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A STUDY OF THE PROPERTIES OF MINE WASTE IN THE MIDWESTERN
COAL FIELDS

Phase I Report

July 4, 1980

Work Performed Under Contract No. AC01-79ET14211

Dames & Moore
Park Ridge, Illinois

U. S. DEPARTMENT OF ENERGY

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PHASE I REPORT

Contract No. DE-RP65-79ET14211

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Dames & Moore

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INTRODUCTION

According to the definition given in Section 77.217 of the Code of Federal Regulations, Title 30, coal mine waste material is a mixture of coal, shale, claystone, siltstone, sandstone, limestone, and related materials that are excavated during mining operations or separated from mined coal and disposed of as waste by-products of either coal mining or coal preparation plants. Mine spoil associated with surface mining operations is not included in this definition. Consequently, this study of the properties of mine wastes in the Midwestern coal fields has been limited to the waste materials obtained from underground coal mines and preparation plants attached to both underground and surface mines.

Prior to enactment of environmental regulations, coal mine wastes were characteristically disposed of in the most economical manner. Coarse refuse was generally deposited on the surface in the form of refuse piles, valley fills, and embankments; whereas the fine waste, generally in the form of slurry, was invariably pumped into the nearest stream or low-lying areas. Consequently, considerable quantities of fine refuse were washed down the streams, while coarse refuse piles generally stood unreclaimed where they were deposited. Most of these piles were placed in undesigned manner (and are aesthetic and environmental disasters). Some of them are unsafe. Recent laws and regulations now require properly designed refuse disposal facilities to ensure that they are safe and environmentally acceptable.

There is an increased emphasis on coal as a source to meet future energy needs. Accordingly, the projections for coal production from the Midwestern coal fields indicate an annual growth rate of 5.4 percent up to the year 2000. However, the production of coal waste is expected to increase at an average annual rate of 8 percent due to the increasing trend to mechanically clean the raw coal. The annual production rate of coal waste in the Midwestern coal fields has been forecast to increase to 135 million tons in the year 2000 from the existing rate of approximately 25 million tons per year.

Due to increasing availability of huge quantities of mine waste, its secondary use is expected to assume a greater importance in the coming years. Waste has been used for secondary recovery of coal, landfills, construction of highway embankments, manufacture of lightweight aggregate, aluminum recovery, etc. Environmental considerations may require adoption of alternatives to surface disposal practiced at the present time. For instance, underground disposal of coal mine waste may become more commonplace in the next 2 decades.

In an effort to assist the coal industry in complying with the applicable regulations, to design safe and environmentally acceptable disposal systems, and to encourage secondary use of coal mine waste, the U.S. Department of Energy has initiated research programs to develop coal mine waste disposal and use technology. The research includes refuse area design and reclamation in order to eliminate future safety problems and minimize adverse environmental conditions and secondary uses of coal waste materials. Additional knowledge of the physical and chemical properties of coal mine wastes is prerequisite to the accomplishment of the above tasks. This program, among others, involves investigation of the properties of mine wastes in the Midwestern coal fields where substantial waste has already accumulated and a large increase in the rate of accumulation is predicted during the next 2 decades. The program has been divided into two phases.

In Phase I, the 20 most important properties relevant to safe disposal, reclamation, underground disposal, and secondary uses have been identified. An inventory of the significant waste disposal sites in the Midwestern coal fields has been prepared. The site locations have been plotted on USGS maps. Estimates of coal production and coal mine waste production during the next 2 decades have been prepared and are presented in this report. Also, all available information obtained from a search of existing literature on physical and chemical properties, including analysis results of the general runoff from the refuse disposal areas, has been collected and is presented.

The available information on properties is meager and incomplete. A great deal of additional information will be needed to enable meaningful analysis of the properties to indicate regional trends and help the industry to formulate design of disposal structures and reclamation plans or to determine suitability for secondary use.

In order to fill the gaps in information, 20 sites have been identified for drilling and sampling to determine the various physical and chemical properties. They have been selected on the basis of the distribution and quantity of waste at the existing locations (both abandoned and active), the future trends in production and likely locations of waste disposal areas, their geographical and geological distribution, and ease of accessibility for drilling and sampling.

Waste Disposal

The waste material contained in coal seams in the form of soil lenses, or inclusions of slate, shale, siltstone,

or claystone, is generally recovered as part of the mining operation. Considerably larger quantities of the roof and floor rock are also excavated by the use of the modern mining equipment as compared to the earlier, manual methods. This has resulted in the increase in the ratio of waste production to raw coal considerably during the last 40 years. Consequently, the percentage of the total run of mine coal production subjected to mechanical cleaning has also increased during the last 40 years.

Coal mine refuse obtained from underground mines or preparation plants may be divided into two broad categories as dry and wet wastes. Dry waste material is generally associated with the ripping of the roof or floor, the excavation of drifts in rock, the excavation of shafts and staple pits, and sometimes from dry mechanical separation. These wastes are usually quite coarse-grained and are characterized by identical mineral and chemical composition similar to the sterile rocks accompanying the coal seams. The particle size generally ranges from 10 to 200 mm.

Wet waste material usually comes from the preparation plants using either the heavy media or flotation process or a combination of the two processes. The process involves crushing, screening, and cleaning one or more fractions separately. Modern preparation plants may handle three fractions, coarse, middlings, and fines, but the wastes from these plants are generally disposed of as coarse and fine fractions. In some plants, coarse waste is crushed and rewashed or made suitable for disposal in slurry lagoons instead of waste piles.

Coarse rejects from the preparation plants associated with surface mines are generally returned to the strip pits to be buried with the overburden material, which is then graded, fertilized, and vegetated. Consequently, the preparation plants associated with strip mines generally have only slurry ponds for disposal of fine waste material.

When coal beneficiation is practiced in conjunction with an underground mine, the coarse rejects are generally required to be disposed of in an open field or a valley. Fine reject material usually smaller than 20 mesh is transported in slurry form to diked ponds, incised lagoons, or embankment-type impoundments as in the case of strip mines.

Basic coal preparation processes and techniques are illustrated on Figure 1.1. Some typical flow diagrams of coal preparation plants are also given on Figure 1.2.

Most preparation plants yield waste up to 15 to 35 percent of run of mine coal. During 1975, 374 million tons of raw coal

were subjected to washing in the United States. This resulted in production of 107 million tons of waste, amounting to nearly 29 percent of the raw coal processed (Mineral Yearbook, 1975).

1. PROPERTIES OF COAL WASTES

General

Determination of important physical and chemical properties of coal wastes is a prerequisite for designing safe, economical, and environmentally acceptable disposal systems. The knowledge of the properties is particularly important if the mine waste is to be put to a secondary use. Twenty of the properties thought most important in this regard have been identified for field investigations. The rationale for the selection of these properties is discussed in this section.

Possible Secondary Uses of Coal Wastes

Coal wastes have been put to several secondary uses. The important ones are as follows:

- Secondary recovery of coal;
- Construction of embankments for roads and railway tracks;
- Preparation of lightweight aggregates for general construction purposes;
- Backfilling in underground mines;
- Landfills;
- Burnt coal mine refuse, generally termed as "red dog," has been used for paving roads and as an antiskid material on the shoulders of highways; and
- Coal waste ash for recovery of alumina.

Secondary recovery of coal from mine waste has been carried out in various coal producing states for the last several years. Depending on the coal content, secondary recovery is effected from both coarse refuse piles and slurry ponds. The process involves excavating of the material, screening, and washing. Heavy media separation or froth flotation or oil agglomeration process is used, depending on the particle size and other physical characteristics. The pertinent properties that determine the feasibility of secondary recovery of coal are carbon content, calorific value, particle size, and washing characteristics.

The utilization of mine wastes in highway construction was evaluated under a research program undertaken by the

Federal Highway Administration in which technical, economic, and environmental factors were taken into consideration (Valley Forge Laboratory, Inc., 1977). Engineering properties and utilization examples of mine tailings were evaluated by Pettibone and Kealy (1972). Anthracite refuse was used for construction of a portion of a highway (Charmburg and Maneval, 1972). Acidic coal mine waste, combined with fly ash, was used for construction of a road and a parking lot, and its effects on environmental pollution were studied (Wilmoth and Scott, 1979). These studies highlighted the important physical and chemical properties of the waste material essential for the design of highway embankments and economic evaluation. These properties are as follows:

- a. Grain size distributions and fractions:
 - Minus No. 200 mesh: silt and clay;
 - No. 200 mesh to No. 4 size: sand;
 - No. 4 size and above: gravel;
- b. Consistency limits:
 - Liquid limit;
 - Plasticity index;
 - Linear shrinkage;
- c. Specific gravity;
- d. Moisture density data:
 - Maximum dry density;
 - Optimum moisture content;
- e. Coefficient of uniformity;
- f. Principal mineral content;
- g. Particle hardness;
- h. Toxicity;
- i. Expansion potential;
- j. Carbon content;
- k. Shear strength:
 - Angle of internal friction;
 - Cohesion; and
- l. Compressibility.

Coal mine waste has also been used as a raw material for expanded lightweight aggregate. Pertinent properties for this use included particle size, particle hardness, particle shape, and mineral content.

Important considerations for disposing mine waste back into underground workings are as follows (Underground Disposal of Coal Mine Wastes, 1975):

- Ease of hydraulic, pneumatic, or mechanical transportation;
- Waste containing toxic material, if transported hydraulically, may necessitate water treatment;
- High permeability is necessary to allow drainage of excess water;
- Low abrasiveness is desirable for transportation through pipes;
- The waste should have a low potential for generating undesirable and excessive airborne dust if pneumatic stowing is planned; and
- Overall economics should be favorable.

Under special circumstances, such as for the purpose of conservation, to improve resource recovery, to protect surface structures, to make mining of other seams in close proximity possible, or for mining thick seams, stowing of mine voids may be unavoidable. In these cases, it may be viable to treat the mine waste, if necessary, to make it suitable for backfilling.

Based on these considerations, the important properties that will need to be investigated would include particle size, particle hardness, specific gravity, abrasiveness, permeability, and toxic material content.

The ash obtained from burning coal waste itself may be a valuable by-product because of its high alumina content. Coal waste ash in most coal fields of the United States contain nearly 25 percent bauxite. It has been quoted that alumina from coal waste could be produced on a commercial scale from coal waste ash (Coal Age, 1974). The important property for designating suitability to use the material for alumina recovery would be identification of major, minor, and trace minerals. This could be done by X-ray diffraction.

Applicable Regulations Pertaining to Coal Waste Disposal

The engineering designs of mine waste embankments and refuse piles came into critical review after the Buffalo Creek and Aberfan disasters. In light of the studies that followed these disasters, the regulations pertaining to the safety

and design of the refuse disposal structures were revised. These revised and updated regulations are found in 30 CFR, Sections 77.214 through 77.216. Additional regulations have been enacted to prevent an adverse effect on water quality, flow, or vegetation; public health; and stability in the disposal areas. These regulations are contained in 30 CFR, Chapter VII. The pertinent regulations have been summarized and are given in Table 1.1.

Engineering Design of Refuse Disposal Systems

The primary materials involved in the construction of disposal structures are the coarse refuse and the slurry. The coarse refuse is generally stored in valley fills, cross-valley fills, sidehill dumps, ridge dumps, or in piles. Similarly, slurry is also stored in several different types of impoundments. Both types of structures are shown on Figure 1.3. In practice, many combinations of these basic forms are used. Many of these structures are built at high elevations, such as in the hilly terrain of West Virginia, eastern Kentucky, and Pennsylvania, posing additional safety problems for the structures on the downstream side at lower elevations.

The method of construction of refuse disposal structures also differs from the construction of ordinary earth dams. Generally, the structure is used for disposal for refuse during its ongoing construction. When it is constructed simultaneously while in use, it is usually built using one or more modifications of the following three approaches:

1. Upstream method;
2. Centerline method; and
3. Downstream method.

These techniques are explained on Figures 1.4 through 1.6. The preconstructed dam is safe but usually more expensive. The simultaneous construction is generally preferred because it is more convenient and cheaper (Schlick and Wahler, 1977).

A knowledge of the materials and site characteristics is necessary for designing safe, permanent or temporary disposal structures and selection of a suitable construction technology. The main considerations in establishing the design criteria are stability and water control.

The engineering properties that are important to establish stability of the structure are as follows:

- a. Particle size distribution;
- b. Maximum density:
 - Maximum dry density;
 - Optimum moisture content;
- c. Specific gravity;
- d. Moisture content;
- e. Density:
 - Initial wet;
 - Initial dry;
- f. Shear strength:
 - Internal friction angle;
 - Cohesion;
- g. Atterberg limits:
 - Liquid limit;
 - Plasticity index.

The important properties that control water leachate, phreatic surface, and degree of saturation are as follows:

- Permeability;
- Particle size distribution;
- Degree of compaction;
- Void ratio; and
- Durability (slake durability index).

Generally, the method of construction and the use of specialized compaction equipment determine the degree of compaction and in-place density. A combination of relative density and degree of saturation determines to some extent the shear strength and the susceptibility to liquefaction of the material. The permeability of the material determines the water retention capacity of the material.

