CHAPTER III

DESCRIPTION OF DEVELOPMENT, ENERGY CONVERSION AND DISTRIBUTION SYSTEM MODELS

Mining Operations

Surface mining

Powder River Basin coal, averaging 70 feet in thickness, occurs as a single bed in some parts of the basin but may be split into as many as four beds separated by shale partings in other areas. Coal present on the outcrop is weathered or burned and as such is unmarketable. Initial mining will therefore begin as far down dip as necessary to avoid this unmarketable coal and will progress into the coal-bearing area.

All proposed operating methods are similar in design but differ as to type of equipment to be used based, in part, on variations in thickness of coal and partings. Extraction operations can be divided into three distinct phases: (1) topsoil removal, (2) overburden removal, and (3) coal removal.

Topsoil removal

Topsoil over most areas to be mined is less than 24 inches thick and, therefore, can be easily removed by self-loading scrapers. Scrapers will be utilized at all operations presently proposed and are expected to be used for any operations developed in the near future. Companies will be required to salvage topsoil in accordance with recommendations of the Wyoming State Department of Environmental Quality, and/or the federal agency having jurisdiction over the land surface.

Prior to initial mining in any area, all available topsoil capable of sustaining plant growth is removed and stored for eventual redistribution during land reclamation. Topsoil covering initial pits, boxcut overburden areas, roads, and plant sites will be stockpiled outside the coal outcrop in areas that will not be disturbed by mining or covered with overburden. The topsoil initially removed from mine areas and facility sites will probably be stockpiled for an extended period of time and will be seeded to reduce erosion.

Topsoil removed in advance of mining, except for that initially stockpiled, will be placed directly onto the graded spoils. This procedure will reduce the amount of soil material that must be stockpiled and rehandled. Soil material from stockpile areas will be used when direct placement cannot be done and will ultimately be used to cover the areas disturbed by the final cuts and highwall sloping operations.

The nature and thickness of available topsoil shall be determined by detailed soil surveys of prospective mining sites. Grading plans will be based on the data thus provided. The objective of such grading shall be to create the soil best suited for plant growth, making optimal use of the available soil materials.

A number of the mining companies have contracted with research organizations to investigate the possible use of various geologic strata in the overburden to support plant growth in addition to existing topsoil. Most of these research projects are presently underway, and no definitive results or conclusions have yet been made.

Overburden removal

After the soil material is removed, the earth and rock overlying the coalbed (overburden) will be excavated from the first cut and placed on land which is otherwise undisturbed and located outside of the area to be mined. Overburden from subsequent cuts will be used to backfill the pit created by the

previous cut. The cuts will vary from 100 to 400 feet in width depending on type of equipment used and thickness of overburden.

Strata overlying the coal consists of Wasatch Formation and slope detritus. The Wasatch Formation is made up of sandstone, siltstone, gray shale, carbonaceous shale, and in some areas, thin coal beds. The bedding is lenticular so that uniform overburden characteristics do not extend over large areas.

Most operators plan to drill and blast overburden material so that it can be more easily and efficiently handled. Those companies which plan no blasting initially will probably have to drill and blast as overburden becomes thicker and less weathered. Bulldozer-equipped crawler tractors will prepare a bench for drills at approximately the desired width of the cut. Then blast holes will be drilled on a predetermined pattern to a depth near the top of the coal bed. Overburden drills will be electrically powered and use relatively large bits. They will be mounted on trucks or crawlers (Figure 1). Drill hole spacings are any combination that will give an economic ratio of pounds of explosive to cubic yards of overburden and produce a material that can be easily handled by the stripping equipment. Holes will be loaded with an ammonium nitrate-fuel oil mixture and detonated.

Blasting can be expected on a daily basis, generally in the afternoon during the period between shifts. Electric delay blasting caps will be used to maximize the breaking effect and minimize seismic shock. The amount of explosive used in each hole will depend on the depth of the hole, the materials encountered in the hole, the location of the various strata that must be broken, and the spacing of adjacent holes.

Typical blasting patterns will range from 18 feet by 18 feet to 25 feet by 25 feet for coal and 20 feet by 20 feet to 30 feet by 30 feet for overburden. Thirty to 60 holes could be detonated at any one time and could

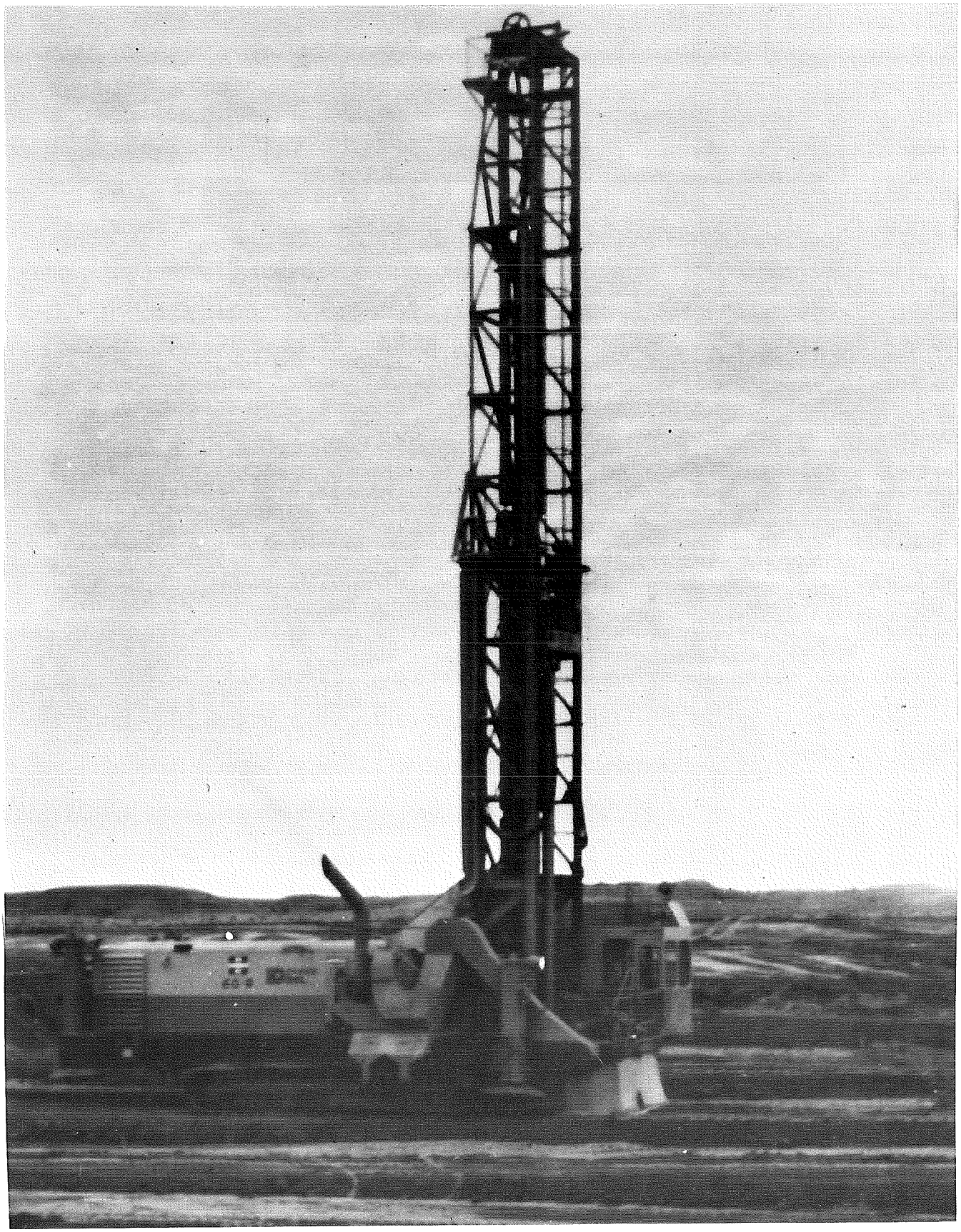


Figure 1

Crawler-mounted, electric-powered, overburden blast-hole drill

contain as much as 30 tons of explosive; however, most blasts will be in the 5- to 12-ton range.

After the overburden has been blasted, it will be removed by either large walking draglines (Figure 2) or by a combination of trucks and power shovels. The walking dragline will move along adjacent to the blasted material and will cast the overburden into the previous pit or, in the case of the initial boxcut, onto ground outside the outcrop line of the coal. When the dragline reaches the end of the pit it will be moved back to begin the next cut.

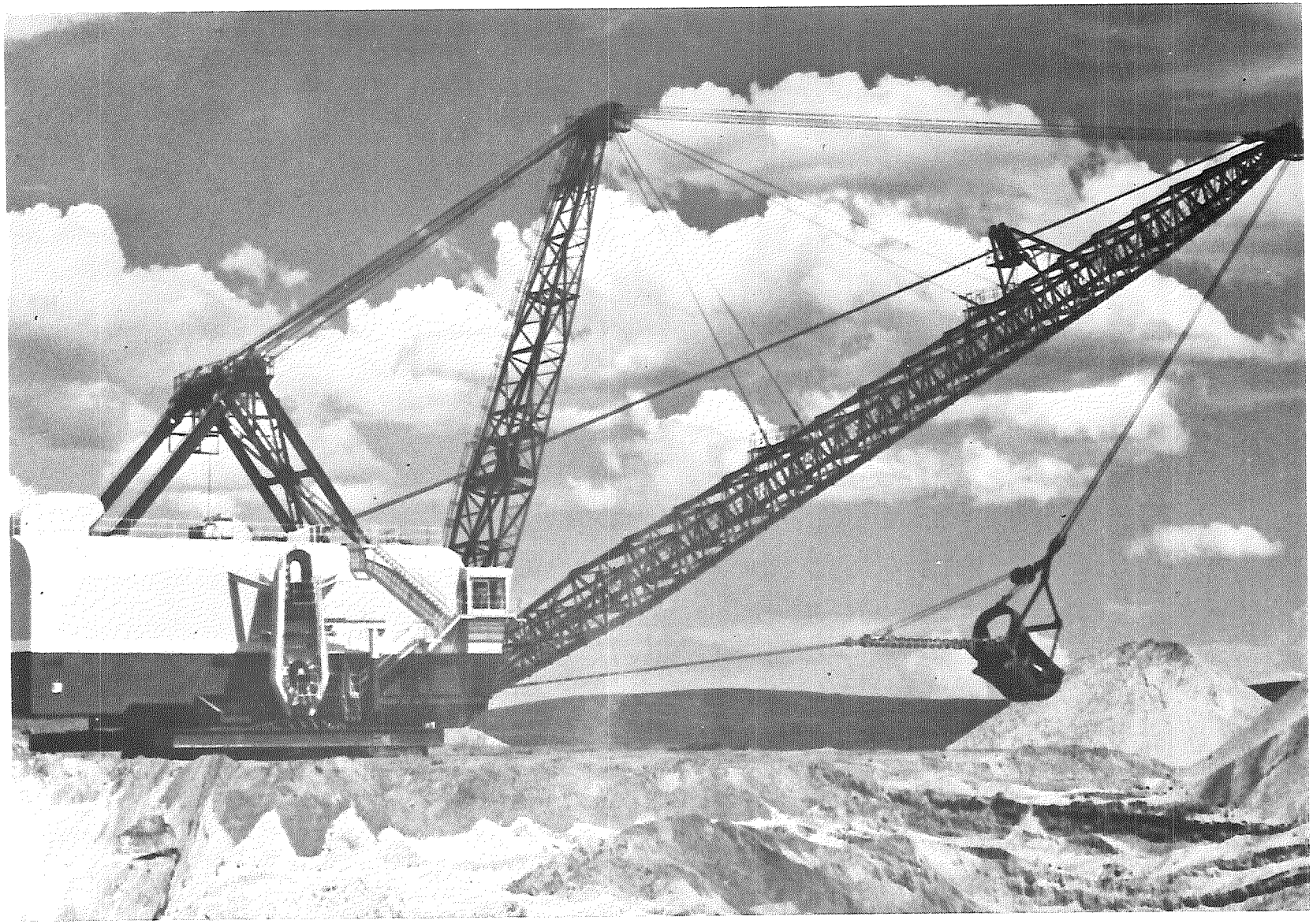
Most companies propose to remove the shale partings between coalbeds with scrapers; however, the use of a small dragline for parting removal and spoil rehandling has been proposed by one company. Figures 3 and 4 give two different views of dragline stripping operations.

