of the pit when a new cut must be excavated.
- Pit access roads would probably enter the pit at each end. This could mean excessive haulage distances in long pits.
- Reclamation will be in closer conformity to legal standards requiring the strata of reclaimed areas to be basically similar to that before mining inasmuch as acidic or lower strata (overburden/interburden) will be buried under desirable overburden strata. Generally, this requires the upper level dragline to spoil over the preceeding lower spoil ridge. Preliminary analysis (for a variety of sample situations) revealed that boom length and effective spoiling radius requirements would exceed current maximum specifications.

Pull-Back Dragline on Spoil

The objective of the pull-back dragline system is to increase the primary stripping machines' capability by providing more relative spoil room, and to selectively deposit overburden. Although the pull-back dragline represents additional equipment and material rehandle, its use would eliminate some of the equipment currently required to level spoil peaks and backfill topsoil (i.e. dozers and scrapers).

The pull-back system would commence at some point subsequent to the initial box cut. The pull-back dragline would operate between the primary stripping machine and coal removal operation from a position approximately