If the embankment is not designed to impound water, a material with higher permeability may be desirable. If, however, it is necessary to impound water, compaction and use of graded material is to be preferred to decrease permeability.

Pollution Abatement

Depending on the chemical characteristics, the refuse disposal areas may give rise to acid drainage, erosion, and sedimentation adversely affecting adjacent terrestrial and aquatic areas. In addition, unreclaimed refuse sites are aesthetically offensive. High acid producing potential, high concentration of soluble salts, low pH values, and phototoxic conditions associated with high levels of aluminum, iron, manganese, and sulfate are required to be characterized in order to design suitable disposal systems. The pertinent chemical properties that determine these characteristics are pH, sulfide content, heavy metal content, suspended solids, and toxicity. These properties, in conjunction with mineral composition and grain size distribution, characterize the potential of the refuse to support vegetation with or without treatment.

Identification of Physical and Chemical Properties Pertinent to Refuse Disposal Technology

Twenty of the coal waste properties felt to be most important have been identified for analysis in the field and laboratory investigations. They represent a cross section of physical and chemical properties essential for design of safe disposal structures, for secondary use, for pollution abatement, and for revegetation as discussed earlier. These twenty properties are as follows:

1. Particle size distribution	6. Shear strength
	a. Internal friction angle
2. Density	b. Cohesion
a. Average in-situ dry density	
b. Maximum density	7. Atterberg limits
c. Minimum density	a. Liquid limit
d. Relative density	b. Plasticity index
3. Specific gravity	8. Particle hardness
a. Plus No. 4 mesh particle size	9. Abrasion
b. Minus No. 4 mesh particle size	10. Slake durability
4. Permeability	11. Proximate analysis
5. Moisture content and degree of saturation	a. Volatile matter
	b. Ash
	c. Fixed carbon

12. Calorific value	16. Suspended solids
13. Ultimate analysis	17. Heavy metal content
a. Hydrogen	18. Lithology and mineral content
b. Carbon	19. Compressibility
c. Oxygen	20. Shrink and swell, expansion potential
d. Nitrogen	
e. Sulfur	
f. Chlorine	
14. Phosphorus	
15. Total sulfide content	

SUMMARY OF FEDERAL REGULATIONS PERTAINING TO COAL WASTE DISPOSAL

SECTION	TITLE	REQUIREMENTS	SECTIONS REFERENCED
77.214	General	<ul style="list-style-type: none"> o Locate at safe distance from air shafts, preparation plant, tippie, and other structures. o Construct fireproof barrier between old and new refuse piles. o Fence or guard roadways to refuse piles. 	
77.215	Construction Requirements	<ul style="list-style-type: none"> o Spread and compact in layers to minimize flow of air through the pile. o Do not deposit refuse on a burning pile. o Use clay or other sealants to seal burning refuse piles. o Protect surface from erosion by drainage facilities. o Do not impede drainage. o Prevent accidental sliding. o Do not deposit extraneous combustible material. o Construct new refuse piles in compacted layers not exceeding 2 feet in thickness and having slopes not exceeding 2n:1v. Variation for slope may be granted provided a minimum factor of safety of 1.5 is attained. o Clear all vegetation and other undesirable material from foundations. o Extinguish all fires in refuse piles. 	
77.215-1	Identification	<ul style="list-style-type: none"> o Locate identification markers on all refuse piles. 	
77.215 2	Reporting Requirements	<ul style="list-style-type: none"> o Report location of new and existing refuse piles. o Submit statement of construction history and abandonment plan. o Submit a topographic map on 1 inch = 400 feet or smaller scale showing the present and the proposed maximum extent and the area within a radius of 500 feet around it. o Submit cross sections of the refuse piles. o Submit above information every 12 months. 	
77.215-3	Certification	<ul style="list-style-type: none"> o Certification by a registered engineer is to be submitted if required by the District Manager. 	
77.215-4	Abandonment	<ul style="list-style-type: none"> o Notify the District Manager in writing and if required by him, the pile shall be abandoned in accordance with an approved plan. 	

SECTION	TITLE	REQUIREMENTS	SECTIONS REFERENCED
77.216	Impoundments and Impounding Structures: General	<ul style="list-style-type: none"> ● Submit design, construction, and maintenance plans if: <ol style="list-style-type: none"> (1) storage volume is 20 acre-feet or more; and (2) impounded water, sediment, or slurry is 20 feet or more from the upstream toe. ● Extinguish all fires in impounding structures. 	
77.216-1	Identification	<ul style="list-style-type: none"> ● Locate identification marker on each impounding structure. 	
77.216-2	Certification	<ul style="list-style-type: none"> ● Show the following on the plan specified in Section 77.216: <ol style="list-style-type: none"> (1) Location on USGS 7-1/2-minute or 15-minute quadrangle map. (2) Purpose. (3) Name and size of the watershed. (4) Physical and engineering properties of the foundation site. (5) Type, size, range, and physical and engineering properties of the materials of the impounding structure; method of site preparation and construction; dates of construction. (6) Detailed dimensional drawings of the structure at a scale not exceeding 1 inch = 100 feet, giving plan, elevation, foundation improvements, all zones, drainage structures, spillways, diversions, instrument locations, and other features. (7) Graphs showing area-capacity curves. (8) Runoff corresponding to 6-hour precipitation event. (9) The storm used for calculating runoff for designing the structure. (10) A description of spillways. (11) The computed minimum factor of safety range for the slope stability. (12) The locations of surface and underground coal mine workings and their extent within 500 feet around the perimeter. (13) Provisions for construction surveillance, maintenance, and repair of the impounding structure. (14) General provisions for abandonment. (15) A certification by a registered engineer. (16) Such other information that may be required by the District Manager. ● Obtain approval for any changes or modifications to plans for water, sediment, or slurry impoundments or structures. 	77.216

Sheet 3 of 6

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SECTION	TITLE	REQUIREMENTS	SECTIONS REFERENCED
817.71 (continued)		<ul style="list-style-type: none"> ● Provide underdrainage system to prevent infiltration of spring, natural, or man-made water courses into the fill material. ● Ensure stability of the foundations and abutments of the fill. ● Underground disposal is permissible if in accordance with referenced sections. 	784.25
817.72	Valley Fills	<ul style="list-style-type: none"> ● Provide long-term static safety factor of 1.5. ● Provide subdrainage system. ● A filter system to ensure proper functioning of the rock underdrain. ● Place waste in lifts no greater than 4 feet thick. ● Divert surface water runoff from the area above the fill. ● Grade top of the fill and terraces no steeper than 1v:20h. ● The outslope of the fill shall not exceed 1v:2h. 	817.43(t)
817.73	Head-of-Hollow Fills	<ul style="list-style-type: none"> ● Fill up to the approximate elevation of the ridgeline. A rock core chimney drain may be used instead of the subdrain and diversion system. ● If rock core chimney drain is provided, grade top of the fill towards the drain at a maximum gradient of 1v:33h. ● Provide a drainage pocket with maximum capacity not to exceed 10,000 cubic feet. ● Grade terraces with a 3 to 5 percent grade towards the fill and a 1 percent grade towards the rock core. ● Design drainage control system to pass the runoff from a 100-year, 24-hour precipitation event. 	817.72
817.74	Durable Rock Fills	<ul style="list-style-type: none"> ● Alternate methods may be approved provided spoil consists of at least 80 percent sandstone, limestone, or other rocks that do not slake in water. 	817.71 through 817.73
817.81	General Requirements	<ul style="list-style-type: none"> ● Place all refuse in approved areas. <ul style="list-style-type: none"> - Prevent combustion. ● Coal processing waste materials from outside areas may be disposed of if approved and if they do not: <ol style="list-style-type: none"> (1) Create an adverse effect on water quality, flow, or vegetation; (2) Create public health hazards; and (3) Cause instability in the disposal area. 	817.71, 817.72, 817.82 through 817.88

SECTION	TITLE	REQUIREMENTS	SECTIONS REFERENCED
817.82	Site Inspections	<ul style="list-style-type: none"> • Quarterly inspections for: <ol style="list-style-type: none"> (1) Environmental protection; (2) Proper operation; (3) Slope stability; and (4) Reclamation. 	
817.83	Water Control Measures	<ul style="list-style-type: none"> • Provide subdrainage systems to: <ol style="list-style-type: none"> (1) Collect ground water; (2) Be protected by a filter; (3) Prohibit surface water from entering the system; and (4) Prohibit leachate from coal processing waste from entering the system. • Divert all surface flow around the refuse embankment. • Provide slope protection to minimize erosion. • Discharges shall comply with: <ol style="list-style-type: none"> (1) Hydrologic balance and effluent limitations; (2) Sedimentation control measures; (3) Detention time; (4) Monitoring; and (5) Limitations on discharge to an underground mine. 	817.72(d), 817.41, 817.42, 817.45, 817.46, 817.52, 817.55
817.85	Construction Requirements	<ul style="list-style-type: none"> • Construct in accordance with referenced sections. • Provide a minimum static factor of safety. • Compaction requirements: <ol style="list-style-type: none"> (1) Less than 24-inch lift thickness; (2) At least 90 percent of Standard Proctor maximum dry density; and (3) Variations for dewatered fine coal waste are allowed (-28 mesh) (does not include combined refuse). • Provide 4 feet of cover -- nontoxic noncombustible -- revegetate (could be less than 4 feet if less cover is demonstrated to be sufficient). 	817.71 and 817.72
817.86	Burning	<ul style="list-style-type: none"> • Extinguish. 	
817.87	Burned Waste Utilization	<ul style="list-style-type: none"> • Removal of refuse from embankment must be in accordance with an approved plan. 	
817.88	Return to Underground Workings	<ul style="list-style-type: none"> • Permissible if in accordance with referenced sections. 	784.17 and 784.18
817.89	Noncoal Waste	<ul style="list-style-type: none"> • Not placed in coal refuse embankments or within 8 feet of coal outcrop. 	

SECTION	TITLE	REQUIREMENTS	SECTIONS REFERENCED
817.91	Dams and Embankments: General Requirements	<ul style="list-style-type: none"> • Dams and embankments may be constructed of coal refuse or impounding fine coal refuse; however, • Waste will <u>not</u> be used unless sufficient stability is demonstrated and no detrimental effect on downstream water quality is demonstrated. 	817.93(a)
817.92	Dams and Embankments: Site Preparation	<ul style="list-style-type: none"> • Trees, shrubs, grasses, and organic material shall be cleared and grubbed from the site and all combustibles removed. • Divert all surface drainage and discharge in accordance with: <ol style="list-style-type: none"> (1) Diversions around impoundment for the 100-year, 24-hour precipitation event; and (2) Sediment control at the discharge of each diversion ditch. 	817.43, 817.47, 817.41 through 817.46
817.93	Dams and Embankments: Design and Construction	<ul style="list-style-type: none"> • Each dam or embankment shall comply with: <ol style="list-style-type: none"> (1) 3 feet of freeboard above maximum water level; (2) Minimum safety factor of 1.5 for steady-state conditions; (3) Minimum safety factor of 1.2 for seismic conditions; and (4) Foundation and abutments shall be stable for all increments of construction. • Design spillways and outlet works to protect against erosion, corrosion, and blockage. • Remove 90 percent of stored water in 10 days. 	817.49(a5), 817.49(e) through 817.49(i)

CRUSHERS

BRADFORD BREAKER
SINGLE ROLL CRUSHER
DOUBLE ROLL CRUSHER
HAMMER MILL AND
RING CRUSHER

SCREENS

BAR SCREENS
VIBRATING SCREENS
SIEVE BEND
VIBRATING CLOTH SCREENS
OTHER MOVING SCREENS

WET PROCESSES

LAUNDERS
JIGS
CLASSIFIERS
(DEISTER TABLES)
DENSE MEDIA SEPARATION
CHANCE CONE PROCESS
MAGNETITE PROCESS
HMS PROCESS
DENSE MEDIA CYCLONE
HYDRO CYCLONE
FROTH FLOTATION

DRY PROCESSES

AIR FLOW JIGS
TABLES AND LAUNDERS

MECHANICAL DEWATERING

DEWATERING SCREENS
CENTRIFUGE
CYCLONE
THICKNESS
FILTRATION

THERMAL DEWATERING

(HOT AIR DRYERS)

NOTE: ANY ONE OR MORE OF THE ABOVE CRUSHING, SCREENING, CLEANING AND DRYING DEVICES ARE USED IN VARIOUS PARTS OF PREPARATION PLANT DEPENDING ON THE EXTENT OF PREPARATION REQUIRED

FIGURE 1.1

COAL PREPARATION PROCESSES
AND TECHNIQUES
(TETRA TECH 1976)

FIGURE 1.2
TYPICAL FLOW DIAGRAMS OF
COAL PREPARATION PLANTS
DAMES & MOORE

(A) Type of dump:

- (1) Valley-fill
- (2) Cross-valley
- (3) Side-hill
- (4) Ridge
- (5) Pile

(B) Type of impoundment:

- (6) Cross-valley
- (7) Side-hill
- (8) Diked
- (9) Incised
- (10) Complex: Cross-valley, side-hill

REFERENCE:

SCHLICK AND WAHLER, 1977

FIGURE 1.3
TYPES OF REFUSE
DISPOSAL STRUCTURES

DAMES & MOORE

A UPSTREAM CONSTRUCTION METHODS
 A-1 MECHANICALLY CONSTRUCTED DIKES
 A-2 HYDRAULICALLY CONSTRUCTED DIKES

FIGURE 1.4
 MINE, MILL, OR PLANT
 REFUSE EMBANKMENT
 CONSTRUCTION METHODS

REFERENCE:

SCHLICK AND WAHLER, 1977

B CENTERLINE CONSTRUCTION METHOD
 B-1 BUTTRESS OR LEANING EMBANKMENT
 B-2 FREESTANDING EMBANKMENT

FIGURE 1.5
 MINE, MILL, OR PLANT
 REFUSE EMBANKMENT
 CONSTRUCTION METHODS

REFERENCE:

SCHLICK AND WAHLER, 1977

C. DOWNSTREAM CONSTRUCTION METHOD
 C-1 INCLINED METHOD
 C-2 HORIZONTAL METHOD

FIGURE 1.6
 MINE, MILL, OR PLANT
 REFUSE EMBANKMENT
 CONSTRUCTION METHODS

2. COAL WASTE DISTRIBUTION

Estimate of Existing Refuse and Projections

The rate at which the coal mine waste accumulates varies according to the total production of coal, the proportion of raw coal subjected to cleaning, the prevailing market preference for different qualities of coal, specific mining and coal preparation methods, and the quality of coal in the seams available for mining.