The truck and shovel operation for overburden removal will be conducted on benches 35 to 50 feet in height in the blasted overburden. Electric crawler-mounted shovels will load the overburden into off-highway, end dump trucks for transfer to the spoil disposal area where it will be pushed into the pit and leveled using bulldozer-equipped crawler tractors. Figures 5, 6, and 7 give some views of truck and shovel overburden removal operations.

One other method of overburden removal has been proposed utilizing bucketwheel excavators and conveyor belts. Figure 8 shows two excavators working, removing overburden which travels on conveyor belts to the spoil area for disposal. Two other excavators are loading the coal which passes from the pit to the crusher on another set of conveyor belts.

Figure 2

39-Cubic Yard Capacity Electric-Powered Walking Dragline



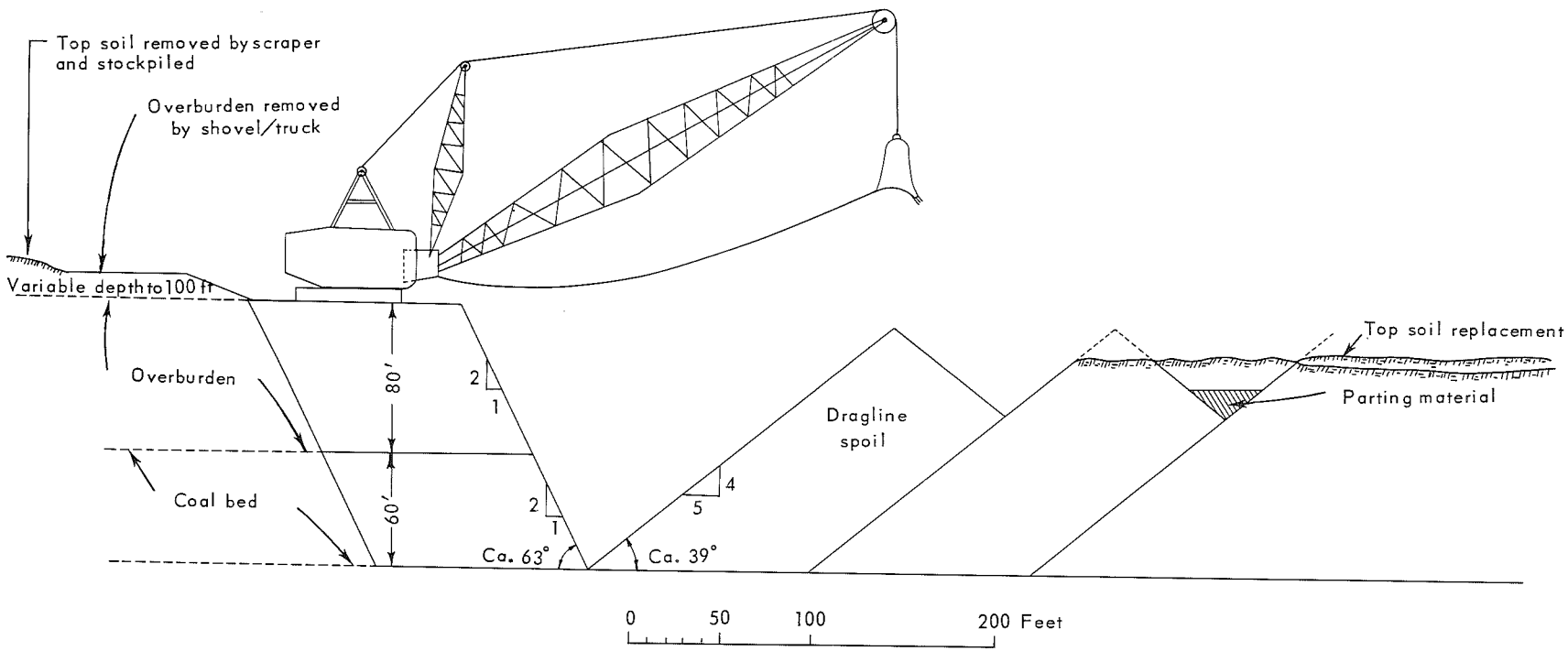
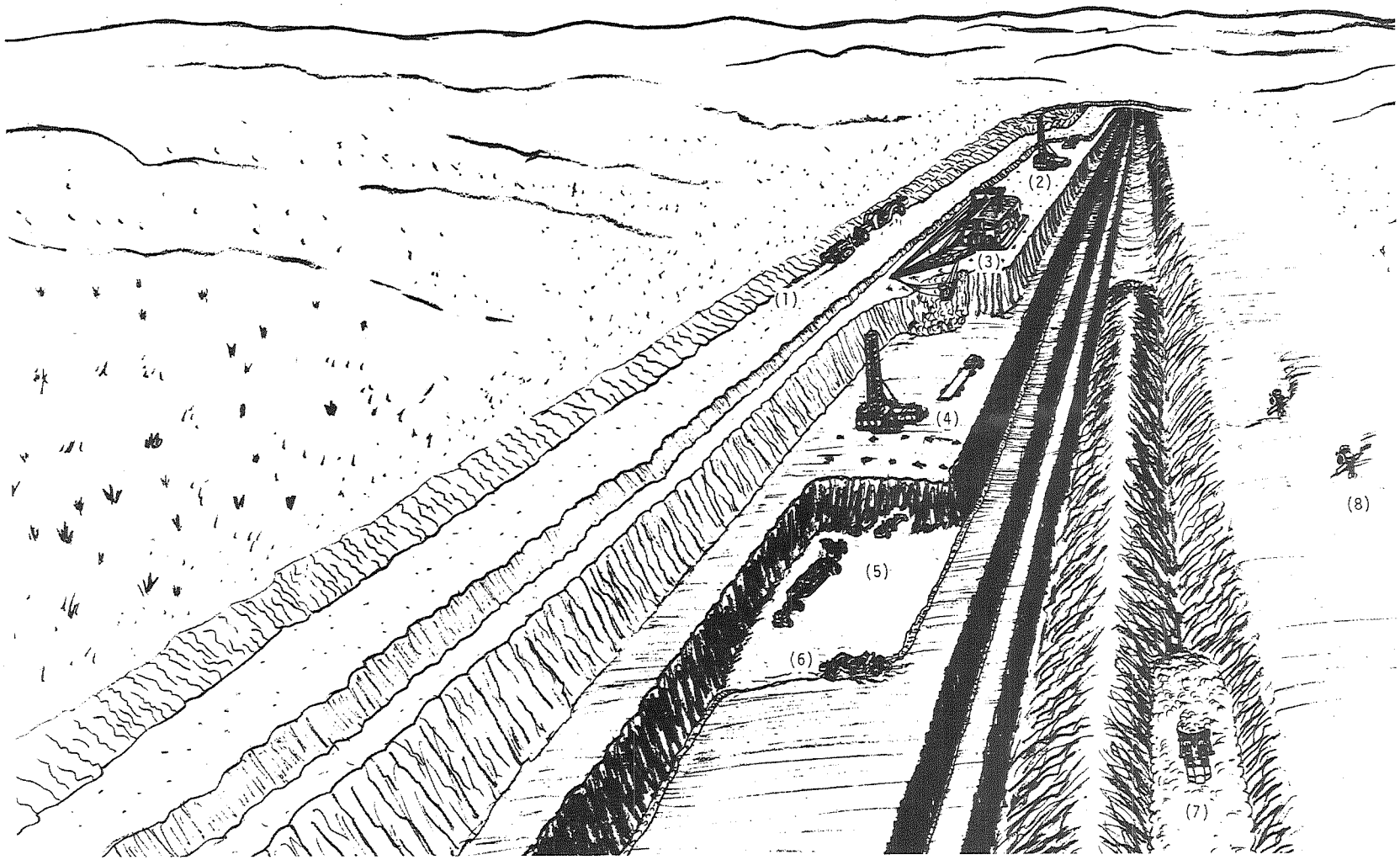