Thin partings, lenses or inclusions of slate, shale, siltstone or claystone which are associated with coal seams are recovered as part of the coal mining operation. With modern equipment, a considerable quantity of roof and floor rocks may also be recovered. Before the advent of current mechanization, this waste rock was removed from the coal by hand and left behind in underground workings; or it was separated on the surface by hand or by screening. Presently, nearly 70 percent of the raw coal production is cleaned in preparation plants by mechanical and physical methods. The waste material from the preparation plants can be designated into two main categories, as coarse and fine refuse. The coarse refuse is disposed of on the surface by conveyor belt, truck, aerial tramway, or other means onto waste piles of different sizes and various shapes. The fine waste material is pumped into settling ponds in slurry form which, upon filling, are abandoned and reclaimed or, upon drying, are disposed of on the waste piles.

Estimates of existing coal mine waste and its regional distribution in the Midwestern coal fields can be made by preparing an inventory of all abandoned and active refuse sites and by determining the volume of the waste at each site by actual physical measurements. Alternatively, fairly accurate estimates can be made based on the history of regional coal production, mining, and cleaning methods. For convenience of estimation, the existing coal mine waste has been divided into two broad categories; namely refuse in abandoned sites associated with deep mines or preparation plants and refuse in active disposal sites associated with deep mines or preparation plants.

The forecast of future waste production and its regional distribution will depend on projections of coal production from different regions in the Midwestern coal fields.

Coal Production Projections for Midwestern Coal Fields

Important coal producing states in the midwestern region are: Illinois, West Kentucky, Indiana, Missouri, Oklahoma,

Kansas, Iowa, and Arkansas. Out of these eight states, only Kentucky and Missouri made an attempt to forecast coal production up to 1987 and 1983, respectively. They also admitted difficulties in making these forecasts due to the various uncertainties affecting use of coal as the main source of energy in the future (Nicholson, 1979; Missouri DNR, 1979). The National Coal Association has made short-term projections up to 1980 only. These are not by state but are by different coal provinces of the United States (Campbell, 1961). The U.S. Department of Energy (DOE), the Electric Power Research Institute (EPRI), and the Environmental Protection Agency have prepared national coal production projections up to 1995. The projections prepared by the U.S. Department of Energy are the latest (EIA, 1979) and reflect to certain extent the rise in cost of crude oil and uncertainties of its supply in adequate quantity following the recent crisis in Iran. Their projections for the entire nation by different regions are given in Table 2.1 and graphically represented on Figure 2.1. The projections for the Midwest and Central West regions which comprise the Interior Province excluding the Gulf region, generally referred to as the Midwestern coal fields in this report, have been taken as the basis for preparing production projections of different states comprising the Midwestern coal fields.

At the turn of the century, coal consumption constituted 89 percent of the total energy used in the United States. This percentage has declined to 19 percent in 1977 as shown on Figure 2.2. The decline occurred as consumers switched to oil and gas which were less expensive, easier to handle and environmentally more acceptable. It will be seen that the total energy consumption started increasing rapidly during the 1950s. By the late 1960s, the coal had a serious contender in nuclear power for the increasing electric utility market. The tightening of the air pollution standards also decreased the market for coal. However, the position of coal appears to have changed dramatically with the increase in world oil prices and decrease in planned nuclear capacity due to safety and nuclear waste disposal questions still remaining unresolved. In view of these considerations, the projected increase in share of coal to 34 percent of the total energy consumption in 1995 by EIA appears to be quite achievable in spite of uncertainties in the coal market at the present time. These uncertainties include revision of sulfur dioxide emission standards by the EPA, the implementation of Section 125 of the 1977 Clean Air Amendments, the passage of the Powerplant and Industrial Fuel Use Act of 1978, and developments affecting coal transportation costs.

According to EIA projections based on historical trends and relationships in national and regional coal production, coal production is expected to increase significantly through

1995 as shown in Table 2.1. This represents an average increase of 6.1 percent per annum from 1977 through 1995 as the country is forced back to coal.

A shift in the regional distribution of coal production from the East to the West is reflected in these projections. The main reason for this shift is attributed to the availability of vast reserves of low sulfur coal in the West and substitution of coal for natural gas in the Southwest in the industrial and electric utility sectors. The changing regional production shares of coal from 1947 through 1995 are shown on Figure 2.3. The distribution remained essentially unchanged between 1947 and 1967 with the East accounting for more than 95 percent of national production. However, East's share had fallen to 78 percent by 1977 and is projected to decline further to 47 percent in 1995.

The coal production projections for the Midwestern coal fields are based on an average growth rate of 5.4 percent per annum from 1977 through 1995. They have been extended up to 2,000 assuming the same growth rate. Depending on the coal mining history, recoverable coal reserves, and geographical locations of individual states comprising the Midwestern coal fields, the coal production projections for each of these states have been drawn up keeping the total for the entire Midwestern region the same as projected by the EIA. These projections are given in Table 2.2. Also, the historical production of these states and the total Midwest production from 1974 through 1978 are given in Table 2.3.

The coal production projections of all states for 1980 are based on the forecast made by National Coal Association (Press Release, 1979). The coal production of Western Kentucky in 1985 is projected based on a report prepared by the Institute for Mining and Minerals Research (1979). The projections for the remaining states have been proportionately adjusted so that the total for the Midwest coal fields tallies with the EIA figures. The rate of growth of annual coal production of Kansas, Iowa, and Arkansas is high through 1985 because their existing production is very low. The annual growth rates from 1985 through 1990 and from 1990 through 2000 are generally 5.2 and 5.4 percent, respectively.

Estimates of Coal Mine Waste Production

The percentage of mechanically cleaned coal has increased several fold during the last 50 years. The trend and also the percentage of waste produced are indicated on Figure 2.4. The increase in percentage of reject production can be attributed to the modern mining equipment which is generally not suitable for

selective mining and removes considerable amount of roof and floor rocks (U.S. Department of Interior, 1975). Total United States production of refuse per year from 1927 through 1973 is shown on Figure 2.5. It is estimated that the existing identifiable coal waste piles and slurry ponds/impoundments contain over 3 billion tons of refuse in the United States (National Academy of Science, 1975).

Table 2.4 gives the status of mechanical cleaning of coal in the Midwestern coal fields in 1975 by state and type of mine. It shows that Illinois accounts for nearly 55 percent of the total coal mine refuse generated in the Midwestern coal fields. On the other hand, the waste generated in Iowa is insignificant at present as there are no preparation plants. About 95 percent of the total coal production in Iowa is sold after crushing or screening only.

Table 2.5 shows the total estimated identified resources and recoverable reserves of bituminous coal in the Midwestern coal fields by state. The reserve base is defined as "... the quantity of (remaining) in-place coals calculated under specified depth and thickness criteria." "Resource" has been defined as the total stock of coal in the ground, irrespective of whether it is minable or not, and the term "reserves" has been defined as the quantity of coal actually recoverable. Table 2.5 shows reserve base up to a depth of 1,000 feet only for beds of coal more than 28 inches thick. The recoverable reserves will improve substantially when the reserve base is extended up to 3,000 feet in depth. The total projected recoverable reserves are given in Table 2.5 after accounting for the cumulative coal production in various states of the Midwestern coal fields. The cumulative coal production by state through 1978 is given in Table 2.6. The total remaining recoverable reserves for individual states are sufficient for sustained production for several years at rates projected for the year 2000 (see Table 2.2).

Illinois

Estimate of Existing Waste Quantity

Commercial production of coal in Illinois was first recorded in 1833. It was 6,000 tons. This production gradually increased with the expansion of railroad transport system and coal became the major source of energy at the turn of the century. By the end of World War I, Illinois coal production reached an all-time record of 90 million tons in 1918. However, the production fell sharply during the depression and picked up again during World War II. The production dropped quickly after the war ended because of oil and natural gas capturing the

majority share in the energy market. The production expanded again during the sixties but is on the decline since 1972 as shown on Figure 2.6 (Carlir, et al., 1974).

A total of 4,730 million tons of coal has been cumulatively produced in Illinois from 1833 through 1978. The production from underground mines accounted for 3,760 million tons.

Prior to enactment of environmental regulations, coarse refuse and slurry were characteristically disposed of in the most economical manner. Coarse refuse was generally deposited in the nearest convenient location and fine refuse in slurry was generally pumped into the nearest stream or low-lying areas. Consequently, considerable quantities of fine refuse were washed down the streams over the years while the coarse refuse piles stood where they were deposited. In Illinois, a detailed inventory of the refuse piles and slurry ponds associated with 700 abandoned underground mines was prepared (Nawrot, et al., 1977). Coarse refuse quantity associated with abandoned underground mines is estimated to be about 71 million cubic yards in sites containing a few cubic yards to large piles over 200 feet high containing over 1 million cubic yards (Nawrot, et al., 1977). The coarse refuse piles associated with 700 abandoned mines in Illinois cover 3,944 acres, and the area covered by individual sites ranges from 0.1 acre to 323 acres (Nawrot, et al., 1977). Over 50 percent of the refuse is located in Franklin, Christian, Saline, Williamson, and Macoupin counties.

Slurry ponds associated with 38 abandoned mines covered 694 acres with sites ranging from 0.1 to 100 acres. Most of these are concentrated in Franklin, Williamson, and Saline counties. An estimate of the quantity of the slurry was not made, as the depth of slurry ponds was not determined. However, based on the acreage covered by slurry ponds in relation to the acreage covered by coarse refuse piles, it can be surmised that the slurry quantity would be less than 15 percent of the coarse refuse volume. Therefore, the total refuse accumulated in Illinois from 1833 through 1977 from 700 abandoned underground coal mines would amount to about 82 million cubic yards.

Estimate of Mine Waste Associated with Active Mines in Illinois, 1978

Cumulative quantity of coal mine waste in active disposal sites in Illinois has been estimated and is given in Table 2.7. These estimates are based on the following considerations:

- The ratio of refuse to cleaned coal produced from a preparation plant averages 0.3;

- The quantity of refuse produced from mines not having preparation plants is insignificant as compared to the quantity of refuse produced from preparation plants and, therefore, can be ignored; and
- The portion of coarse refuse from preparation plants associated with strip mines returned to the pits along with the spoil is also small and, therefore, can be ignored. It will be seen that this and the preceding consideration are compensatory in nature.

The number of preparation plants in operation in 1978 was 39, of which 22 were associated with underground mines. The quantity of refuse in active disposal sites in Illinois at the end of 1978 has been estimated to be nearly 260 million tons, as shown in Table 2.7. Therefore, the total quantity of identifiable coal mine refuse in Illinois at the end of 1978 is about 362 million tons (293 million cubic yards).

Projections of Coal Mine Waste Production in Illinois: 1980 - 2000

Currently, the average ratio of cleaned coal to total annual marketable production is 0.78 in Illinois. The coal production in Illinois is projected to increase to 201 million tons in 2000 at an average growth rate of 5.9 percent per annum. Due to specific quality requirements and various environmental constraints (particularly on account of high sulfur content of Illinois coals), the entire additional capacity which may be developed would be planned to be mechanically cleaned. Therefore, the ratio of mechanically cleaned coal to total marketable production will increase substantially. It is expected to rise to 0.92 in 2000. The estimates of coal mine waste production projections from 1980 through 2000 are given in Table 2.8. It will be seen that the production of cleaned coal in 2000 is expected to be 185 million tons with accompanying production of nearly 55 million tons of mine waste. If the projected coal production growth rate is maintained, the total production of coal mine refuse in Illinois alone during the period 1980 through 2000 would amount to 658 million tons.

Indiana

Estimate of Existing Quantity of Coal Mine Waste at Abandoned Disposal Sites

Indiana's total estimated identified resources of coal are 33 billion tons, of which 3.8 billion tons are recoverable

(Table 2.5). About 29 percent of the recoverable reserves are strippable. The cumulative coal production from the state through 1978 was 1.5 billion tons. About 55 percent of this cumulative production came from surface mines.

An inventory of significant coal mine refuse disposal sites was compiled by Indiana Geological Survey (Eggert, 1979). Based on this inventory, total quantity of refuse in the abandoned disposal sites has been estimated and is presented in Table 2.9. The quantity of refuse in individual disposal sites has been derived from the cumulative coal production of the associated mines. The total quantity of refuse in these abandoned sites is estimated to be about 50 million tons.

Existing Quantity of Coal Mine Waste at Active Disposal Sites

Table 2.10 gives the estimated quantity of refuse at active disposal sites in Indiana. The estimates are based on the cumulative coal production from the associated mines and a waste to cleaned coal production ratio of 0.29. As may be seen from Table 2.10, the total quantity of refuse in active disposal sites amounts to about 64 million tons. In addition to this, a small percentage of coarse refuse is also generated at the mines having no preparation plants. Since most of these are surface mines, the coarse refuse is returned to the pits along with the spoil.

Projections of Coal Mine Waste Production in Indiana: 1980 - 2000

An average growth rate of 5.9 percent per annum has been contemplated for achieving a production rate of 101 million tons per year by 2000 in Indiana (see Table 2.2).

The ratio of cleaned coal to total production in the state was 0.77 during 1975 until which the statistics are available. It is expected to gradually increase to 0.92 in 2000 because of the assumption that all additional production in the future will be subjected to mechanical cleaning. Most of the future mines will be individually large, highly mechanized, and will have to cope up with more difficult mining situations as compared to the existing conditions. Some of these conditions will comprise working of thinner seams, seams containing more ash and sulfur, working multiple seams, working in geologically disturbed areas, etc. All these factors tend to increase the percentage of waste material in the raw coal. Consequently, it will be necessary to wash the raw coal in order to make it fit for marketing. The prevailing ratio of waste to the cleaned coal

produced in Indiana is 0.29. Assuming this ratio remains constant for the remaining part of the century, the production of coal mine refuse will increase from 5 million tons in 1978 to 27 million tons in 2000 as shown in Table 2.11. The estimated quantity of waste likely to be produced during 1980 through 2000 would amount to approximately 319 million tons.

Missouri

Estimate of Existing Quantity of Coal Mine Waste and Projections: 1980 - 2000

Missouri coal fields are part of the Western Interior Region. All coal of commercial importance occurs in strata of Middle Pennsylvanian age which underlies approximately 23,000 square miles of the northern and western counties of the state. Missouri coals are high volatile bituminous in rank and have high sulfur content. The estimated identified resources of Missouri are 31,184 million tons, of which 1,585 million tons are projected to be recoverable. The cumulative coal production through 1978 was 309 million tons. The entire current production comes from strip mines. Presently, there are four active preparation plants having installed capacity to clean 12,500 tons coal per day.

A detailed inventory of abandoned refuse disposal site was not made in Missouri. However, eleven significant abandoned disposal areas associated with preparation plants spread in Callaway-Boone, Macon, Randolph, Bates, Henry-Johnson, Henry, Vernon, and St. Clair counties were identified. The coarse refuse piles and the slurry ponds in these disposal areas cover nearly 419 acres (Missouri Water Quality Report, 1978). It is estimated that these disposal areas contain over 7 million tons of coal mine waste. There are several other small abandoned coal refuse disposal sites in Missouri, but the quantity of refuse in them is insignificant.

The refuse generated from the active preparation plants amount to nearly half million tons per year at the current rate of production. Therefore, it is estimated that the active disposal areas have accumulated nearly 2.4 million tons of refuse since 1974.

The coal production in Missouri is expected to increase to 20 million tons in year 2000 at an annual growth rate of 5.9 percent. The ratio of cleaned coal to total production at present is 0.27. As most of the additional production above the present level will be subjected to mechanical cleaning, this ratio is expected to increase to 0.85 in 2000. Assuming ratio of waste produced to coal cleaned is equal to 0.3, the waste

production will increase to 5.1 million tons in 2000 as shown in Table 2.12. The estimated quantity of waste likely to be produced in Missouri during 1980 through 2000 is 55 million tons.

Oklahoma

Estimate of Existing Quantity of Coal Mine Waste and Projections: 1980 - 2000

All coal of commercial importance occurs in strata of middle and late Pennsylvanian age which occupies the eastern part of Oklahoma. This area is in the southern part of the western region of the Interior Coal Province of the United States (Campbell, 1971). The estimated identified coal reserves up to 1,000 feet in depth are 468 million tons (Table 2.5). The cumulative coal production in Oklahoma through 1978 is 200 million tons. This production came from both deep and strip mines. However, all current production is from strip mines. Presently, Oklahoma has four active preparation plants, two inactive preparation plants, and one preparation plant under construction.

Most of the abandoned mines in Oklahoma were small in size and also there were not many preparation plants. Consequently, most of such like mines had only small coarse refuse piles associated with them. Many of these refuse piles got burnt due to self-heating over the years. The burnt refuse material commonly called "red dog" was burrowed and used for paving the roads and driveways. Many of the remaining refuse piles were naturally revegetated and have since blended with their surroundings. Consequently, the existing quantity of refuse in abandoned sites is not significant.

All current production in Oklahoma comes from strip mines. However, the combined capacity of the four active preparation plants is 7,200 tons per day. The present rate of accumulation of coal refuse in the active disposal areas associated with these four preparation plants is about half million tons per year. The total refuse accumulated in these disposal areas since 1974 is approximately 1.8 million tons.

The coal production in Oklahoma is projected to increase to 20 million tons in 2000. The ratio of mechanically cleaned coal to total production is expected to increase to 0.85 in the year 2000 from the current level of 0.36. Consequently, the production of waste will increase to 5.1 million tons in 2000 from the present level of about half million tons per annum as shown in Table 2.13. The total cumulative production of waste in Oklahoma is projected to amount to about 56 million tons during 1980 through 2000.

Kansas

Estimate of Existing Waste Quantity

The coal bearing strata occur in an area of nearly 18,800 square miles comprising nearly 23 percent of the entire area of the state. The estimated identified resources of Kansas bituminous coal amount to 18.7 billion tons (Averitt, 1974) of which 375 million tons are recoverable by underground methods and up to 300 million tons by surface methods. Nearly all of the reserves are high sulfur coal.

A total of 301 million tons of coal have been cumulatively produced through 1978 in Kansas of which 196 million tons were produced from underground mines. Most of the abandoned mines were worked side by side of strip operations. Consequently, refuse from underground mines was mixed with spoil from strip mines and returned to the spoil disposal areas. Also, small volumes of waste associated with small abandoned underground mines have naturally been vegetated over the years and are no longer significant as regards deterioration of the surrounding environment. However, based on the cumulative coal production and a general location of the identifiable refuse disposal areas associated with underground abandoned mines, it has been estimated that the refuse contained in these sites would amount to only a few million tons.

The entire current production comes from strip mines. At present, four preparation plants are in operation with a capacity to produce 7,600 tons of cleaned coal per day. The refuse contained in the active disposal areas associated with these preparation plants is less than one-half million tons.

Projections of Coal Mine Waste

Production in Kansas: 1980 - 2000

The ratio of cleaned coal to total production in 1975 was 0.98. The total production of coal in Kansas in 1975 was only 479,000 tons. The current production rate is approximately 1.5 million tons per annum and about 68 percent of this production is cleaned coal. The coal production in Kansas is projected to increase to 9.8 million tons in 2000 at an average growth rate of 5.9 percent per annum. It is expected that the percentage of cleaned coal will also increase to 96 in 2000 with the rise in production. Assuming that the ratio of waste production to cleaned coal production is equal to 0.3, the rate of waste production would increase to 2.8 million tons in 2000 as compared to a quarter million tons per year at present. Estimates of waste production in Kansas from 1974 through 2000 are given in Table 2.14. It is forecast that the quantity of

coal mine waste likely to be produced during 1980 through 2000 would be approximately 33.5 million tons.

Iowa

Estimate of Existing Waste Quantity

Coal beds of economic interest in Iowa belong to Wabannese Group of the Virgil Series and in the Marmaton and Cherokee Groups of the Des Moines Series. They occupy a total of about 1,316,040 acres in 37 counties. The estimated identified resources of Iowa's bituminous coal amount to 6.5 billion tons, of which 701 million tons are recoverable (Table 2.5).

A total of 358 million tons of coal has been cumulatively extracted through 1978 in Iowa. More than 50 percent of the cumulative production came from underground mines. However, the current production is obtained only from strip mines. There are no active preparation plants in Iowa. In the past also, only one preparation plant was in operation for a period of 5 years from 1912 through 1917. Most of the underground mines were small in size. Therefore, only small piles of hand-picked or screened refuse were associated with abandoned underground mines. Quite a few of these refuse piles caught fire due to self-heating and turned into "red dog." This "red dog" was dug out by the local inhabitants and used for paving driveways, walkways, etc. A number of unburnt refuse piles were used for supply of material for various types of fills. The remaining existing waste piles are insignificant, both as regards to quantity and environmental pollutants. Consequently, no attempt was made by any state or federal agency to prepare a detailed inventory of these abandoned waste disposal areas.

Projection of Coal Mine Waste

Production in Iowa: 1980 - 2000

The total coal production in Iowa in 1978 was 0.52 million tons. This production is projected to increase to 10.8 million tons in 2000. In keeping with the trends in other coal producing states, it is expected that most of the raw coal production in the future will be subjected to washing in modern preparation plants. It is projected that the ratio of cleaned coal to total marketable production will gradually increase to 0.83 in 2000. Assuming that the ratio of waste production to cleaned coal production is equal to 0.3, the rate of waste production would also increase to 2.7 million tons per year in 2000 as given in Table 2.15. It is estimated that the quantity of coal mine waste to be generated in Iowa from 1980 through 2000 would amount to about 25 million tons.

Arkansas

Estimate of Existing Waste Quantity and Projections

The coal bearing strata consisting mainly of sandstone and shale of Pennsylvanian Age extend over an area of approximately 1900 square miles in west central Arkansas. Of the 19 different coal beds described, the four having the most economic significance are the Lower Hartshorne, Upper Hartshorne, Charleston, and Paris.

The trend of coal production in Arkansas from 1880 when first significant production was recorded, through 1977 is shown on Figure 2.7. The production was at its peak during the World War I. It declined during the depression but again picked up during World War II. The production started declining again soon after the war and reached its low of 189,000 tons in 1967. The production has been increasing since then.

Accumulative coal production in Arkansas through 1978 is 104.5 million tons of which 90.6 million tons came from underground mines. Most of the abandoned mines in Arkansas were small in size. A number of underground and surface mines were worked in close proximity to each other. Consequently, refuse from underground mines was mixed with spoil from surface mines in a large number of instances. An inventory of the areas disturbed by underground and surface mines was prepared by Arkansas Geological Society (Bush and Gilbreath, 1978).

During the inventory process, it was found that most of the refuse dumps had revegetated voluntarily, and they were generally small in size. However, no attempt was made to determine the volume of the waste material as they did not pose any serious environmental problem. Based on accumulative coal production, nature, and size of the mines, it may be surmised that the quantity of refuse contained in the disposal sites associated with abandoned underground mines would not amount to more than a few million tons.

The entire current production comes from strip mines. At present, only two preparation plants are in operation and one is under construction. Consequently, there are only two active refuse disposal sites associated with the two operating preparation plants. These plants have a capacity to produce 1,800 tons of clean coal per day. The refuse contained in these active disposal areas is approximately 0.3 million tons.

The ratio of cleaned coal to total production in 1975 was 0.43. It is expected to increase to 0.95 in the year 2000. The current production rate is about half million tons per annum of which about 45 percent is cleaned coal. The coal production in

Arkansas is projected to increase to 6.5 million tons in 2000 at an annual growth rate of 5.9 percent. Assuming that the ratio of waste production to cleaned coal production is 0.3, the waste production would increase to 1.8 million tons in 2000 as compared to only 75 thousand tons per annum at present. Estimates of waste production in Arkansas from 1974 through 2000 are given in Table 2.16. It is estimated that approximately 22 million tons of waste will be generated in Arkansas from 1980 through 2000.

Western Kentucky

Estimate of Existing Quantity of Coal Mine Waste at Abandoned Disposal Sites

The coal bearing strata of Western Kentucky occur in an area of approximately 6,400 square miles covering 17 counties. The estimated identified resources of bituminous coal in Western Kentucky amount to 40.9 billion tons of which 3.86 billion tons are Class I recoverable reserves (Kentucky Geological Survey, 1970). Class I reserves fall under "measured" category. The important coal producing counties are Butler, Davies, Henderson, Hopkins, Muhlenberg, Ohio, Union, and Webster. Muhlenberg is the largest coal producing county in the state at present. The principal coal seams being mined in western Kentucky at present are No. 9, No. 11, No. 12, No. 13, and No. 14. The most widespread and persistent coal seam is No. 9, which contains nearly 25 percent of the total estimated identified resources of western Kentucky. These coals are generally high volatile and have higher ash and sulfur content than the eastern Kentucky coals.