Figure 3

Cross section of typical dragline surface mining operation

Figure 4

View of Pit Operation and Reclaimed Area



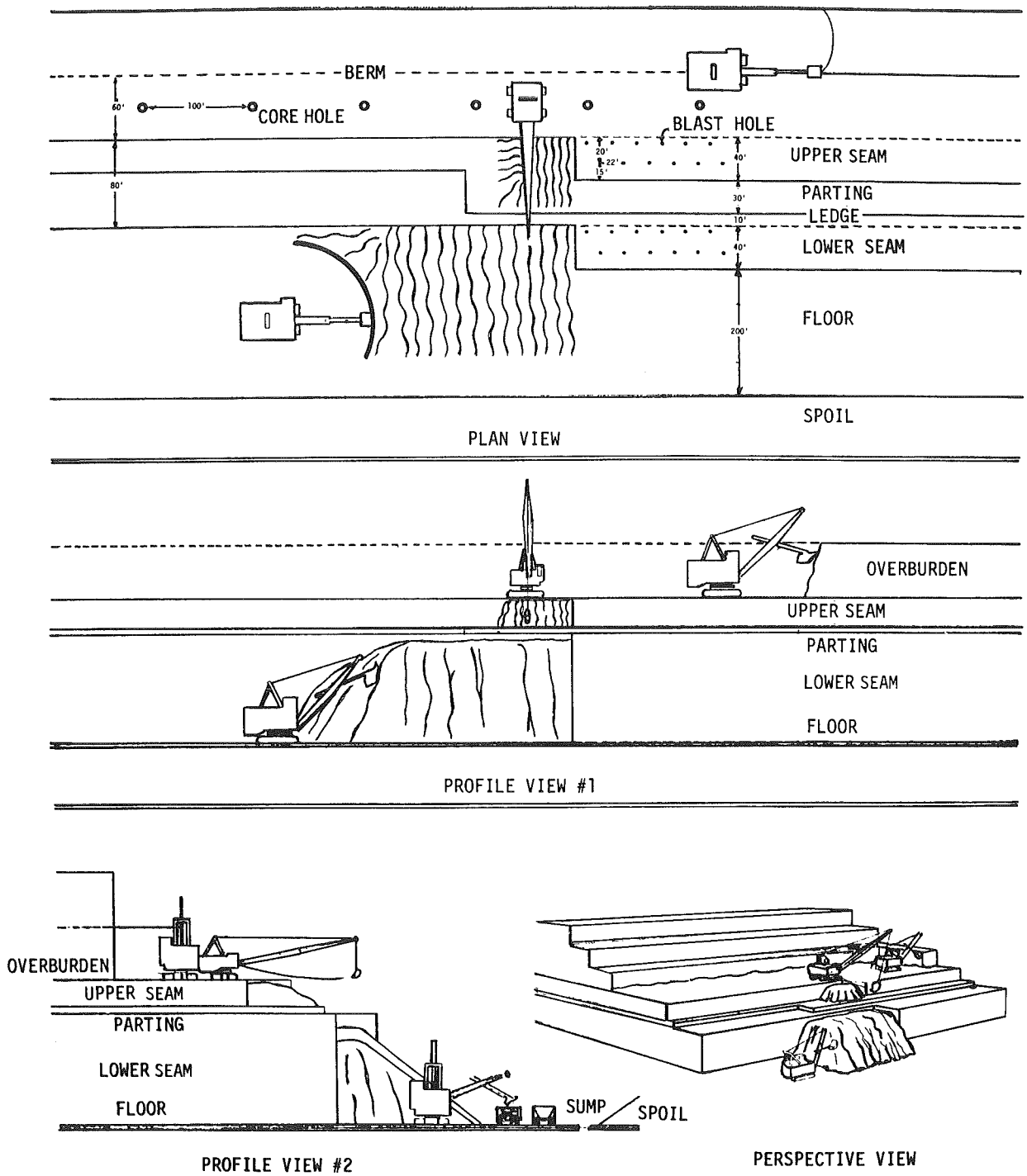
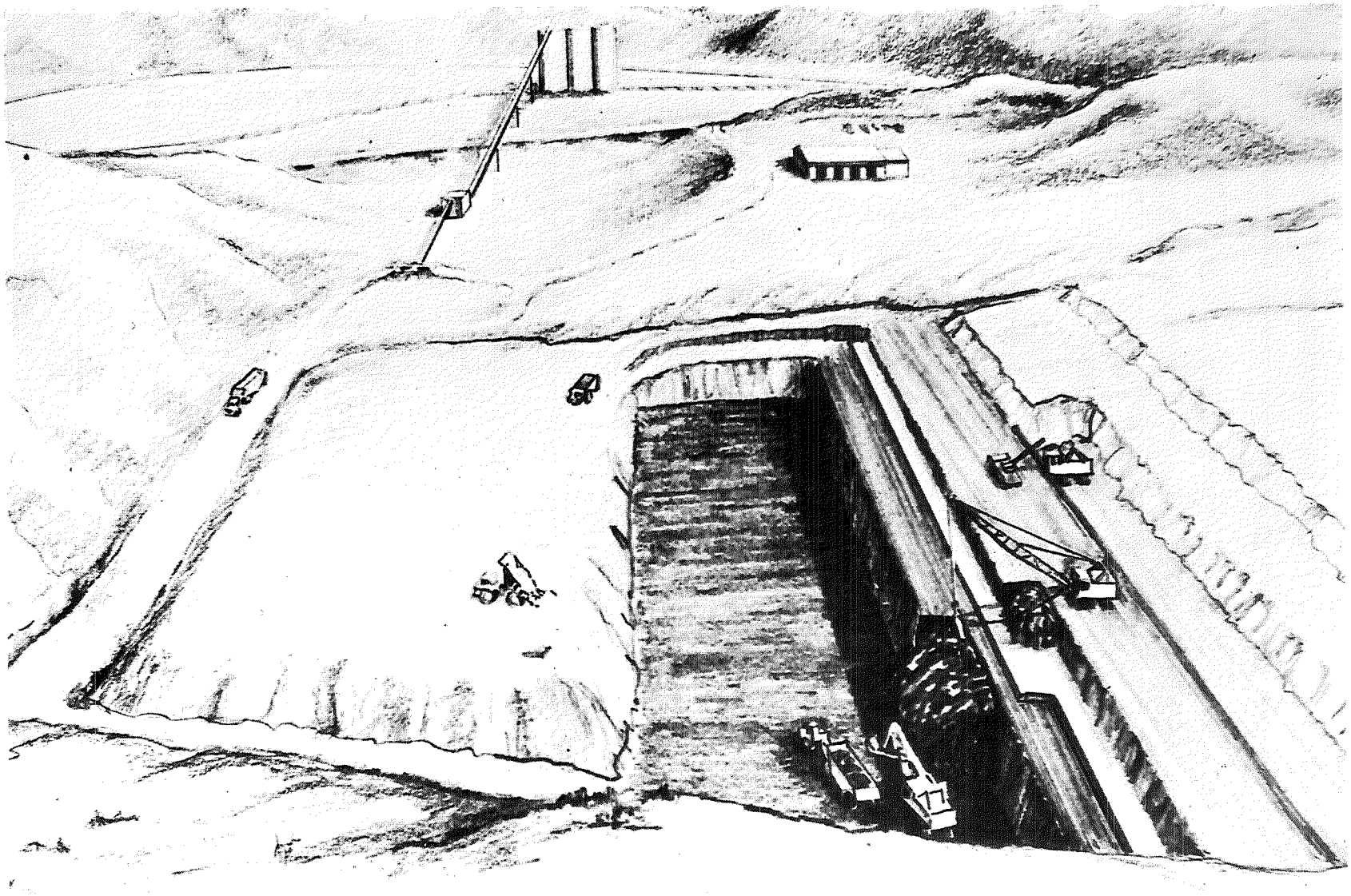


Figure 5

Mining of coal by combined shovel and dragline operation

Figure 6

Perspective of Typical Mining Facilities, Haulage Roads, Pit Operation, and Reclamation



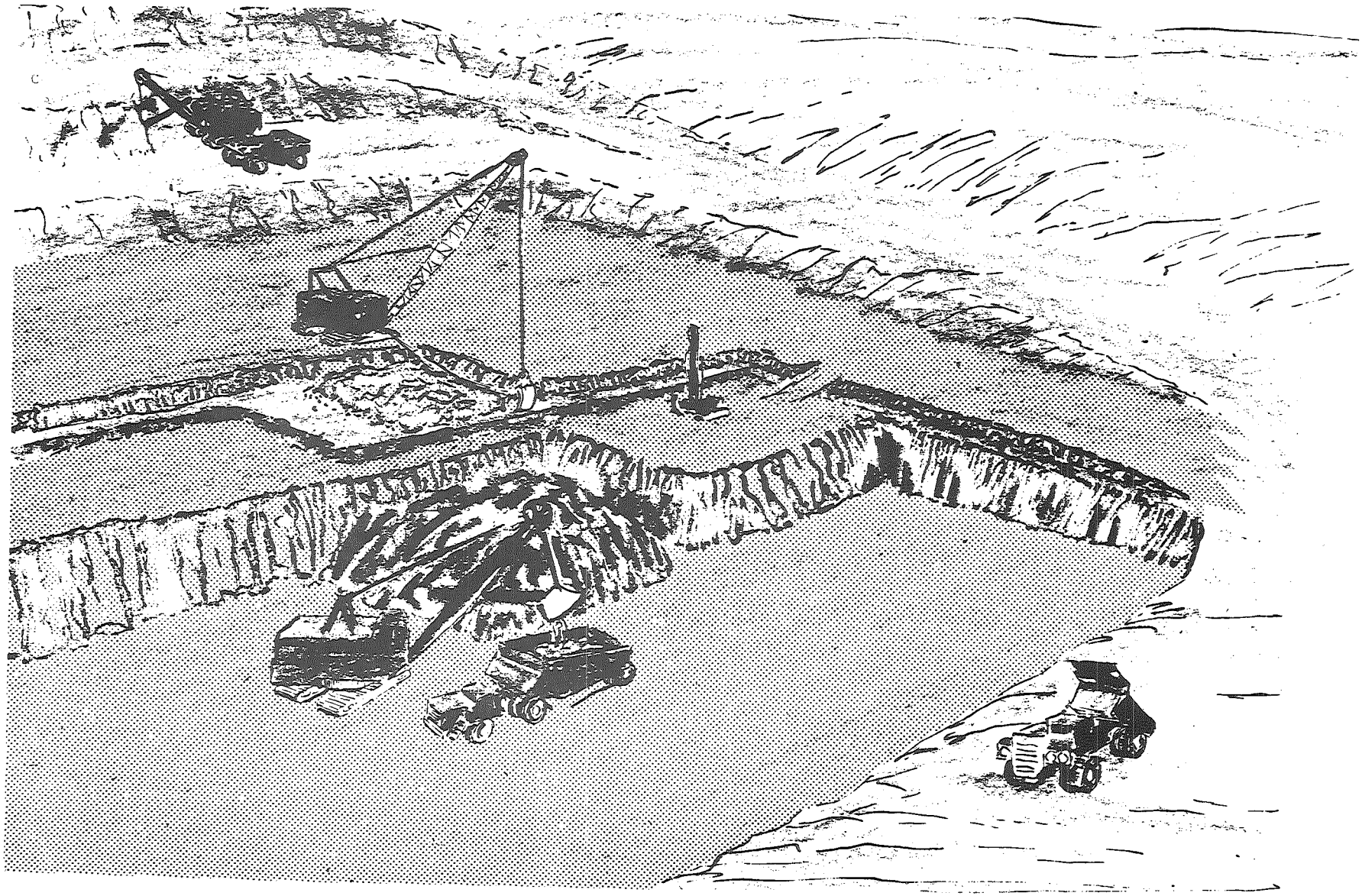


Figure 7

Multilevel removal of overburden and coal by shovel, trucks and dragline, and reclamation by truck

Figure 9
10-Cubic Yard Electric, Crawler-Mounted Shovel Loading Coal From a 39-Foot Thick Coalbed into a 65-Ton Off-Highway End-Dumping Coal Truck

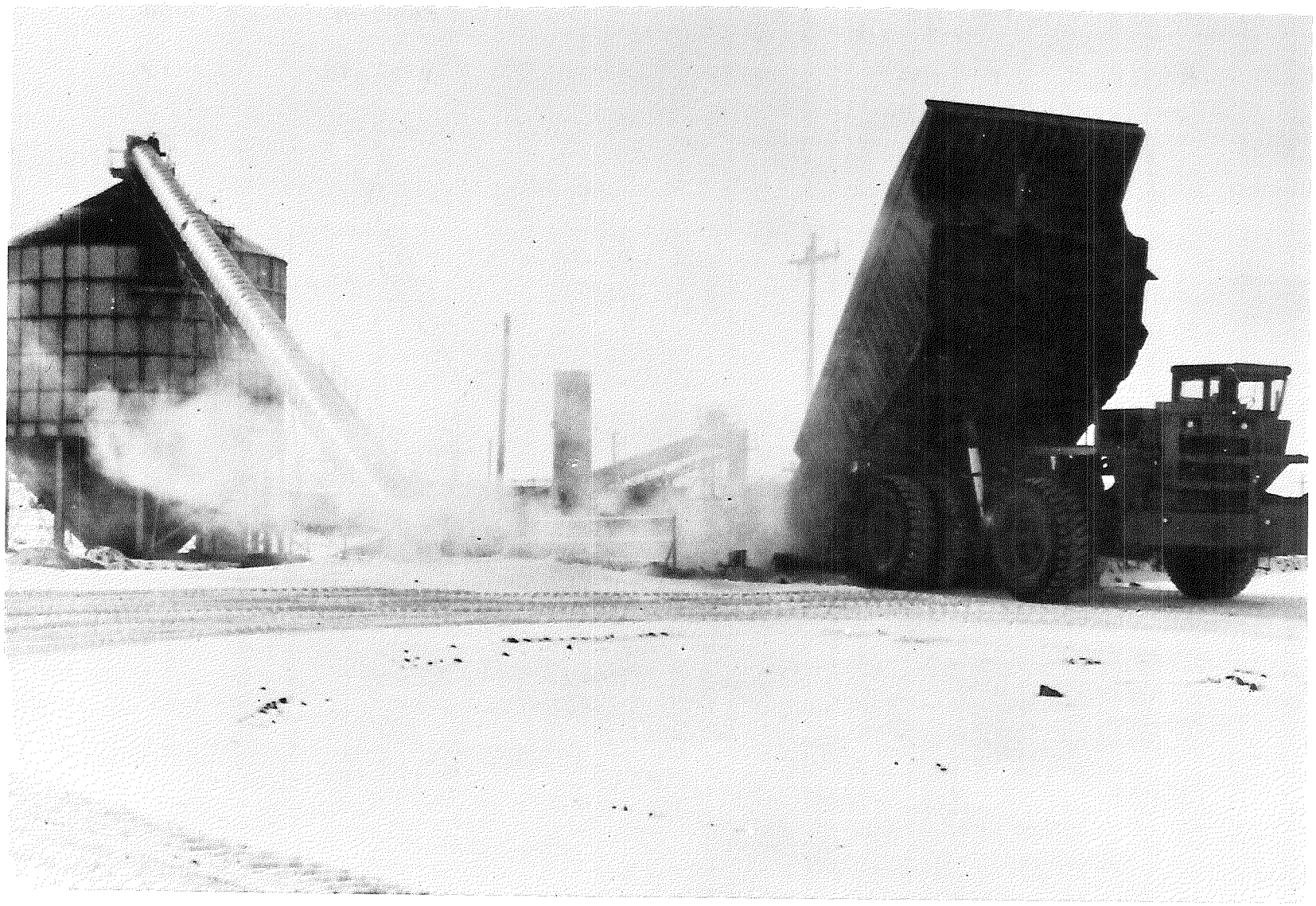
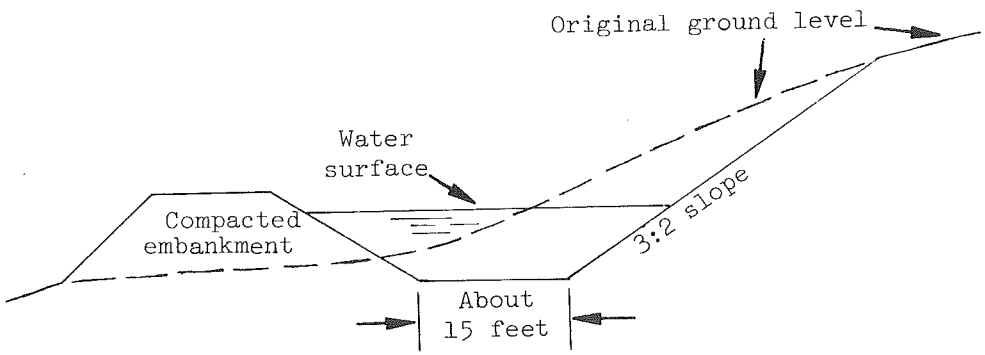