An inventory of significant coal mine refuse disposal sites in western Kentucky was compiled by Mine Safety and Health Administration, Madisonville. The location of these sites and the quantity of refuse where estimated are given in Table 2.17. The quantity of refuse was estimated with respect to 19 locations which adds up to 18 million tons. The estimates of quantity of refuse in the remaining 17 locations are not available. However, it may be conjectured from the land area covered that the total quantity of refuse in these 36 disposal sites is approximately 35 million tons. In addition to these inventoried refuse disposal sites, there are several others which contain relatively small quantities of coal mine waste individually.

The cumulative coal production from western Kentucky through 1978 was 1.5 billion tons. The current production of washed coal is about 35 percent of the total western Kentucky production.

Existing Quantity of Coal Mine Waste in Active Disposal Sites

Significant active waste disposal sites are those that are associated with preparation plants. Table 2.18 gives the particulars of these sites in western Kentucky. Cumulative production of washed coal from the associated mines is not available at present; therefore, it is difficult to estimate the quantity of refuse in individual disposal areas. However, it is estimated that approximately 26.5 million tons of waste was deposited in these active disposal sites from 1974 through 1978 (Table 2.20).

Projections of Coal Mine Waste Production: 1980 - 2000

A rate of growth of 4 percent per annum has been projected in order to achieve a production rate of 63.7 million tons in 1985 (Nicholson, 1979). An average growth rate of 5.4 percent has been envisaged beyond 1985 through 2000 (EIA, 1979).

The ratio of cleaned coal to total production in western Kentucky was 0.35 during 1975, the last year for which the statistics are available. It is expected to increase to 0.80 in year 2000 based on the assumption that all additional production in the future will be subjected to mechanical cleaning. The current ratio of waste to cleaned coal produced in western Kentucky is 0.3. Assuming that this ratio remains constant through 2000, the production of coal mine refuse will increase from 4.2 million tons in 1978 to 34.6 million tons in 2000, as shown in Table 2.19. The estimated quantity of waste likely to be produced during 1980 through 2000 would amount to approximately 319 million tons.

Midwestern Region

Estimates of Mine Waste Production in Midwestern Region: 1974 - 2000

Estimates of waste production from different states comprising the Midwestern region are summarized in Table 2.20 covering the period from 1974 through 2000. The existing rate of waste production is approximately 25 million tons per year, which is forecast to increase to 135 million tons per year in 2000. This represents a growth rate of nearly 8 percent per annum as compared to an average growth rate of 5.4 percent per annum for the coal production. The differential in growth rates represents the increasing trend to mechanically clean the coal before it is marketed.

It is estimated that the coal mine waste likely to be produced during 1980-2000 would amount to approximately 1.5 billion tons in the entire Midwestern region.

The total quantity of refuse in significant abandoned disposal sites associated with underground mines and preparation plants has been estimated to amount to approximately 198 million tons. This is contained in both abandoned slurry ponds or gob piles. The quantity of refuse in active disposal sites of the Midwestern region amounts to approximately 355 million tons. Therefore, the total refuse in the Midwestern region as of the end of 1978 would amount to approximately 553 million tons or 450 million cubic yards spread in eight states in slurry ponds or gob piles of various sizes.

Waste production rates for various states comprising the Midwestern region projected to the year 2000 are shown on Figure 2.8.

TABLE 2.1

COAL PRODUCTION BY REGION AND MINING METHOD - HISTORY AND PROJECTIONS, 1962-1995

REGION	MINING METHOD	HISTORY				PROJECTIONS			ACTUAL GROWTH RATES			
		(million tons)				(million tons)			(percent)			
		1962	1967	1972	1977	1985	1990	1995	1977-1985	1985-1990	1990-1995	
Northern Appalachia	Surface	52	60	73	91	72	51	45	- 2.9	- 6.6	- 2.3	
	Deep	92	125	107	83	104	196	275	2.9	13.5	7.0	
	Total*	144	186	180	174	176	247	320	0.2	7.0	5.3	
Central and Southern Appalachia	Surface	20	38	71	105	110	86	76	0.6	- 4.7	- 2.4	
	Deep	141	170	136	115	156	151	152	3.9	- 0.7	- 0.1	
	Total*	161	208	207	220	267	237	228	2.4	- 2.3	- 0.8	
Midwest and Central West	Surface	62	91	101	96	67	46	45	- 4.3	- 7.2	- 0.5	
	Deep	40	46	52	52	167	256	349	15.6	8.9	6.4	
	Total*	102	137	153	148	235	301	393	5.9	5.2	5.4	
East	Surface	134	189	245	292	249	183	166	- 2.0	- 6.0	- 1.9	
	Deep	273	341	295	150	427	603	776	6.9	7.1	5.2	
	Total*	407	530	540	542	677	786	942	2.8	3.0	3.7	
Gulf	Surface	-	-	4	16	70	72	72	20.3	0.6	0.0	
	Deep	-	-	-	-	-	-	-	-	-	-	
	Total*	-	-	4	16	70	72	72	20.3	0.6	0.0	
Great Plains	Surface	5	8	25	85	220	528	869	12.6	19.1	10.5	
	Deep	1	1	1	1	4	8	12	18.9	14.9	8.4	
	Total*	6	9	26	86	224	536	881	12.7	19.1	10.5	
Rest of West	Surface	2	6	16	35	31	32	34	- 1.6	0.8	1.6	
	Deep	7	8	8	13	30	38	69	10.7	4.7	12.4	
	Total*	9	14	24	48	62	71	103	3.0	2.8	8.1	
West	Surface	7	14	45	136	321	632	975	11.3	14.5	9.0	
	Deep	8	9	9	14	34	46	81	11.7	6.2	12.0	
	Total*	15	23	54	150	357	678	1,056	11.4	13.8	9.3	
National	Surface	141	203	290	428	570	815	1,141	3.6	7.4	7.0	
	Deep	281	350	304	264	461	649	857	7.2	7.1	5.7	
	Total*	422	553	595	691	1,033	1,465	1,999	5.1	7.2	6.4	
Total Production (Quadrillion Btu)		-	11.2	14.2	14.5	15.8	22.7	31.2	41.7	4.6	6.6	6.0

Source: EIA, 1979.

*Data may not add to total shown due to independent rounding.

TABLE 2.2

MIDWEST COAL PRODUCTION BY STATE AND MINING METHOD
HISTORY AND PROJECTIONS 1977 - 2000

STATE	MINING METHOD	HISTORY ^a (million tons)		PROJECTIONS ^{b,c} (million tons)				
		1977	1978	1980	1985	1990	1995	2000
Illinois	Underground	29.6	24.9	30.8	66.3	101.1	137.0	184.0
	Surface	24.3	23.8	25.3	26.4	17.9	17.0	17.0
	Total	53.9	48.7	56.1	92.7	119.0	154.0	201.0
Western Kentucky	Underground	22.8	18.4	23.2	38.7	69.7	97.9	132.3
	Surface	28.8	21.4	29.4	25.0	12.3	12.1	12.1
	Total	51.6	39.8	52.6	63.7	82.0	110.0	144.4
Indiana	Underground	0.5	0.6	1.0	23.6	51.0	69.4	93.0
	Surface	26.7	23.3	26.8	23.0	9.0	8.6	8.6
	Total	27.2	23.9	27.8	46.6	60.0	78.0	101.6
Missouri	Underground	0.0	0.0	0.	3.3	10.2	13.6	18.3
	Surface	6.6	5.7	8.8	6.5	1.8	1.7	1.7
	Total	6.6	5.7	8.8	9.8	12.0	15.3	20.0
Oklahoma	Underground	0.0	0.0	0.0	3.7	10.2	13.6	18.3
	Surface	5.3	5.0	7.3	6.0	1.8	1.7	1.7
	Total	5.3	5.0	7.3	9.7	12.0	15.3	20.0
Kansas	Underground	0.0	0.0	0.0	1.5	4.2	6.5	9.0
	Surface	0.6	1.4	3.4	3.0	1.6	0.8	0.8
	Total	0.6	1.4	3.4	4.5	5.8	7.3	9.8
Iowa	Underground	0.0	0.0	0.0	3.0	5.4	7.3	9.9
	Surface	0.5	0.5	2.0	2.0	1.0	0.9	0.9
	Total	0.5	0.5	2.0	5.0	6.4	8.2	10.8
Arkansas	Underground	0.02	0.0	0.1	1.5	3.2	4.4	5.9
	Surface	0.5	0.3	1.4	1.5	0.6	0.6	0.6
	Total	0.6	0.3	1.5	3.0	3.8	5.0	6.5
Total Midwest	Underground	52.9	43.9	55.1	141.6	255.0	349.7	470.7
	Surface	93.4	81.4	104.4	93.4	46.0	43.4	43.4
	Total	146.3	125.3	157.5	235.0	301.0	393.1	514.1

^aInformation on production of states in 1977 and 1978 obtained from annual reports of Illinois Department of Mines and Minerals, Kentucky Department of Mines and Minerals, Indiana DNR Geological Survey, Missouri DNR, and Keystone Coal Industry Manual, 1978 and 1979.

^bProjections of production in 1980 are based on forecast made by National Coal Association (press release on December 26, 1979).

^cProjections of production from 1985 to 2000 based on Energy Information Administration Report to the Congress, 1978.

TABLE 2.3

COAL PRODUCTION IN MIDWESTERN REGION, 1974 - 1978

STATE	MINING METHOD	PRODUCTION (thousand tons)				
		1974	1975	1976	1977	1978
Illinois	Underground	31,105	31,880	30,912	29,589	24,889
	Surface	26,968	27,659	27,244	24,291	23,855
	Total	58,073	59,539	58,136	53,880	48,744
Western Kentucky	Underground	22,890	25,100	26,888	22,790	18,437
	Surface	28,900	31,300	26,669	28,803	21,381
	Total	51,790	56,400	53,557	51,593	39,818
Indiana	Underground	146	187	430	525	587
	Surface	22,601	24,951	22,870	26,654	23,354
	Total	22,747	25,138	23,300	27,179	23,941
Missouri	Underground	0	0	0	0	0
	Surface	4,625	5,683	6,075	6,625	5,667
	Total	4,625	5,683	6,075	6,625	5,667
Oklahoma	Underground	0	0	0	0	0
	Surface	2,375	2,872	3,635	5,345	5,000
	Total	2,375	2,872	3,635	5,345	5,000
Kansas	Underground	0	0	0	0	0
	Surface	679	479	590	630	1,405
	Total	679	479	590	630	1,405
Iowa	Underground	0	0	0	0	0
	Surface	590	622	616	525	520
	Total	590	622	616	525	520
Arkansas	Underground	0	0	0	20	0
	Surface	455	488	534	550	319
	Total	455	488	534	570	319
Total Midwest	Underground	54,141	57,167	58,230	52,924	43,913
	Surface	87,193	94,054	88,213	93,423	81,501
	Total	141,334	151,221	146,443	146,347	125,414

TABLE 2.4
MECHANICAL CLEANING OF COAL IN MIDWESTERN COAL FIELDS IN 1975
BY STATE AND TYPE OF MINE

STATE	UNDERGROUND MINES		STFIP MINES		ALL MINES		NUMBER OF CLEANING PLANTS	RAW COAL SUBJECTED TO WASHING	TOTAL REFUSE	RATIO OF WASHED COAL TO TOTAL PRODUCTION	RATIO OF REFUSE TO WASHED COAL	CRUSHED OR SCREENED ONLY	NO PROCESSING
	PRODUCTION	WASHED COAL	PRODUCTION	WASHED COAL	PRODUCTION	WASHED COAL							
Illinois	31,875	20,807	27,661	24,312	59,537	45,120	34	59,991	14,872	0.76	0.33	12,957	1,460
Western Kentucky	25,004	5,974	31,353	13,840	56,357	19,814	17	25,751	5,938	0.35	0.30	25,404	11,139
Indiana	188	-	24,935	19,402	25,124	19,402	11	24,986	5,535	0.77	0.29	5,425	297
Missouri	-	-	5,683	1,523	5,633	1,523	4	1,980	457	0.27	0.30	2,407	1,753
Oklahoma	-	-	2,872	601	2,872	601	4	781	180	0.21	0.30	2,139	132
Kansas	-	-	479	471	479	471	4	612	141	0.98	0.30	-	8
Iowa	-	-	622	-	622	-	0	-	-	0.00	0.00	593	29
Arkansas	-	-	483	211	488	211	2	274	62	0.43	0.30	230	47
Total Midwest	57,067	26,781	94,091	60,360	151,162	87,142	76	114,375	27,226	0.58	0.31	49,155	14,865

- Notes: 1. Based on data obtained from Minerals Yearbook, 1975, Vol. 1;
U.S. DOI, Bureau of Mines, 1978.
2. Data may not add to totals shown because of independent
rounding.
3. All values except ratios are expressed in thousand short tons.