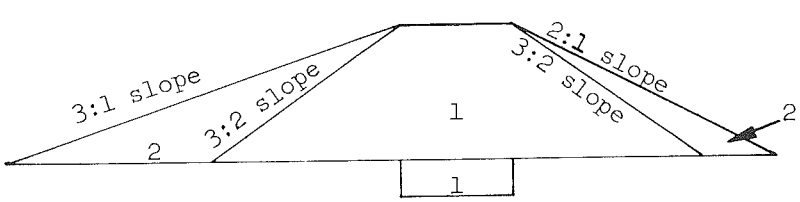
Figure 10

Off-highway truck dumping into hopper at unit train loading facility



A. Typical Ditch Section. Slopes Cut at 3:2; Bottom of Ditch Width of Bulldozer Blade.

Ratio distance to rise	Percent grade	Angle of slope
3:2	67	33.7°
2:1	50	26.6°
3:1	33	18.5°
5:1	20	11.3°



1. Impervious clay or clay sand and shale
2. Semi-pervious material of selected stability, graduated in coarseness to outer slopes; compacted.

B. Typical Earth Fill Dam Section. Core Trench Depth One-Fourth of Dam Height; Top of Dam and Core Trench 15 Feet Wide.

Figure 11

Sections of ditch and dam showing slopes of embankments

Figure 12

View of typical diversion ditch

Monitoring

Hydrologic monitoring wells will be drilled to assess ground water quality, quantity, and flow. These wells will be drilled at various locations on and adjacent to the leases. Pumping tests will be performed to measure drawdown and recovery to determine hydrologic characteristics of the aquifer.

Gauging stations will be installed in drainages and data collected on surface water quality and quantity. These stations will be located above and below the mine areas so that the effects of the operation on surface water can be determined. Surface meteorological and air quality stations will be built in various places near the operations and will record wind speed and direction, air temperature, precipitation, relative humidity, and air quality.

Underground mining

No underground development activities are proposed in the near future for coal deposits in the Eastern Powder River Basin. Also, no underground development or mining has been proposed for uranium, sand and gravel, bentonite, or clinker deposits in the areas of the federal coal leases or near proposed or active coal mines.

Reclamation of mined lands

Climate, especially in relation to available soil moisture, will be a major determining factor to successful rehabilitation of mined lands. Climate has controlled the character of land prior to disturbance and will determine what can be maintained after rehabilitation. The National Academy of Sciences study committee on the potential for rehabilitating lands surface mined for coal in the western United States considered -

> "The mixed grass area of the Northern Great Plains also offers a rather high probability for satisfactory rehabilitation. Rainfall is generally adequate for establishing vegetation by seeding. This has been demonstrated in rangeland seeding

projects through this region. Predicting such results assumes that the best technology will be applied, including the addition of topsoil and selective sorting of spoils to avoid placement of clays and toxic substances on or near the surface."

Reclamation research is a continuing process involving the operators and local, state, and federal agencies. Soil blending, fertilizer application techniques, compaction, acclimated agronomic species selection, seed selection irrigation, wind studies, soil erosion, physical and chemical soil analysis, grading, and growth rates are but some of the areas which are being researched in order to achieve a successful reclamation program.

Results of research studies into the characteristics of overburden and its revegetation potential have, so far, been inconclusive. They do, however, indicate that most spoil material is capable of sustaining plant growth. The only strata suspected of not being conducive to good plant growth are the shale partings between coalbeds. As a result, all operators propose to bury this material within the spoils. Much of the plant growth research to date has been conducted in greenhouses, and the companies propose to conduct onsite research with spoil obtained from initial box cuts. Generally, operating surface mines have not been in production for a sufficient length of time to provide a full assessment of reclamation techniques on land subjected to surface mining within the region. Currently, the most extensive reclamation research within the Powder River Basin is being conducted in Montana.

Reestablishment of vegetative conditions that existed previous to mining is technically impossible at present. Duplication of a near climax vegetative type is prevented due to the disruption of soil structure, accompanying loss of fertility, and unavailability of a suitable means of propagating most native plant species.

An attainable reclamation objective would be to leave a final topography shaped to suitable ecological conditions and to meet proper drainage and hydrologic conditions. The land surface should offer proper conditions for land stability, drainage control, and maintenance of vegetation. Some failures are anticipated owing to extreme climatic conditions, applications of improper reclamation techniques, and unanticipated circumstances. Pressures such as excessive grazing and recreation will contribute to failures, especially where unstable surface conditions exist on unconsolidated spoil materials.

Reclamation of mined land will commence with removal of topsoil in advance of mining to be stockpiled where required or spread over graded spoil prior to seeding or planting. Land will be reclaimed to a terrain compatible with present topography and planted to provide soil stability and reestablish a viable land use.

Overburden deposited by draglines will form parallel ridges of spoil, Figures 3 and 4, which will be leveled and shaped by bulldozers, sometimes aided by smaller draglines. Shaping work for truck and shovel overburden removal is performed on an almost continuous basis. As each truck of overburden is dumped, it is pushed into the pit and shapes a portion of the spoil (Figure 6). Graded areas will be sloped no steeper than 3 to 1 (33%) to provide optimum surface stability and to reduce erosion. As appropriate, the area may be mulched to produce a permeable, less erodable land surface.

Topsoil will be spread on the graded spoil using self-loading scrapers, bulldozers, or road graders. Finally, resoiled areas will be mulched and seeded with predominantly native species. Figures 13, 14, 15, and 16 illustrate the various stages of reclamation.

Reclamation objectives

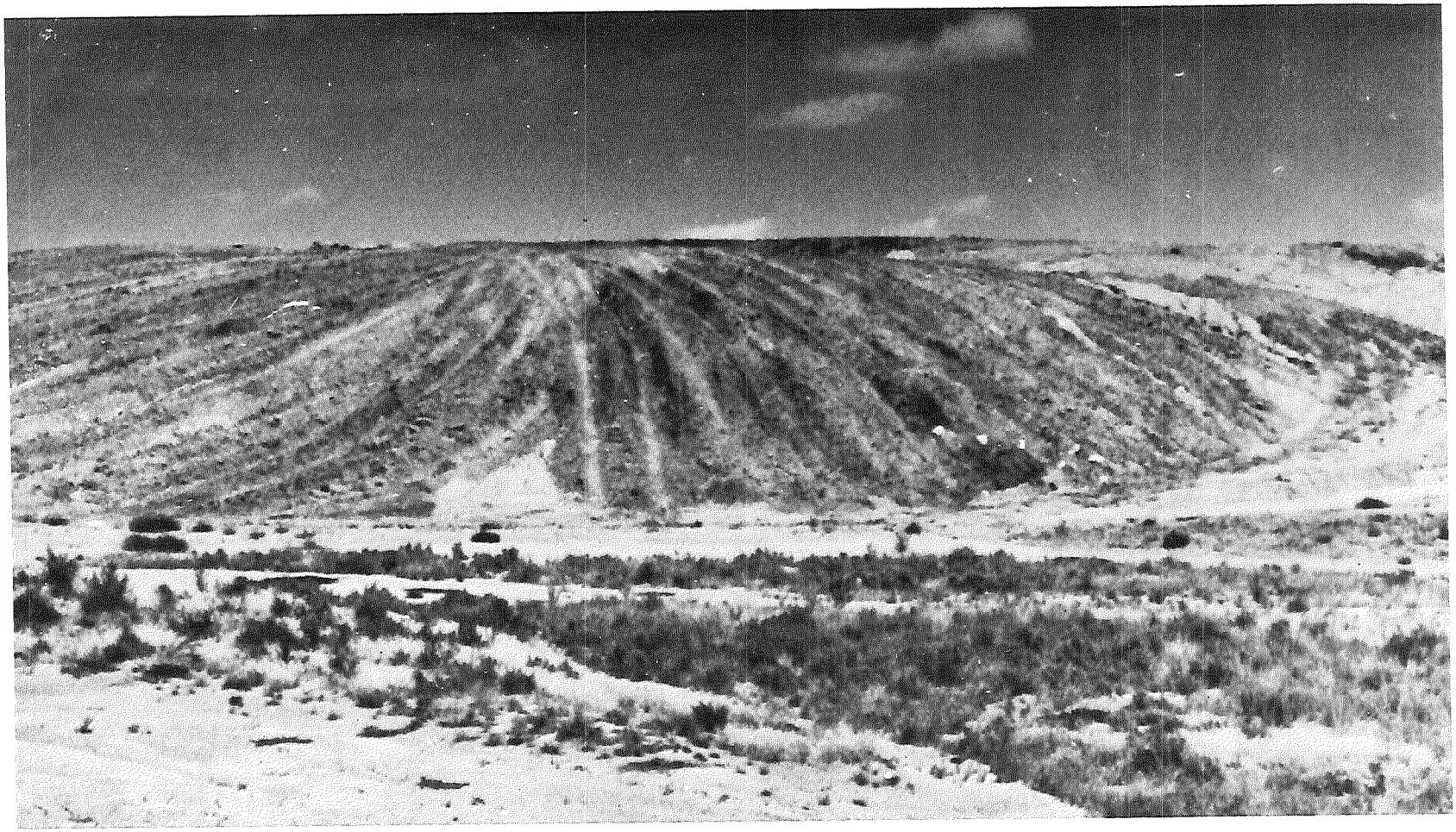
Reclamation objectives are to leave soil of such a quality that the land has the maximum number of alternative uses and the maximum productivity for priority uses, including the growth of plants necessary to maximize environmental quality after mining. To this end, spoil will be graded to a topography compatible with the land use objectives and the surrounding natural land surface. Final graded initial boxcut spoil piles will be covered with previously stockpiled topsoil prior to seeding.