TABLE 2.5

RESERVE BASE AND RECOVERABLE RESERVES OF BITUMINOUS COAL IN MIDWESTERN COAL FIELDS

STATE	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
	TOTAL ESTIMATED IDENTIFIED RESOURCES JAN. 1, 1974 0 - 3,000 ft	TOTAL MEASURED AND INDICATED RESERVE BASE JAN. 1, 1976 0 - 1,000 ft	TOTAL STRIPPABLE RESERVE BASE 0 - 150 ft	TOTAL UNDERGROUND RESERVE BASE [2] - [3]	ESTIMATED STRIPPABLE RESERVES	PROJECTED RECOVERABLE RESERVES [4] x 30%	TOTAL PROJECTED RECOVERABLE RESERVES [5] + [6]	RECOVERABLE RESOURCES AS PERCENT OF IDENTIFIED RESOURCES [7] ÷ [1] x 100
Illinois	146,001	67,969	14,841	53,128	3,247	15,938	19,185	13
Western Kentucky*	40,900	16,525	8,089	8,436	1,125	3,374	4,499	11
Indiana	32,868	10,714	1,775	8,939	1,096	2,681	3,777	11
Missouri	31,184	5,014	3,596	1,418	1,160	425	1,585	5
Oklahoma	7,117	1,618	425	1,193	111	357	468	7
Kansas	18,668	1,373	998	375	NA	375	375+	2
Iowa	6,505	2,202	465	1,737	180	521	701	11
Arkansas	1,638	270	107	163	149	49	198	12
Total Midwest	284,881	105,685	30,296	75,389	7,068+	23,720	30,778+	11

*Data for western Kentucky identified resources obtained from Kentucky Geological Survey and derived for recoverable reserves.

Sources: Kentucky Geological Survey.

Col. 1 - U.S. Bureau of Mines, Demonstrated Coal Reserve Base of the United States on January 1, 1974.

Col. 2 - Electric Power Research Institute.

Col. 3 - U.S. Bureau of Mines Information Circular 8531.

Col. 4 through 8 - Schmidt, 1979.

TABLE 2.6

CUMULATIVE COAL PRODUCTION
IN THE MIDWESTERN COAL FIELDS
BY STATE THROUGH 1978

STATE	MILLION SHORT TONS		
	SURFACE	UNDERGROUND	TOTAL
Illinois	970*	3,760	4,730
Western Kentucky	NA	NA	1,507
Indiana	846	690	1,536
Missouri	NA	NA	309
Oklahoma	56	144	200
Kansas	105	196	301
Iowa	NA	NA	358
Arkansas	14	91	105
Total Midwest			9,046

*Strip mining production prior to 1920 is not included in this figure.

TABLE 2.7

Sheet 1 of 2

ESTIMATED CUMULATIVE QUANTITY OF COAL MINE WASTE IN ACTIVE DISPOSAL SITES IN ILLINOIS - 1978

NAME OF OPERATOR AND MINE	TYPE OR MAKE OF PREPARATION PLANT	YEAR MINE OPENED	TYPE OF MINE	COAL SEAM MINED	TOTAL QUANTITY OF COAL PRODUCED SINCE MINE OPENED (thousand short tons)	ESTIMATED TOTAL QUANTITY OF REFUSE IN ACTIVE DISPOSAL AREAS (thousand short tons)
Amax Coal Co., Delta	Mechanical Jig Type	1946	strip	6	30,489	9,146
Amax Coal Co., Leahy	Crushing Jig Type	1971	strip	5 & 6	18,833	5,649
Amax Coal Co., Sunspot	Heavy Media	1962	strip	2	12,328	3,698
Consolidation Coal Co., BS #2	Jig Washing	1950	strip	6	36,268	10,880
Consolidation Coal Co., BS #3	Jig Washing and Air-Water Wash Box	1966	strip	5	16,966	5,089
Consolidation Coal Co., BS #4	Jig Washing and Air-Water Wash Box	1973	strip	5 & 6	11,852	3,555
Consolidation Coal Co., BS #5	Heavy Media	1976	strip	5 & 6	3,595	1,078
Consolidation Coal Co., Morris	J. O. Lively	1969	strip	5	9,948	2,984
Freeman United, Crown II	Jig Plant	1976	shaft & slope	6	2,796	836
Freeman United, #3	Heavy Media, Jig, Froth Flotation	1951	slope	6	79,398	23,819
Freeman United, #4	Heavy Media	1952	slope	6	28,175	8,452
Freeman United, #6	Heavy Media	1968	shaft	6	14,848	4,454
Freeman United, #11	Koppers Rheolaveur	1929	strip	6	66,705	20,011
Freeman United, #17	Heavy Media	1962	strip	5	49,519	14,855
Harrisburg Coal Co.	Deister Tale	1949	slope	5	1,581	474
Inland Steel Coal Co.	Modern Preparation Plant	1966	shaft	6	19,201	5,760
Midland Coal Co., Elm Mine	McNally-Pittsburgh Preparation	1968	strip	5 & 6	9,472	2,841
Monterey Coal Co., #1	Baum Jig Type	1970	shaft & slope	6	18,816	5,644
Monterey Coal Co., #2	Jig Plant	1977	shaft & slope	6	461	138
Monterey Coal Co., #5	Jig Plant	1977	drift	5	197	59

TABLE 2.7 (continued)

Sheet 2 of 2

NAME OF OPERATOR AND MINE	TYPE OR MAKE OF PREPARATION PLANT	YEAR MINE OPENED	TYPE OF MINE	COAL SEAM MINED	TOTAL QUANTITY OF COAL PRODUCED SINCE MINE OPENED (thousand short tons)	ESTIMATED TOTAL QUANTITY OF REFUSE IN ACTIVE DISPOSAL AREAS (thousand short tons)
Old Ben Coal Co., #26	Heavy Media, Froth Flotation, Mogul Jig	1968	shaft	5	17,354	5,206
Old Ben Coal Co., #21	Heavy Media, Froth Flotation, Mogul Jig	1960	shaft	6	38,199	11,459
Old Ben Coal Co., #25	Heavy Media, Froth Flotation, Mogul Jig	1977	shaft	6	1,126	337
Old Ben Coal Co., #27	Heavy Media, Froth Flotation, Mogul Jig	1978	shaft	6	120	36
Old Ben Coal Co., #24	Heavy Media, Froth Flotation	1965	shaft	6	28,843	8,652
Peabody Coal Co., Eagle Surface	McNally-Pittsburgh	1966	strip	6	1,959	587
Peabody Coal Co., Eagle #2	Cyclone Plant	1969	slope	5	4,632	1,389
Peabody Coal Co., #10	Allis Chalmers Vibrator	1952	slope	6	109,871	32,961
Peabody Coal Co., River King U/G	McNally-Pittsburgh	1970	slope	6	14,431	4,329
Peabody Coal Co., Randolph Prep. Plant	Roberts & Schaefer	1957 1972	strip slope	6	18,372	5,511
Peabody Coal Co., Will Scarlet	Baum Jig Type, Centrifugal Dryers	1953	strip	Davis Dekovan	19,134	5,740
Peabody Coal Co., #3	McNally-Pittsburgh	1960	strip	6	10,438	3,131
Robertson & Assoc., "Eads"	Jig Plant	1970	strip	Opdyke	5,123	1,536
Sahara Coal Co., #6, #20, #21		1936/70/71	strip/slope/slope	6/E/5	37,862	11,358
Southwestern Coal Co., Captain	McNally-Pittsburgh	1964	strip	5 & 6	59,867	17,960
Southwestern Coal Co., Streamline	McNally-Pittsburgh	1936	strip	5 & 6	5,867	1,760
Ziegler Coal Co., #2	Roberts & Schaefer	1952	slope	6	19,409	5,822
Ziegler Coal Co., #4	McNally Jig Washer	1943	slope	6	26,764	8,029
Ziegler Coal Co., Mudrock & #2	McNally #223 Washer	1946 1973	shaft slope	6	16,486	4,945
TOTAL						260,170

TABLE 2.8

ESTIMATES OF COAL MINE WASTE PRODUCTION IN ILLINOIS
1974 - 2000

YEAR	PRODUCTION (tons)	RATIO OF CLEAN COAL TO TOTAL PRODUCTION	CLEANED COAL (tons)	RATIO OF WASTE TO CLEANED COAL	WASTE (tons)
1974	58,073,000	0.78	45,297,000	0.30	13,589,000
1975	59,539,000	0.76	45,120,000	0.33	14,872,000
1976	58,136,000	0.78	45,346,000	0.30	13,603,000
1977	53,880,000	0.78	42,026,000	0.30	12,608,000
1978	48,744,000	0.81	39,700,000	0.30	11,910,000
1980	56,055,000	0.78	43,723,000	0.30	13,117,000
1985	92,700,000	0.86	79,722,000	0.30	23,916,000
1990	119,000,000	0.88	105,000,000	0.30	31,500,000
1995	154,000,000	0.90	139,500,000	0.30	41,850,000
2000	201,000,000	0.92	184,920,000	0.30	55,475,000

Estimated quantity of coal mine waste likely
to be produced during 1980 through 2000

657,809,000

TABLE 2.9

ESTIMATE OF EXISTING QUANTITY OF COAL MINE WASTE
AT ABANDONED DISPOSAL SITES IN INDIANA - 1978

COUNTY	NAME OF OPERATOR AND MINE	ACTIVE DATES	COAL SEAM MINED ^a	MINING METHOD ^b	CUMULATIVE COAL PRODUCTION ^c	ESTIMATED TOTAL QUANTITY OF REFUSE AT ABANDONED SITES ^d
Vermillion	Sunspot	1953-59	VII	S	6,259	939
Vigo	Otter Creek	1953-58	III	S	149	4
	Talleydale	1921-59	III, IV	U	21,786	3,268
	Saxton No. 1	1924-58	IV	U	12,660	1,899
	Green Valley-Wabash	1947-62	III, V	U	14,236	2,135
	Victory-Bobolink	1941-54	III	S, U	7,741	1,161
	Springhill	1921-64	V	U	2,400	360
	Mt. Pleasant	1928-74	V	U	1,854	278
	Dresser	1936-53	V	U	7,256	1,088
	Chieftain	1953-68	V, VII	S	18,839	2,826
	Black Hawk	1942-48	V	U	6,223	933
Clay	Old Chinook	1938-74	III	S	26,000	3,900
Sullivan	Thunderbird	1958-72	V, VI	U	12,685	1,902
	Jonay	1947-55	VI	U	1,496	59
	Friar Tuck-New Hope	1930-65	V, VI, VII	S, U	15,000	2,250
	Pandora	1937-67	V	U	1,875	281
	Regent-New Harmony	1943-54	VI	U	4,018	160
	Allendale	1974-46	VI, VII	S	6,632	225
Greene	Ax	1955-57	VI, VII	S	100	4
	Airline	1938-65	III, IV, V, VI, VII	U	20,000	3,000
Knox	Shasta	1944-57	VI	S	7,433	1,115
	Knox Consolidated No. 2	1918-49	V	U	13,112	1,967
	Knoco-Knox Consolidated No. 5	1942-62	V	U	11,879	1,782
	Julian	1942-49	VI	U	4,917	196
	Standard No. 2	1928-45	V	U	7,167	1,075
Daviess	Maid Marian	1947-53	St	S	1,496	60
Gibson	Kings Station	1923-73	V	U	31,668	4,750
	Buckskin	1918-40	V	U	2,486	373
Pike	Blackfoot No. 5	1959-77	V	S	16,821	2,523
	Wick	1929-40	V	U	1,807	72
	Blackfoot	1941-64	IV, V	S	14,606	2,191
Warrick	Tecumseh	1940-65	V	S	20,864	3,129
	Buckskin	1946-56	V	S	2,387	358
	Sunlight	1934-55	V, VI, VII	S	19,600	2,940
TOTAL					343,418	49,973

^a Coal seam mined: St = Unnamed coal in Staunton Formation
 III = Seeleyville Coal Member
 IV = Survant Coal Member
 V = Springfield Coal Member
 VI = Hymers Coal Member
 VII = Danville Coal Member

^b S = Surface
 U = Underground

^c Preparation plant production or total mine production when preparation plant production was unknown. Production is listed in thousand short tons.

^d It has been assumed that the washers worked on an average for half-life of the mine given waste/coal production ratio of 0.15. Waste quantity is listed in thousand short tons.