Once reclamation work has started, it will continue concurrently with mining. Topsoil will no longer be stockpiled; instead, newly stripped

Figure 13
Overburden dump area showing unreclaimed spoil piles in center with leveled and planted spoils in foreground

Figure 14

Shaped and Topsoiled Spoils Prior to Seeding



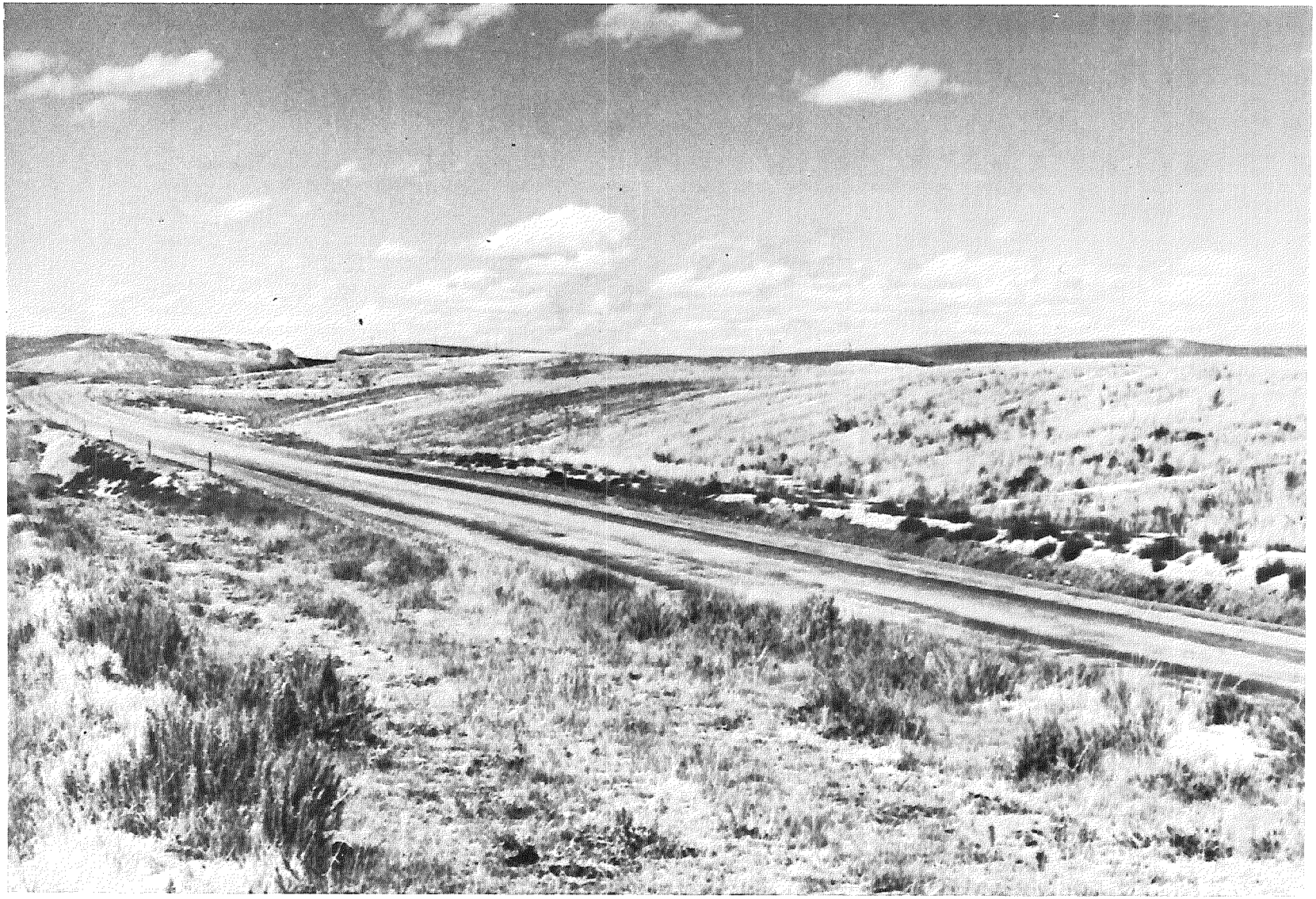


Figure 15
Mine area showing natural vegetation in foreground and reclaimed spoil above road, active pit in center left

Figure 16

Planted Area After Two Growing Seasons

soil will be spread directly on previously graded spoil. Thereafter, topsoil will be stockpiled only when a new series of boxcuts is begun.

The highwalls of final cuts will be reduced by blasting and by grading the spoil back against the blasted highwall. Material from the highwall and adjacent spoil bank will cover the face of the coalbed and fill the cut. Final grading, redistribution of topsoil on the spoil and highwall, and seeding may complete reclamation.

Because of thickness of coal and shallowness of overburden in some areas, several companies have proposed constructing lakes within their mine area. As in the highwall reduction method, all coal exposures would be covered with spoil. Highwalls are covered to control generation of acid water in the coal and to prevent spontaneous or accidental ignition of the coalbeds. The companies will consult with officials of the Forest Service, the Bureau of Land Management, Wyoming Department of Environmental Quality, and with the U.S. Geological Survey to determine where further reclamation of the final cut or other mined areas is needed.

Mining equipment and facilities

Mining equipment used in the Powder River Basin may vary in size and quantity depending on the production and mining methods used at each mine but in general can consist of the following: Large bulldozer-equipped crawler tractors, e.g., D-8, D-9 Caterpillar tractors, self-loading, rubber-tired scrapers, and roadgrader type tractors can be used to remove the vegetation and topsoil in preparation of overburden removal. If necessary, the overburden will be drilled with large rotary blast hole drills, e.g., 60-R Bucyrus Erie rotary drill. Smaller drills will be used for the coal. Explosives equipment may consist of a truck to haul ammonium nitrate-fuel oil (ANFO) explosive components. Overburden

can be removed either by a combination of 100- to 200-ton capacity trucks loaded by 10- to 30-yard capacity front-end loaders, power shovels, or a walking dragline of 30- to 70-cubic yard capacity. Bucketwheel excavators combined with converyor belts or trucks can also be used.

Facilities for storing explosives will be necessary. These could consist of an appropriate building, storage silo, and tanks for ANFO or an area to park tractor-trailer type trucks in which explosives are delivered and stored until used. Whatever the type of structure, explosives will be stored and handled in accordance with all applicable state and federal safety regulations.

Broken coal may be loaded by rubber-tired 20- to 30-yard front-end loaders, crawler type 20- to 30-yard power shovels, or possibly a small dragline. Coal will be loaded into 100- to 200-ton trucks (Figure 17) and hauled to a dumping bin. Another method may use a large mobile storage bin into which coal can be loaded directly by dragline, then crushed and loaded into trucks.

Other supplemental mine equipment may include water trucks, fuel trucks, pickup trucks, ambulance and fire equipment, supply and service trucks (maintenance, welding, and lubrication), motor graders, and a mobile crane.

Processing equipment will include primary and secondary crushers in which the coal will be reduced to minus 2-inch size, belt conveyors for transporting coal during processing, weighing devices for recording accurate weight of coal, various in-process surge bins, and final storage silos from which the coal can be loaded into unit trains. Storage silos will vary in diameter, height, and number depending on mine production and train scheduling. Silos 180 feet high by 60 feet in diameter are typical. Figures 18 and 19 show typical silos and coal loading facilities.