TABLE 2.10

ESTIMATE OF EXISTING QUANTITY OF COAL MINE WASTE
AT ACTIVE DISPOSAL SITES IN INDIANA - 1978

COUNTY	NAME OF OPERATOR AND MINE NAME	YEAR MINE OPENED	COAL SEAM MINED ^a	TYPE ^b OF MINE	TOTAL QUANTITY ^c OF COAL PRODUCED SINCE MINE OPENED	ESTIMATED TOTAL QUANTITY OF REFUSE AT ABANDONED SITES ^d
Vermillion	Universal	1970	VII	S	20,000	5,800
Clay	Chinook	1974	III, IV	S	7,000	2,030
Sullivan	Minnehaha	1936	V, VI, VII	S,U	28,000	8,120
Green	Linton-Latta	1938	III, IV, V, VI, VII	S	23,000	6,670
	Hawthorn	1966	V, VI, VII	S	19,500	5,655
Pike	Old Ben No. 2	1976	V, VI	S	6,575	1,906
	Old Ben No. 1-Enos	1923	V	S	70,891	10,633
Warrick	Lynnville	1953	V, VI, VII	S	61,000	17,690
	Squaw Creek	1966	V, VI, VII	S	20,000	3,000
	Ayershire	1974	VI, VII	S	10,400	3,016
TOTAL					266,366	64,520

^aCoal Mined: St = Unnamed coal in Staunton Formation
 III = Seelyville Coal Member
 IV = Survant Coal Member
 V = Springfield Coal Member
 VI = Hymera Coal Member
 VII = Danville Coal Member

^bS = Surface
 U = Underground

^cPreparation plant production or total mine production when preparation plant production was unknown.
 Production is listed in thousand short tons.

^dWaste/coal production ratio assumed to be equal to 0.29. Waste quantity is listed in thousand short tons.

TABLE 2.11

ESTIMATES OF COAL MINE WASTE PRODUCTION
IN INDIANA: 1974 - 2000

YEAR	PRODUCTION	RATIO OF CLEANED COAL TO TOTAL PRODUCTION	CLEANED COAL	RATIO OF WASTE TO CLEANED COAL	WASTE
1974	22,747	0.77	17,515	0.29	5,079
1975	25,138	0.77	19,402	0.29	5,585
1976	23,300	0.77	17,941	0.29	5,203
1977	27,179	0.77	20,927	0.29	6,069
1978	23,941	0.77	18,434	0.29	5,346
1980	27,828	0.77	21,427	0.29	6,213
1985	46,600	0.85	39,610	0.29	11,486
1990	60,043	0.88	52,837	0.29	15,322
1995	78,002	0.90	70,291	0.29	20,384
2000	101,593	0.92	93,465	0.29	27,105

Estimated quantity of coal mine waste likely
to be produced during 1980 through 2000

319,254,000

Note: Quantities are listed in thousand short tons.

TABLE 2.12

ESTIMATES OF COAL MINE WASTE PRODUCTION
IN MISSOURI: 1974 - 2000

YEAR	PRODUCTION	RATIO OF CLEANED COAL TO TOTAL PRODUCTION	CLEANED COAL	RATIO OF WASTE TO CLEANED COAL	WASTE
1974	4,625	0.27	1,249	0.30	375
1975	5,683	0.27	1,523	0.30	457
1976	6,075	0.27	1,640	0.30	492
1977	6,625	0.27	1,789	0.30	537
1978	5,667	0.27	1,530	0.30	459
1980	8,783	0.45	3,951	0.30	1,185
1985	9,800	0.60	5,880	0.30	1,760
1990	12,000	0.70	8,400	0.30	2,520
1995	15,300	0.79	12,087	0.30	3,626
2000	20,000	0.85	17,000	0.30	5,100

Estimated quantity of coal mine waste likely
to be produced during 1980 through 2000

55,143,000

Note: Quantities are listed in thousand short tons.

TABLE 2.13

ESTIMATES OF COAL MINE WASTE PRODUCTION
IN OKLAHOMA: 1974 - 2000

YEAR	PRODUCTION	RATIO OF CLEANED COAL TO TOTAL PRODUCTION	CLEANED COAL	RATIO OF WASTE TO CLEANED COAL	WASTE
1974	2,375	0.38	900	0.30	270
1975	2,872	0.21	601	0.30	180
1975	3,635	0.25	900	0.30	270
1977	5,345	0.34	1,800	0.30	540
1978	5,000	0.36	1,800	0.30	540
1980	7,282	0.52	3,786	0.30	1,135
1985	9,700	0.64	6,208	0.30	1,862
1990	12,000	0.72	8,640	0.30	2,592
1995	15,300	0.78	11,934	0.30	3,580
2000	20,000	0.85	17,000	0.30	5,100

Estimated quantity of coal mine waste likely
to be produced during 1974 through 2000

55,847,000

Note: Quantities are listed in thousand short tons.

TABLE 2.14

ESTIMATES OF COAL MINE WASTE PRODUCTION
IN KANSAS: 1974 - 2000

YEAR	PRODUCTION	RATIO OF CLEANED COAL TO TOTAL PRODUCTION	CLEANED COAL	RATIO OF WASTE TO CLEANED COAL	WASTE
1974	679	0.75	509	0.30	153
1975	479	0.98	471	0.30	141
1976	590	0.75	442	0.30	133
1977	630	0.75	472	0.30	142
1978	1,405	0.68	950	0.30	285
1980	3,378	0.85	2,870	0.30	860
1985	4,500	0.89	4,005	0.30	1,201
1990	5,800	0.92	5,336	0.30	1,600
1995	7,300	0.94	6,862	0.30	2,058
2000	9,800	0.96	9,408	0.30	2,822

Estimated quantity of coal mine waste likely
to be produced during 1980 through 2000

33,499,000

Ncte: Quantities are listed in thousand short tons.

TABLE 2.15

ESTIMATES OF COAL MINE WASTE PRODUCTION
IN IOWA: 1974 - 2000

YEAR	PRODUCTION	RATIO OF CLEANED COAL TO TOTAL PRODUCTION	CLEANED COAL	RATIO OF WASTE TO CLEANED COAL	WASTE
1974	590	-	-	-	-
1975	622	-	-	-	-
1976	616	-	-	-	-
1977	525	-	-	-	-
1978	520	-	-	-	-
1980	2,000	-	-	-	-
1985	5,000	0.60	3,000	0.30	900
1990	6,400	0.70	4,480	0.30	1,344
1995	8,200	0.77	6,314	0.30	1,894
2000	10,800	0.83	8,964	0.30	2,689
Estimated quantity of coal mine waste likely to be produced during 1980 through 2000					25,162,000

Note: Quantities are listed in thousand short tons.

TABLE 2.16

ESTIMATES OF COAL MINE WASTE PRODUCTION
IN ARKANSAS: 1974 - 2000

YEAR	PRODUCTION	RATIO OF CLEANED COAL TO TOTAL PRODUCTION	CLEANED COAL	RATIO OF WASTE TO CLEANED COAL	WASTE
1974	455	0.55	250	0.30	75
1975	488	0.43	211	0.30	63
1976	534	0.47	250	0.30	75
1977	570	0.44	250	0.30	75
1978	319	0.49	156	0.30	47
1980	1,500	0.80	1,200	0.30	360
1985	3,000	0.90	2,700	0.30	810
1990	3,800	0.92	3,496	0.30	1,048
1995	5,000	0.94	4,700	0.30	1,410
2000	6,500	0.95	6,175	0.30	1,852

Estimated quantity of coal mine waste likely
to be produced during 1980 through 2000

21,870,000

Note: Quantities are listed in thousand short tons.

TABLE 2.17

Sheet 1 of 3

ESTIMATED EXISTING QUANTITY OF COAL MINE WASTE
AT SIGNIFICANT ABANDONED DISPOSAL SITES IN WESTERN KENTUCKY - 1978

COUNTY	NAME OF OPERATOR AND MINE	LOCATION REFERENCE	OPENING AND CLOSING DATES	COAL SEAM MINED	TYPE OF MINE	PREPARATION PLANT	CUMULATIVE COAL PRODUCTION	ESTIMATED TOTAL QUANTITY OF REFUSE AT ABANDONED SITES
Hopkins	Norton Coal Co.	87°26'06"E 37°11'51"N	NA	NA	NA	yes	NA	45,800
Hopkins	Valley Mining Co.	87°28'08"E 37°31'17"N	NA	NA	NA	yes	NA	1,184,000
Hopkins	Valley Mining Co.	87°38'08"E 37°31'17"N	NA	NA	NA	yes	NA	319,200
Hopkins	Unknown	87°40'03"E 37°10'05"N	NA	NA	NA	no	NA	94,400
Hopkins	Rex. Slaton	87°35'26"E 37°18'29"N	NA	NA	NA	yes	NA	768,500
56 Hopkins	Unknown	87°33'05"E 37°10'28"N	NA	NA	NA	yes	NA	1,532,500
Hopkins	Island Creek Coal Co.	87°33'31"E 37°18'30"N	NA	NA	NA	yes	NA	1,364,300
Hopkins	Island Creek Coal Co.	87°33'17"E 37°19'01"N	NA	NA	NA	yes	NA	1,973,000
Hopkins	Island Creek Coal Co.	87°31'45"E 37°17'26"N	NA	NA	NA	yes	NA	747,600
Hopkins	Island Creek Coal Co.	87°30'00"E 37°08'40"N	NA	NA	NA	yes	NA	317,100
Hopkins	Island Creek Coal Co.	87°30'10"E 37°09'00"N	NA	NA	NA	yes	NA	744,000
Hopkins	Island Creek Coal Co.	87°30'00"E 37°09'00"N	NA	NA	NA	yes	NA	1,452,500
Hopkins	Island Creek Coal Co.	87°27'00"E 37°19'00"N	NA	NA	NA	yes	NA	446,700

Note: Quantities are listed in short tons.

TABLE 2.17 (continued)

Sheet 2 of 3

COUNTY	NAME OF OPERATOR AND MINE	LOCATION REFERENCE	OPENING AND CLOSING DATES	COAL SEAM MINED	TYPE OF MINE	PREPARATION PLANT	CUMULATIVE COAL PRODUCTION	ESTIMATED TOTAL QUANTITY OF REFUSE AT ABANDONED SITES
Hopkins	Island Creek Coal Co.	87°27'00"E 37°18'50"N	NA	NA	NA	yes	NA	1,634,000
Hopkins	Island Creek Coal Co.	87°27'00"E 37°18'50"N	NA	NA	NA	yes	NA	107,100
Hopkins	Island Creek Coal Co.	87°27'00"E 37°18'50"N	NA	NA	NA	yes	NA	817,000
Hopkins	Island Creek Coal Co.	87°27'00"E 37°18'40"N	NA	NA	NA	yes	NA	4,165,800
Hopkins	Unknown	87°36'55"E 37°12'30"N	NA	NA	NA	yes	NA	632,300
Muhlenberg	Peabody Coal Co.	87°02'44"E 37°17'40"N	NA	NA	NA	yes	NA	NA
Ohio	Peabody Coal Co.	86°58'16"E 37°20'00"N	NA	NA	NA	yes	NA	NA
Ohio	Peabody Coal Co.	Do	NA	NA	NA	yes	NA	NA
Muhlenberg	Peabody Coal Co.	87°14'19"E 37°15'18"N	NA	NA	NA	yes	NA	NA
Muhlenberg	Peabody Coal Co.	Do	NA	NA	NA	yes	NA	NA
Hopkins	Peabody Coal Co.	87°31'39"E 37°12'46"N	NA	NA	NA	yes	NA	NA
Hopkins	Peabody Coal Co.	87°31'39"E 37°12'46"N	NA	NA	NA	yes	NA	NA
Hopkins	Peabody Coal Co.	87°31'39"E 37°12'46"N	NA	NA	NA	yes	NA	NA
Hopkins	Peabody Coal Co.	87°25'09"E 37°14'45"N	NA	NA	NA	yes	NA	NA
Hopkins	Peabody Coal Co.	87°25'00"E 37°14'00"N	NA	NA	NA	yes	NA	NA

TABLE 2.17 (continued)

Sheet 3 of 3

COUNTY	NAME OF OPERATOR AND MINE	LOCATION REFERENCE	OPENING AND CLCSING DATES	COAL SEAM MINED	TYPE OF MINE	PREPARATION PLANT	CUMULATIVE COAL PRODUCTION	ESTIMATED TOTAL QUANTITY OF REFUSE AT ABANDONED SITES
Hopkins	Peabody Coal Co.	87°25'09"E 37°14'45"N	NA	NA	NA	yes	NA	NA
Hopkins	Peabody Coal Co.	87°25'00"E 37°14'00"N	NA	NA	NA	yes	NA	NA
Muhlenberg	Peabody Coal Co.	87°03'14"E 37°12'41"N	NA	NA	NA	yes	NA	NA
Muhlenberg	Peabody Coal Co.	87°02'12"E 37°12'41"N	NA	NA	NA	yes	NA	NA
Hart	Peabody Coal Co.	86°02'12"E 37°20'57"N	NA	NA	NA	yes	NA	NA
Ohio	Peabody Coal Co.	86°59'39"E 37°26'40"N	NA	NA	NA	yes	NA	NA
Muhlenberg	Peabody Coal Co.	87°12'47"E 37°13'42"N	NA	NA	NA	yes	NA	NA
Muhlenberg	Peabody Coal Co.	87°12'47"E 37°13'42"N	NA	NA	NA	yes	NA	NA

TABLE 2.18

Sheet 1 of 2

ESTIMATED CUMULATIVE QUANTITY OF COAL MINE WASTE
IN ACTIVE DISPOSAL SITES IN WESTERN KENTUCKY - 1978

NAME OF OPERATOR AND MINE	TYPE OR MAKE OF PREPARATION PLANT	YEAR MINE OPENED	TYPE OF MINE	COAL SEAM MINED	TOTAL QUANTITY OF COAL PRODUCED SINCE MINE OPENED	ESTIMATED TOTAL QUANTITY OF REFUSE IN ACTIVE DISPOSAL AREAS
Cimmaron Coal Corp., Volunteer	cyclones, centrifuges 6,500	NA	strip	9, 11, 12, 14	NA	NA
Gibraltar Coal Corp., Gibraltar	jigs, dryers 12,000	NA	strip	11, 12	NA	NA
Green Coal Co., Mine #K-9	tables 2,000	NA	strip	9	NA	NA
Island Creek Coal Co., Fies	jigs, centrifuges 7,000	NA	shaft and slope	11	NA	NA
Island Creek Coal Co., #9	cyclones, centrifuges 58,000	NA	shaft and slope	9	NA	NA
Island Creek Coal Co., Crescent	jigs, centrifuges 5,000	NA	shaft and slope	NA	NA	NA
Island Creek Coal Co., Hamilton #1	heavy media washers, cyclones, centrifuges 9,200	NA	slope	9	NA	NA
Island Creek Coal Co., Hamilton #2	heavy media washers, cyclones, centrifuges 8,400	NA	slope	9	NA	NA
Island Creek Coal Co., Ohio #11	heavy media washers, centrifuges, dryers 4,200	NA	shaft and slope	11	NA	NA
Island Creek Coal Co., Providence #1	heavy media washers, cyclones, centrifuges 6,500	NA	drift	9	NA	NA

*Coal mined at other locations.