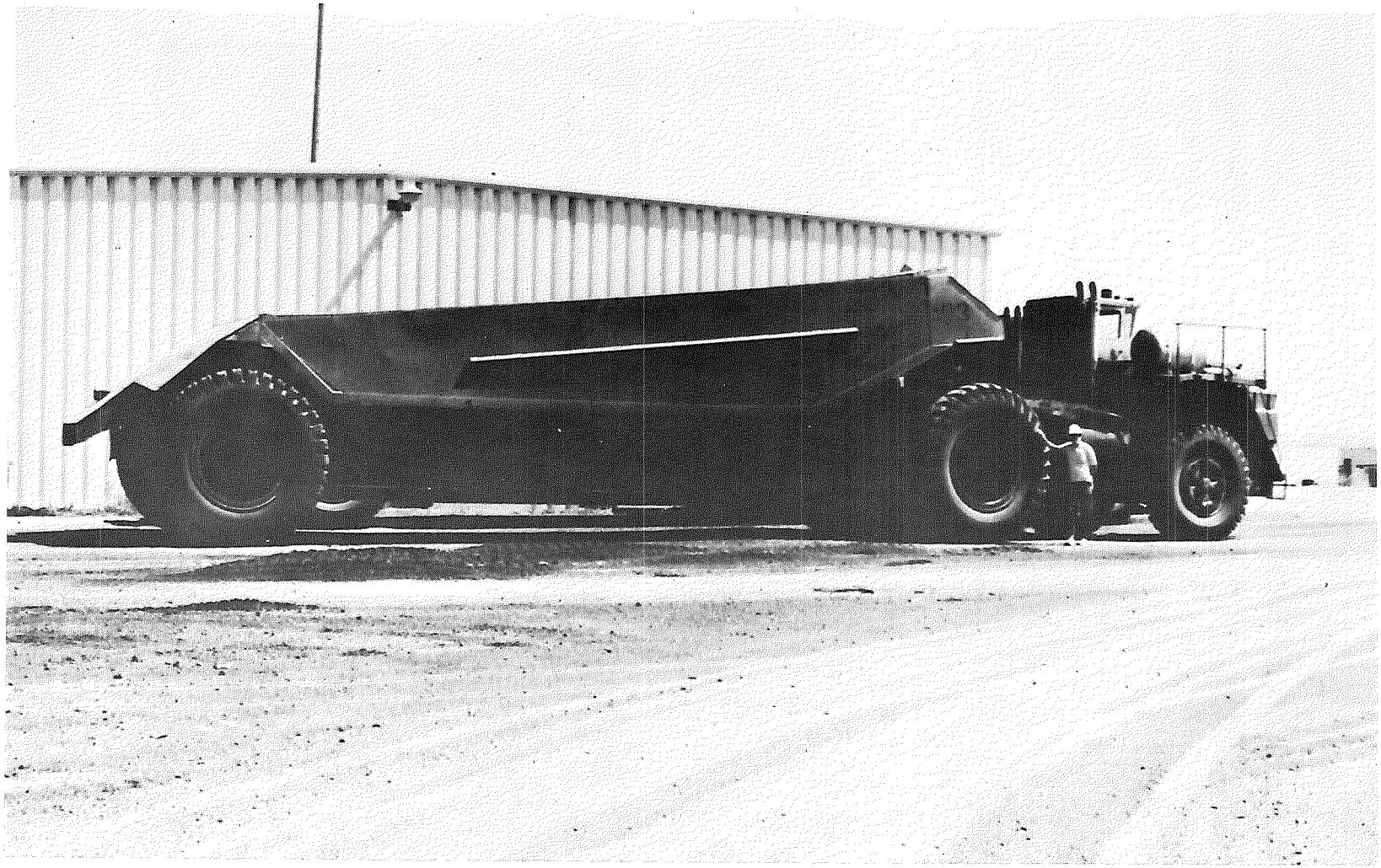


Figure 17

100-ton capacity, off-highway coal truck

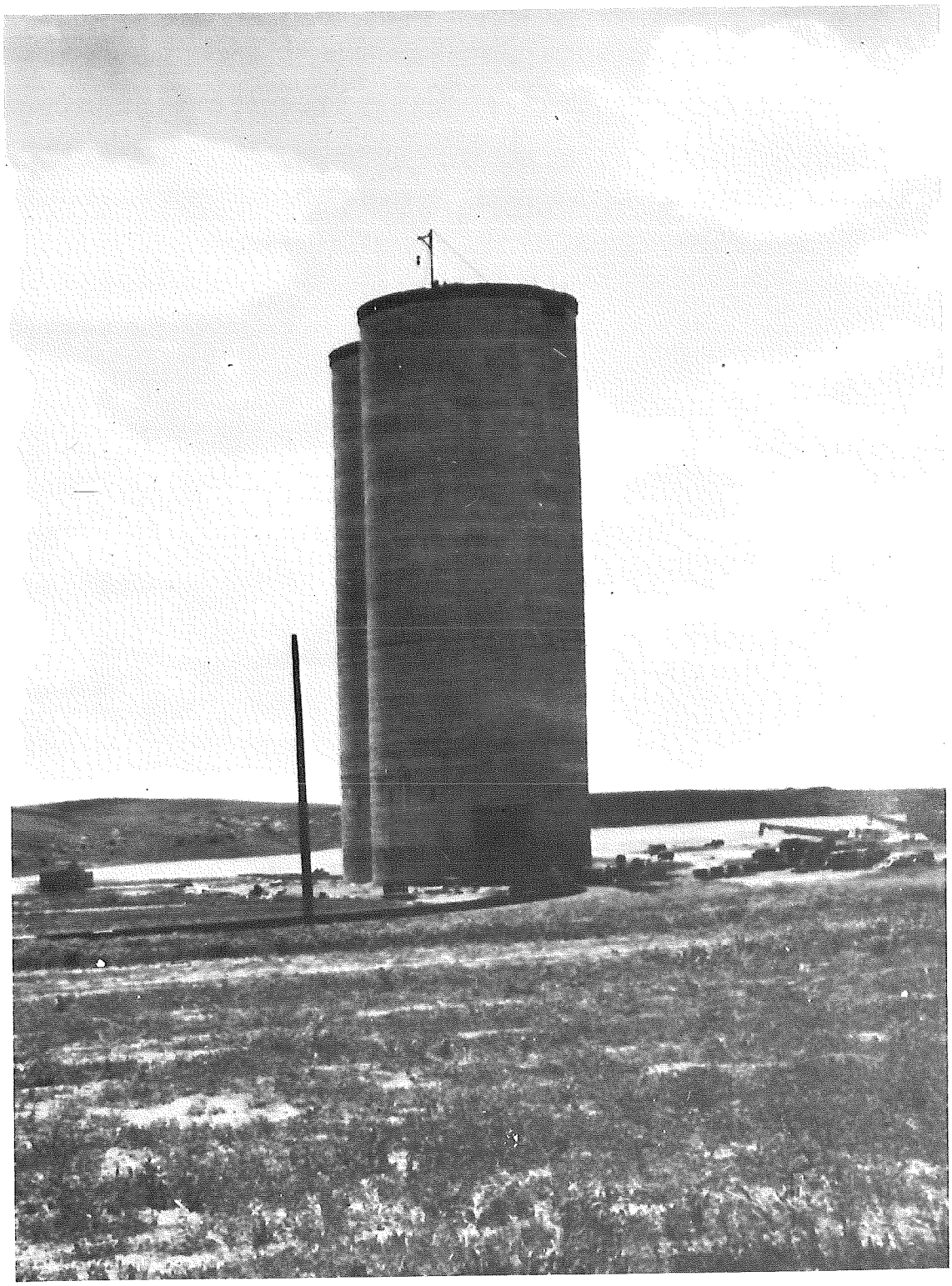


Figure 18

Two 12,000-ton capacity gravity-loading storage silos

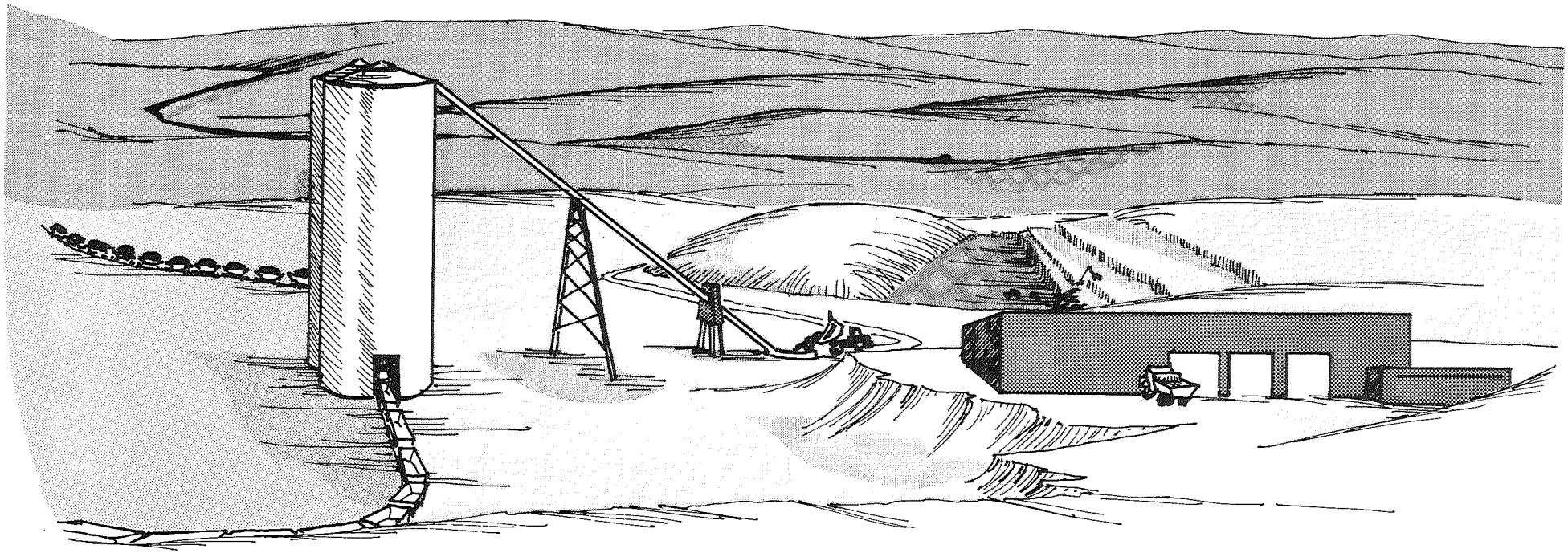


FIGURE 19
Mine Layout

Coal weighing equipment will be installed at rail loading facilities to maintain accurate weights for royalty payments and consumer billing purposes. Collection of coal samples for quality control will be done at the rail loading facility or in the pit prior to blasting. This will be done so that the operation can maintain a customer product of uniform quality.

Each mine usually may have a large building housing mine offices (engineering, health and safety, and administrative), warehouse, shower and change room facilities, and another large building for equipment repair. Actual configuration will vary from mine to mine. Smaller buildings may house the heavy-welding shop, electrical supply warehouse, and materials inventory. An area will be needed for the primary electric substation where incoming high voltage power may be transformed to desired voltages for operations. On the periphery of the building complex, a materials storage area will be required. Finally, a parking lot and security guard building will also be necessary.

Water wells will be drilled to supply the office, shower room, equipment, and for dust control in coal handling and on haul roads. Water that accumulates in the sump area of the mine pit and behind check dams may also be used for dust control if quality is suitable. Waste water and sewage from offices, changehouse, and other plant facilities will be treated in septic tanks and discharged into buried drain fields.

At the completion of operations, all surface facilities and structures will be removed or disposed of in accordance with the terms of the leases and other applicable regulations.

Utilization Processes

Power generation

Coal-fired steam-electric generating plants in Wyoming vary from one megawatt (MW) to 500 MW per unit with the largest being the Jim Bridger Plant which will have three (and possibly four) 500-MW units when completed. The only definitely proposed new plant in the Powder River Basin is a 330-MW unit adjacent to an existing 30-MW plant at Wyodak, Wyoming. Two additional plants of 30 to 60 MW may be constructed in conjunction with coal gasification plants now under consideration. Also, it is assumed that two additional mine mouth generating plants will be constructed by 1990.

The generation system consists of a coal-fired steam boiler and a turbine generator. See Figure 20 for a simplified cross section of the equipment. Steam from the boiler passes the turbine where heat energy is converted to mechanical energy. Mechanical energy is transmitted to the generator where it is converted to electrical energy. The unrecovered portion of the heat is released to the atmosphere either through evaporative cooling towers or an air-cooled condenser system. The former is the common method, and it requires large amounts of water. The latter method is used at the Wyodak plant due to the limited availability of water. No steam plume is visible in the air-cooled system.

The typical appurtenant facilities for a large power plant include a power house, cooling system, emission control systems, and stacks. The emission control system will be either a wet scrubber system or more likely an electrostatic precipitator. Height of the stacks of the only known planned power plant will be approximately 400 feet tall. Other land uses adjoining the plant may include water supply reservoirs and pipelines, haul roads, evaporation ponds, and electric transmission lines.

Coal gasification

Test projects for different gasification methods are currently underway by both private industry and the Federal Government. All known full-scale commercial projects now being planned or constructed in the United States are based on variations of a German process called the Lurgi process. The Lurgi process has been used for many years on a small scale as a means of producing low Btu gas, commonly referred to as "town gas." By adding a methanation process, this gas can be upgraded to "pipeline quality" comparable to natural gas.

Other gasification processes are being extensively tested and are showing promise, but none have been proved on a commercial scale. Table 1 lists the tests and their present status.

In addition to the various gasification methods for mined coal, the U.S. Bureau of Mines is working on an in situ gasification project near Hanna, Wyoming. Although still in experimental stages, this process shows potential, especially under certain circumstances. In situ gasification has the following advantages:

(1) Coal which cannot be economically mined can be gasified (coal seam too deep, thin, etc.).

(2) No open pit or underground mining is required.

(3) Water needs are minimal.

(4) Employment needs are low.

In situ should probably be considered as an additional method for only certain circumstances rather than an alternative to gasification. Land surface subsidence is a possible problem associated with in situ gasification process.

Since the Lurgi process is the only method currently being considered for large-scale use, this method will be described in some detail. Figures 21

and 22 give schematic diagrams of the Lurgi gasifier and the flow within a gasification plant. Statistics for a typical plant are outlined in Table 2.

Gasifiers require coal to be crushed to a size between one and one-half inches and a #4 mesh. Disposition of the remaining fines, amounting to 20 to 30 percent, can be handled in various ways.

If a power generating plant is a part of the facility, the fines can be used for coal or, if a market is available, the fines can be sold. Experiments in briqueting fines into a useable size are now taking place.

A typical large-scale unit contains about 30 Lurgi gasifiers with three or four being spares for use during maintenance and repair. Each unit is nearly 100 feet high and 14 feet in diameter. Coal is fed in at the top and distributed evenly over a moving bed. Oxygen and steam are introduced through the ash removal grate at the bottom. Fourteen percent of the coal is burned in the process, and this provides the heat for the gasification reaction process which takes place at 1150°F to 1600°F. Temperature and steam-oxygen ratio are dependent upon the exact nature of coal.

About 86 percent of the coal is gasified and passes to the gas scrubber where hot gas is quenched and washed before continuing on through a cooling system. The ash is continually removed through the grate at the bottom and returned to the mine for fill material. Crude gas leaving the gasifier contains carbonization products such as tar, oil, naphtha, phenols, ammonia, and traces of coal and ash dust are bonded to tar and removed. Part of the gas is directed through a shift conversion to convert it to a more favorable composition before entering the methanation section. The crude gas is further cooled to remove hydrocarbon oils and water containing phenols and ammonia. The next step, the rectisol unit, selectively removes hydrogen sulfide, carbon dioxide, and carbon monoxide. Utilizing temperatures down to -50°F, all hydrocarbons heavier than

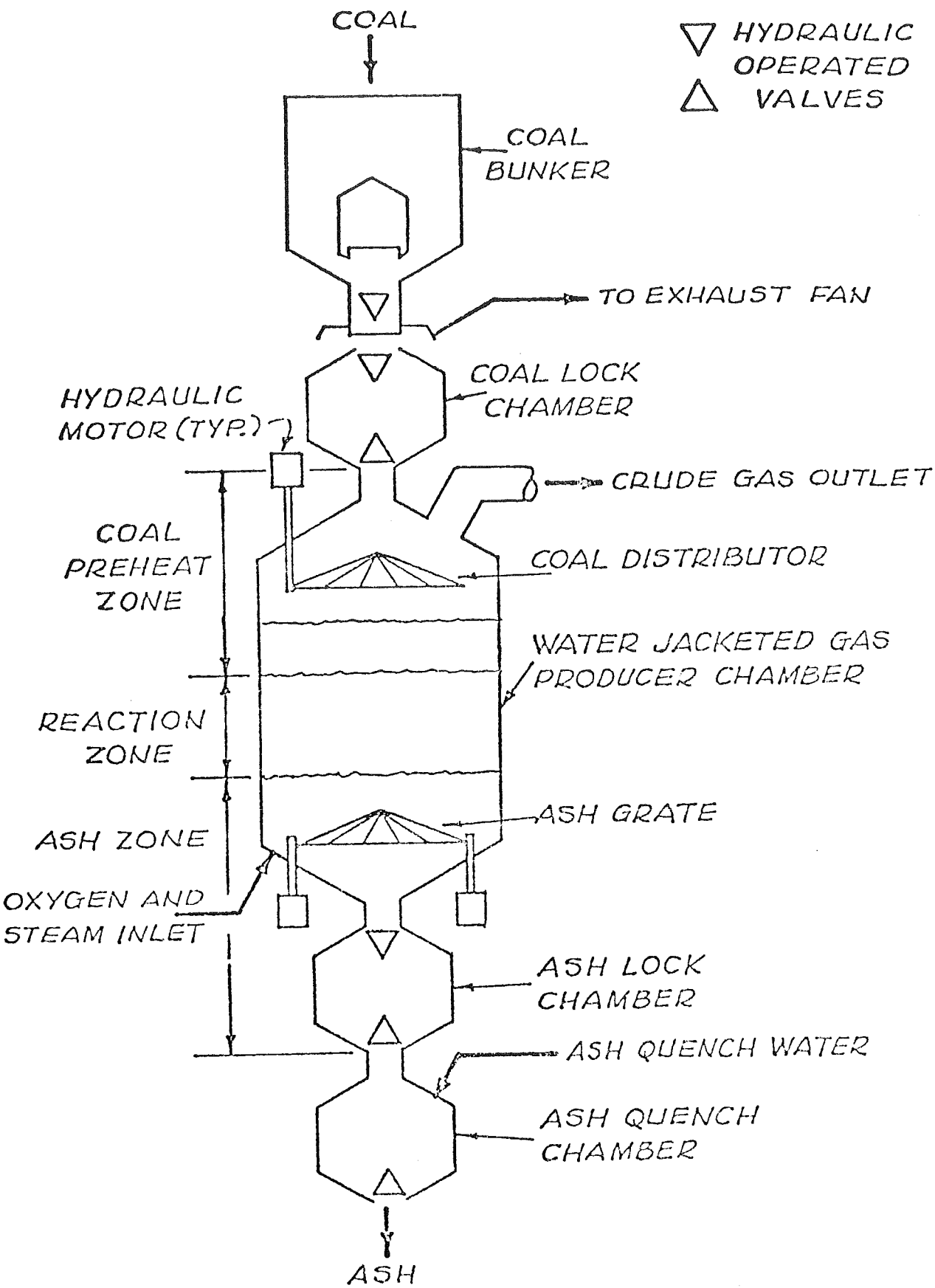


Figure 21

Schematic Diagram of Lurgi Gasifier (Batelle E.A. for Wesco)

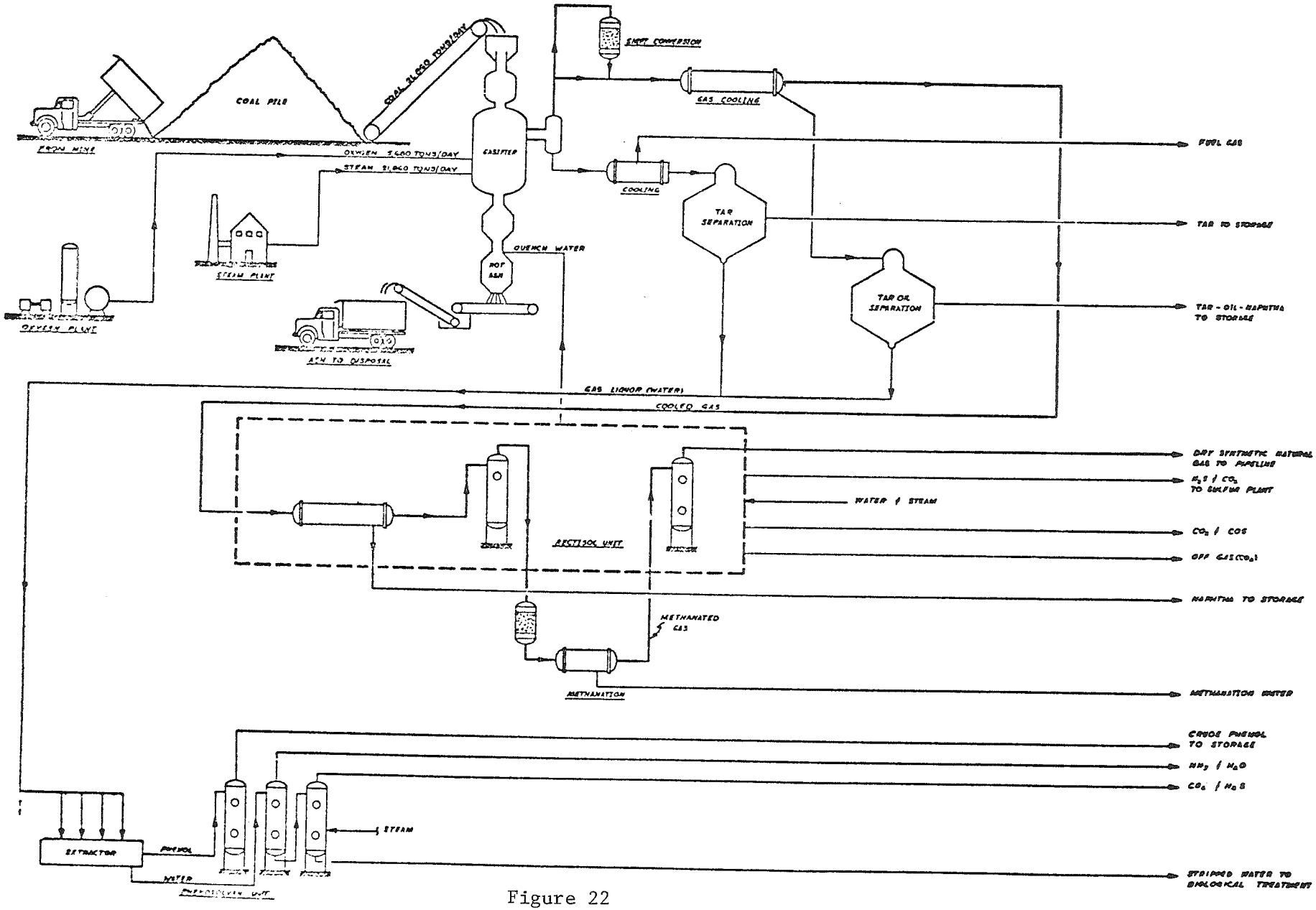


Figure 22

Schematic Flow Diagram of Coal Gasification Plant (Battelle E.A. for Wesco)

Table 1

Experimental Coal Gasification Processes

HYGAS	A 1.5 million cubic feet per day pilot plant is being operated in Chicago, Ill., by the Institute of Gas Technology. Three variations of this process are Electrothermal (used in the pilot plant), Steam-Iron (pilot plant under contract), and Steam Oxygen.
CSG (CO_2 Acceptor)	A 2 million cubic feet per day pilot plant is being operated near Rapid City, S. D., by Consolidation Coal Company.
Bi-Gas	A 2.4 million cubic feet per day plant is scheduled for completion in 1974 near Homer City, Pa., to be operated by Bituminous Coal Research.
Synthane	A 1½ million cubic feet per day pilot plant is scheduled for completion in 1974 by the U.S. Bureau of Mines.
Fixed Bed	A 2.2 million cubic feet per day pilot plant is operating at Morgantown, W. Va., by the U.S. Bureau of Mines.

Other processes include COGAS, Kellogg Molten Salt, ATGAS and Hydrane. Pilot plants for some of these are now being considered.

Table 2

Typical Gasification Project Summary

1.	Process used	Lurgi
	Synthetic gas output	250 to 300 million cubic feet/day
	Heating value of pipeline gas	950 to 980 Btu/cu. ft.
2.	Coal consumption	9 to 11 million tons/yr.
3.	Water requirements	5,000 to 9,500 acre feet/yr.
	Maximum of known estimates	17,000 acre feet/yr.
4.	Land needs (plant and appurtenant facilities; does not include mine area)	1,000 acres
5.	Size of power plant (if required)	30 to 60 megawatts
6.	Employment (full production)	a. plant 600 to 800
		b. mine 200 to 300
7.	Construction employment (three years)	a. peak 2,500 to 3,500
		b. average 1,500 to 2,000
8.	Mine and plant payroll	$12 to $16 million annually
9.	Total plant investment	$370 to $500 million
10.	By-products a. salable	sulfur 30 to 40,000 tons/yr.
		liquid petroleum products 3,000,000 bbls/yr.
		others 100,000 tons/yr ammonia phenols

Note: Sulfur production is based on use of low-sulfur coal (.5 to .7% sulfur). Marketability of sulfur is questionable.

	b. waste	ash 6 to 10 percent
		sludge
		Solid wastes are returned to mine
	c. emissions	particulate matter
		sulfur in various forms
		nitrogen oxides
11.	Heat efficiency rating of gasification	70 percent

C_2 are removed, leaving a clean gas to enter the methanation unit. The methanation process upgrades the gas to 950 to 980 Btu/cubic feet, which is comparable to natural gas. A pipeline about 24 inches in diameter will be required to transport the gas to market.

Resources used, output, and by-products are shown in Table 2.

An electric power plant of about 60 MW is required for the plant and mine. The plant may have its own generator with alternatives for fuel being coal fines or product gas and/or by-products or necessary power may be purchased from existing sources.

About 1,000 acres are required for plant and related facilities. This includes coal preparation and storage area, power plants, raw water storage reservoir, evaporation ponds, haul and access roads, and other general plant facilities. Most estimates for water needs range from 5,000 to 9,500 acre feet per year.

Apparently there is a ready market for all by-products except sulfur. Adequate storage facilities for nonsalable by-products will be required. Solid wastes are normally returned to the mine and used as fill material.

Mr. Kenneth Ancell of Panhandle Eastern in reply to a request supplied the following data: Tests on the coal to be gasified indicate that the average ash content is 5.58 percent and sulfur content averages 0.32 percent. The tests also indicated that the ash content of the coal fines averaged 11 percent. These fines will be used as fuel for a power plant. See Table 3 for summary of material balance for overall gasification plant using Wyodak zone coal from Peabody Coal Company lease area.

Construction time for a gasification plant is about three years with employment averaging 2,000, with a maximum of 3,500. Production should begin in

the third year with full operating employment for both mine and plant reaching 900 to 1,000 by the fourth year. Mine and plant payrolls should be between $12 and $16 million annually at full production.

Total plant investment has been estimated to be between $370 and $500 million.

Detailed analyses of the gasification projects are not included in this study; an environmental impact statement would be prepared at the time specific gasification projects are proposed.

Table 3

Summary Material Balance for Overall Gasification Plant

Inputs	Short Tons/Day	Percentage
Coal to gasifiers	22,728	19.0
Coal to boilers	4,870	4.1
Coal to sales	4,870	4.1
Water	13,701	11.4
Air to oxygen plant	23,625	19.7
Air to boilers and incinerators	49,707	41.6
Air to sulfur recovery unit	134	0.1
Chemicals	55	---
Total	119,690	100.0
Outputs		
SPG Product gas	5,744	4.8
Coal Lines to sales	4,870	4.1
Sulfur	62	---
Ammonia	101	0.1
Phenols	115	0.1
Tar, oil and naphtha	1,023	0.9
Boiler stack gases	45,005	37.6
Incinerator off gases	28,821	24.1
Final CO_2 removal off gases	2,380	2.0
Boiler ash (bottom and reg)	532	0.5
Gasifier ash	1,409	1.2
Sludges	550	0.4
Waste nitrogen	17,729	14.8
Cooling tower losses	9,120	7.6
Water with ash	582	0.5
Evaporation losses	1,647	1.3
Total	119,690	100.0

Liquefaction of coal

Studies of coal liquefaction processes have been continuing for several years in the United States, but there is not yet any commercial developments here. Most early pilot developments were aimed at producing synthetic gasoline which so far has proved uneconomical. As prices rise for gasoline made from petroleum, interest may be revived in this process. Present emphasis is on a cheaper, simpler conversion to produce a fuel oil containing very little sulfur. Four processes are receiving the most attention and are described below.

The Solvent-Refined-Coal Process is the project of Pittsburgh and Midway Coal Co., a subsidiary of Gulf Oil, and is the most heavily funded project. This process is based upon extraction of coal with a solvent that is a distillate fraction of the product extract. Ash and pyritic sulfur are removed by filtering dissolved extract. Recent modifications call for adding hydrogen or carbon monoxide under pressure to react with coal, thus releasing organic sulfur. Removal is adequate to meet air quality standards when high-sulfur coals are used. If not, this process may be limited to low-sulfur coals such as are found in the west.

Hydrocarbon Research, Inc., supported by a consortium of petroleum companies, is working on the H-coal process. The pilot plant reactor contains a recycle oil-coal-catalyst medium ebullated by hydrogen to liquefy the coal. Scale-up plans are unknown, but high conversion and good catalyst recovery are claimed for the pilot.

FMC Corporation is developing the COED process which uses fractional carbonization of coal to maximize yield of tar and the product fuel oil after hydrotreating. Yield of liquid fuels is lower, and the product char may contain sulfur exceeding air quality standards. Depending on the sulfur content of the feed coal, desulfurization of the feed coal may be required.

The most information is available about the Bureau of Mines' hydrodesulfurization coal-to-oil process. Raw coal conveyed in a recycled portion of its own product oil is propelled by rapid, turbulent flow of hydrogen through a reactor packed with immobilized (fixed-bed) catalyst pellets. The combined effect is to liquefy and desulfurize the coal at high yields and high throughput. Sulfur is removed as hydrogen sulfide which can be converted for industrial use or converted and stored as inert elemental sulfur. This process attempts to use a minimum amount of hydrogen, with the main aim being to remove sulfur rather than to totally liquefy the coal. The U.S. Bureau of Mines is now expanding its project and feels that in two or three years this process may be ready for commercial consideration.

Development of liquefaction is a few years behind gasification, and it is not expected to be an alternative process prior to 1980 or 1985.

Distribution Systems

Railroads

The first step in railroad construction operations is clearing the right-of-way. All vegetative materials will be removed from areas to be excavated or where embankments will be constructed. This refuse is stripped off the ground by bulldozing.

At approximately the same time, culvert and cattle pass structures will be transported to planned locations. A bed for the culvert or cattle passes will be prepared by grading equipment, after which the culvert sections are set in place. Backfill is then placed carefully around the pipe.

As the installation of culverts proceeds, grading work will be underway. This involves movement of earth material from excavation areas to embankment areas to create a roadbed shaped to its final elevation. Movement of earth material is generally accomplished by self-powered scrapers. Where rock is encountered in excavation, it is customary to use a ripper drawn by a large caterpillar-type tractor to loosen the rock so it can be moved. Blasting may be used to loosen massive consolidated rock formations.

As material is brought into embankment areas, it will be compacted to provide a dense fill that will not settle. To accomplish this, the material is spread in layers less than 12 inches thick and rolled. Water content of earth material must be at the proper level if desired compaction is to be obtained. This normally requires that water trucks sprinkle water on the fill. Motor graders are used to shape and smooth the side slopes of the excavation and embankment areas and to finish the roadbed surface when the desired elevation has been attained.

Bridges are constructed as soon as embankment sections and bridge ends are in place. Construction sequences of bridges vary according to the type of structure designed.

A layer of good quality granular material will be placed on the finished roadbed surface. This material is screened at the source of supply to remove particles over three inches in diameter and trucked to the construction area. This material is rolled and compacted to a dense smooth layer approximately 12 inches thick. Track ties are then installed to correct alignment and spacing on the finished roadbed surface.

Rail used for the line is transported to the point of beginning on special trains. Rail is pulled off the train and onto the track ties by a special piece of equipment that straddles the ties as it runs along the line pulling the rail from the train. As soon as the rail sections have been pulled off the train, aligned and spaced, they are spiked to the ties, the rail carrying train moves ahead on the new line, and the operation is repeated.

Following behind the rail placement operation is a ballast train which places rock ballast between the ties to the top of rail elevation. Track is then jacked up through the ballast as a tamping machine packs the ballast to a dense condition.

Roads

Construction operations for a road are similar to those just described for a railroad up through excavation and shaping of the roadbed.

If the road is to be surfaced, the next step will be to add surfacing base. This is normally graded, crushed rock. Aggregate will be spread in even layers not exceeding six inches thick and compacted by rolling.

The last step would be the application of the surface material, whether it is graded aggregate, bituminous, or concrete surfacing. The various steps are detailed in site specific analyses. After surfacing is completed, the road is ready for use.

Roads on mine properties will consist of main haul roads which will carry large 150-200 ton capacity trucks and smaller access roads for lighter equipment and trucks. Haul roads will be between 50 and 80 feet wide and elevated one to three feet to provide drainage and minimize snow drifting. Roadbeds will consist of graded and compacted overburden, sandy shale of the Wasatch Formation, and will be surfaced with coarsely crushed clinker from nearby deposits. Where these roads cross natural drainages, culverts and drainage ditches will be required. Where silt and sand may wash from haul roads or from mined areas, silt settling basins will be provided downstream to temporarily collect runoff and settle suspended solids.

Water trucks will control dust by spraying the road surface and adjacent berm. The porous road materials readily drain water, and runoff is negligible. Shoulders of access and haul roads will be revegetated. When a road is no longer needed, the surface material or crushed clinker will be removed for disposal within the mining area. If the subgrade material is not suitable for revegetation, it will also be removed and the remaining material scarified, shaped, topsoiled, and seeded.

Pipelines

The first construction operations in building a pipeline consist of clearing the right-of-way of all vegetative materials and litter. A bulldozer is normally used to scrape this material to the sides of right-of-way for disposal.

At approximately the same time, work begins on access roads to the construction site. These roads are not normally intended for public use and are built to low standards. Excavation of cut material and placement of fill is usually immediately adjacent and bulldozers are used for most of this cut and fill operation. A minimum of culverts are placed as construction progresses. Motor graders are used for grooming culvert sites, cut and fill side slopes, and the road surface. When construction access roads and clearing have been completed, work may proceed on pipeline construction.

First, a wheel trencher digs the pipeline trench. This machine can dig the trench in most unconsolidated materials. However, massive consolidated material may require ripping with a crawler-type tractor drawn ripper or possibly even a blasting operation. Final removal of this type material is done with backhoe type machinery.

While the trench is being excavated, the pipe to be used is transported to and spaced along the route. Three separate operations are performed on the pipe before it is placed in the trench.

The first pipe operation is welding the individual sections together. A special pipe welding machine places each section in precise alignment with the previous section and then makes the weld to assure a joint which will withstand the anticipated pressure. Immediately following welding, a special machine bends the pipe to conform to the shape of the trench. Finally, the pipe is given a bituminous coating, wrapped with a protective covering and given another bituminous coating.

At this time, the pipe is lowered into the trench. This step is accomplished in a continuous moving operation employing specially equipped short lift machines. Special bedding material is not used under or around the pipe except in sharp rock formations.

The final step is filling the trench, thereby covering, protecting and supporting the pipe. The material that was excavated from the trench is pushed into the trench by a bulldozer or loader. A tamping machine straddles the trench and tamps the fill material. However, since the material placed in the trench is not compacted to a specified density as in most other construction operations, some subsidence does occur. This is minimized by placing excess material in a windrow along the trench centerline after tamping.

Transmission lines

The first operation in construction of a transmission line is a joint operation of clearing the right-of-way and constructing necessary access roads. All vegetative materials will be removed from areas to be excavated or in which embankments will be constructed. This refuse is bulldozed off the ground for disposal.

Concurrent with clearing operations, access roads are being constructed. These roads are not intended for normal public road usage and are built to low standards. Most grading will be accomplished with bulldozer equipped crawler tractors. Culverts are placed and backfilled to specifications. Motor graders are used to dress cut slopes and the running surface of the final grade. Once access roads and tower site clearing have been completed, construction of the transmission line commences.

First, tower footings are placed. Holes for footings are usually excavated with a backhoe. Reinforcing materials are placed in the excavation and concrete is poured to make the footing. After the concrete has cured, tower placement begins. Towers are usually fabricated from materials trucked to the site. Crews fabricate the towers in sections by bolting individual pieces

together. Cranes lift the sections into place, first over the footings and so on until the result is a finished tower.

After the towers are complete, transmission cable and jerrie cable are brought to the site. Cable is on large spools that are spaced along the transmission line route for the line stringing. Jerrie cable is placed between the towers first to add strength to the tower system. The most common method is to place the spool of cable on a crawler-type tractor and unroll it along the line route. Cranes raise the jerrie cable into position for attaching to the towers. Next, power conductor cables are attached to insulators suspended from the towers. After cable installation is complete, all that is necessary to use the system is to connect conductors to the generating station or substation power source.

Recently helicopters have often been used to transport materials to the site, erect towers and string cable. This method is becoming increasingly popular to lessen environmental impacts and costs of constructing access roads in rough terrain.

A variation of clearing procedures calls for minimal clearing at each stage of construction. Final clearing to provide adequate clearance for conductor cables is postponed until cable stringing operations are complete. This method, although more expensive and time consuming, results in much less impact on the environment. This process is referred to as the "grooming process."

Waste Disposal Systems

Coal and energy development in the Powder River Basin will result in solid and liquid by-products that are not economically marketable and will have to be disposed of as waste.

Needs for municipal waste treatment facilities are included in Chapter V. This analysis of disposal systems will first consider waste generated in industrial processes then discuss domestic and construction wastes associated with building and operating the facility.

Process wastes

Process wastes are defined as nonmarketable by-products resulting from converting one product to another. More specifically here, they are residues from various coal combustion processes that also use water. Ash from coal and minerals from water used will be the primary waste products for the processes expected in the Powder River Basin.

The magnitude of waste products that must be handled is indicated by the following generalized computations.

Gasification plant (250 million cu. ft. of gas per day) yields:

Boiler ash	530 tons per day
Gasifier ash	1,400 tons per day
Sludges	550 tons per day
Total	2,480 tons per day

Power plant (500 MW--250 tons/hour of coal, 10 percent ash) yields:

Fly ash	450 tons per day
Bottom ash	150 tons per day
Mineral residues	unknown
Total	600 tons per day plus minerals.

Two techniques are commonly used to dispose of these wastes. Where the plant is operated in conjunction with a surface mine, process waste is usually placed in mined-out areas and covered with spoil. If the plant is remote, surface storage using an evaporation or tailings pond is commonly used for liquid wastes. For the 1,500-MW Jim Bridger southwestern Wyoming power plant, an evaporation pond 500 acres in size is being designed to store and evaporate mineralized wastes from the water consumed. Ash is placed in the strip mine.

Domestic and construction wastes

Domestic and construction wastes include sanitary wastes from construction and operating employees, debris from packaging, and used construction material.

Sewage treatment systems vary with amount of sewage to be treated. Larger sewage systems consist of collector lines transporting sewage to a treatment site. Basic treatment for this type of system is the lagoon method. Sewage flows into holding ponds and bacteria convert the sewage to an effluent which will meet discharge standards. The next basic addition to the system to enable it to handle larger volumes of sewage is an aeration system. This equipment sprays sewage into the air to enrich it with oxygen. Oxygen enhances the bacterial action and speeds the process of conversion to an acceptable discharge standard.

High volume systems include sludge conversion capability. The discharge liquid is returned to settling ponds until the sludge reaches a predetermined depth. The liquid is then diverted to other settling ponds while the first is cleared of sludge. Liquid is drained off and the sludge is

mechanically stirred to aid drying. After the sludge has dried to an acceptable level, it is removed from the settling ponds for disposal.

Several different package units are available for treatment of sewage, but they all use the same basic process with variations to meet special disposal conditions. They can also include treatment of effluent with chlorine to further purify the final product and reduce odors from bacterial action.

A sanitary treatment system for use at the Wyodak Power Plant has been described as follows by the companies proposing the project:

During construction of the proposed steam-electric generating plant, sanitary wastes from the station and the nearby residential community will be treated in an extended aeration treatment facility. Following construction, sanitary wastes will be treated by a packaged treatment plant.

The treatment will consist of primary settling, extended aeration, and gas postchlorination. The dissolved oxygen content of the effluent will be maintained continuously at 2 ppm or more. The system will be designed to treat approximately 3,500 gallons per day of sanitary waste. The system will include a 4,000-gallon aeration, a 1,000-gallon settling tank, and 1,200-gallon sludge tank.

The Wyodak proposal will evidently use an aerated sewage lagoon for treatment of wastes from onsite temporary housing and an estimated 600 construction workers and a package system to meet the needs of 50 to 60 people operating the power plant.

A rule of thumb for sizing community sewage lagoons is one acre per 100 population. Thus, a construction force of 1,000 could require a 10-acre sewage lagoon. The size could be reduced if no onsite housing of workers and families is comtemplated.

Solid waste disposal at construction sites ordinarily involves both burning and landfill techniques. Flammable material is burned to reduce bulk either in incinerators or, at remote sites, by open burning. Ash and other residue can be placed in selected landfill sites or incorporated into strip mine spoils.