TABLE 2.18 (continued)

Sheet 2 of 2

NAME OF OPERATOR AND MINE	TYPE OR MAKE OF PREPARATION PLANT	YEAR MINE OPENED	TYPE OF MINE	COAL SEAM MINED	TOTAL QUANTITY OF COAL PRODUCED SINCE MINE OPENED	ESTIMATED TOTAL QUANTITY OF REFUSE IN ACTIVE DISPOSAL AREAS
Peabody Coal Co., River Queen	McNally-Pittsburgh Mfg. Corp. 4,900	NA	strip	11, 12, 9	NA	NA
Peabody Coal Co., Homestead	McNally-Pittsburgh Mfg. Corp. 8,500	NA	strip	11, 13, 9	NA	NA
Peabody Coal Co., Ken	heavy media washers, dryers 10,000	NA	strip	9	NA	NA
Peabody Coal Co., Riverview	jigs, dryers 3,500	NA	strip	9, 14	NA	NA
Pittsburgh & Midway Coal Mining Co., Colonial	jigs, cyclones, dryers 10,000	NA	strip	9	NA	NA
Pittsburgh & Midway Coal Mining Co., Pleasant Hill	under construction, McNally-Pittsburgh	NA	strip	NA	NA	NA
Pittsburgh & Midway Coal Mining Co., Paradise	jigs 7,000	NA	strip	9	NA	NA
Rocky Hill Coal Co., Inc., Rocky Hill Prep. Plant	under development	NA	*	NA	NA	NA
Valley Mining Co., Inc., Diamond	NA	1976	strip	9, 11, 13, 14	NA	NA
Valley Mining Co., Inc., Nortonville	NA	1976	drift	9, 11, 13, 14	NA	NA
Webster County Coal Corp., Dotiki	under construction	NA	slope	9	NA	NA

TABLE 2.19

ESTIMATES OF COAL MINE WASTE PRODUCTION
IN WESTERN KENTUCKY: 1974 - 2000

YEAR	PRODUCTION	RATIO OF CLEANED COAL TO TOTAL PRODUCTION	CLEANED COAL	RATIO OF WASTE TO CLEANED COAL	WASTE
1974	51,790	0.35	18,126	0.30	5,438
1975	56,400	0.35	19,814	0.30	5,938
(Mineral Year Book)					
1976	53,557	0.35	18,745	0.30	5,623
1977	51,593	0.35	18,057	0.30	5,417
1978	39,818	0.35	13,936	0.30	4,181
1980	52,560	0.35	18,400	0.30	5,520
1985	63,700	0.50	31,850	0.30	9,555
1990	82,000	0.62	50,840	0.30	15,250
1995	110,000	0.73	81,030	0.30	24,309
2000	144,400	0.80	115,520	0.30	34,656

Estimated quantity of coal mine waste likely
to be produced during 1980 through 2000

346,008,000

Note: Quantities are listed in thousand short tons.

TABLE 2.20

ESTIMATES OF MINE WASTE PRODUCTION
IN MIDWESTERN REGION: 1974 - 2000

STATE	YEAR									
	1974	1975	1976	1977	1978	1980	1985	1990	1995	2000
Illinois	13,539	14,872	13,603	12,608	11,910	13,117	23,916	31,500	41,850	55,475
Western Kentucky	5,438	5,938	5,623	5,417	4,181	5,520	9,555	15,250	24,309	34,656
Indiana	5,079	5,585	5,203	6,069	5,346	6,213	11,486	15,322	20,384	27,105
Missouri	375	457	492	537	459	1,185	1,760	2,520	3,626	5,100
Oklahoma	270	180	270	270	540	1,135	1,862	2,592	3,580	5,100
Kansas	153	141	133	142	285	860	1,201	1,600	2,058	2,822
Iowa	—	—	—	—	—	—	900	1,344	1,894	2,689
Arkansas	75	63	75	75	47	360	810	1,048	1,410	1,852
Total Midwest	24,979	27,236	25,399	25,118	22,768	28,390	51,940	71,176	99,111	134,799

Note: Quantities are listed in thousand short tons.

FIGURE 2.1
CHANGE IN NATIONAL
COAL PRODUCTION, 1947-1995

REFERENCE:

ENERGY INFORMATION ADMINISTRATION, 1979

FIGURE 2.2
 COAL'S CHANGING SHARE
 OF U.S. ENERGY
 CONSUMPTION, 1900-1955

REFERENCE:

ENERGY INFORMATION ADMINISTRATION, 1979

FIGURE 2.3

COAL'S CHANGING REGIONAL
PRODUCTION SHARES, 1947-1995

REFERENCE:

ENERGY INFORMATION ADMINISTRATION, 1979

DAMES & MOORE

FIGURE 2.4
TRENDS IN CHANGE
OF PERCENTAGE OF
MECHANICALLY CLEANED
COAL AND REJECT

REFERENCE:

66

NATIONAL ACADEMY OF SCIENCES, 1975

DAMES & MOORE

FIGURE 2.5
TOTAL PRODUCTION
OF REFUSE PER YEAR

REFERENCE:

NATIONAL ACADEMY OF SCIENCES, 1975

FIGURE 2.6
COAL PRODUCTION
BY UNDERGROUND AND SURFACE
MINES IN ILLINOIS FROM 1830 TO
1978 (AFTER CARTER ET AL. 1974)

10805-031-07

FIGURE 2.7
COAL PRODUCTION IN
ARKANSAS, 1880-1977
PRODUCTION SHOWN
BY UNDERGROUND AND
SURFACE METHODS

REFERENCE:

ARKANSAS GEOLOGICAL SURVEY, 1978

EXPLANATION :

- OTHER STATES (MISSOURI, OKLAHOMA, KANSAS, IOWA, AND ARKANSAS)
- INDIANA
- WEST KENTUCKY
- ILLINOIS

FIGURE 2.8

COAL MINE WASTE PRODUCTION PROJECTIONS FOR
VARIOUS STATES OF MIDWESTERN REGION

3. EXISTING INFORMATION ON PROPERTIES OF COAL WASTES

Available information on the physical and chemical properties of coal waste including analyses of general runoff was obtained from various state and federal agencies in the midwestern coal fields and publications. The information has been tabulated and is given in Table 3.1.

The information on properties of coal mine waste in Arkansas, Indiana, Iowa, Kansas, Missouri, Oklahoma and western Kentucky is scanty or nonexistent. However, sufficient information on a few chemical properties and drainage runoff analyses are available for refuse disposal areas in Illinois. These chemical properties were determined mainly to assess the pollution contributed by the coal mine refuse at different locations. However, the information available on physical, engineering, and other chemical properties was meager.

Illinois

The Cooperative Institute for Environmental Quality collected and analyzed 500 samples of water and sludge from 245 abandoned underground coal mine refuse disposal sites in Illinois (Nawrot, et al., 1977). Earlier analysis results of drainage runoff for eight disposal areas in Illinois were reported (Martin, 1974). Table 3.1 includes a selection of results of analyses of their samples collected from relatively larger disposal areas. The objective of these analyses was to determine as to what extent the unreclaimed coal refuse disposal areas are responsible for pollution of the environment.

Freshly deposited coal refuse generally has a near neutral pH; however, weathering and breakdown of the nonpyritic material results in reduced pH levels. Oxidation of pyritic materials which are usually present in coal refuse accelerates and further lowers the pH through leaching of sulfuric acid produced by chemical reaction and atmospheric iron-oxidizing bacteria (Doubleday and Jone, 1977; Silverman and Ehrlich, 1964).

Table 3.2 gives statistical data for 21 samples collected from abandoned slurry ponds. These samples are characterized by low pH, high total acidity, conductivity, and soluble aluminum content.

Table 3.3 gives statistical data for general runoff, unburned, burned, and slurry refuse samples' analyses results. General runoff samples have very low pH and high sulfate, acidity, conductivity, and soluble aluminum values. About fifty percent of the locations had a pH of less than 3 which was responsible for leaching of large concentrations of metallic

ions into on-site waters and adjacent streams. The analyses results indicate the toxicity of drainage from abandoned refuse areas. Unburned sludge also had low acidity and high sulfate, aluminum, and other metallic ion contents. Burned refuse had the lowest acidity and low aluminum, iron, manganese, and sulfate contents. These results indicate that completely burned refuse causes less pollution than unburned refuse. However, burning coal refuse can release significant amounts of CO, SO₂, H₂S, nitrogen oxides, hydrocarbons and particulates into the atmosphere, which can be harmful to the health of nearby residents and environment (Sussman and Mueller, 1964; Hoffman, 1970).

Slurry samples also have low mean acidity, sulfate, aluminum, iron, and manganese levels. It is mainly because of limited air contact with the refuse material.

Physical and Engineering Properties

According to Section 77.215(h) of 30 CFR all new refuse piles are required to be constructed in compacted lifts not exceeding 2 feet in thickness and slopes not exceeding 2 horizontal to 1 vertical (27°). However, these provisions can be relaxed by the MSHA District Manager provided supporting engineering data ensures a minimum safety factor of 1.5 for the refuse pile. It implies that stability analysis is called for only if the operator wants to construct the pile on layers thicker than 2 feet or if he wants to provide slopes steeper than 27°.

Inquiries from MSHA offices at Vincennes, Indiana and Madisonville, western Kentucky revealed that no operator had asked for exemptions under Section 77.215(h) of 30 CFR.

Section 77.216 of 30 CFR requires preparation and approval of plans for the design, construction, and maintenance of structures which impound water, sediment or slurry, if the impounding structure is required to:

1. Impound water, sediment, or slurry to an elevation of 5 feet or more above the upstream toe of the structure and can have a storage volume of 20 acre-feet or more; or
2. Impound water, sediment, or slurry to an elevation of 20 feet or more above the upstream toe of the structure; or
3. As determined by the MSHA District Manager, presents a hazard to coal miners.

The pile type disposal structures predominated in the generally level topography of the Midwestern coal fields in the past. However, most of the currently active disposal structures are of diked or incised impoundment type. Consequently, the mine operators are generally required to submit plans for the design of impounding structures pursuant to Section 77.216 of 30 CFR. Some of the operators had included stability analyses for the impounding structures in their plans submitted to the MSHA District Manager. The information on engineering properties determined by these operators for carrying out the stability analyses was collected from the open files of the MSHA office at Vincennes, Indiana, and is included in Table 3.1. This information was available for only seven active disposal areas in Illinois.

Inquiries made from several large mining companies revealed that they had generally not developed any information on physical or engineering properties of coal refuse. However, they did have information on proximate analysis of coal refuse.

Indiana

Published information on properties of coal refuse in Indiana was very limited. Generally, no information was available on physical and engineering properties. The only documented information was on effluent drainage analyses (Martin, 1974), which is included in Table 3.1. The Indiana Geological Survey has collected information on proximate analysis and calorific value of coal refuse from some of the mine operators. This information was not made available as it was of propriety nature. Secondary recovery of coal from the abandoned slurry ponds was in progress at a few locations.

Western Kentucky

Excepting effluent analyses results from two coal waste disposal areas (Martin, 1974), no other published information was available on physical, chemical, or engineering properties of coal refuse. The available analyses results are included in Table 3.1. Information on calorific value and proximate analyses for the current disposal areas was generally available with the mine operators.

Other Midwestern States

No information was available on properties of coal mine waste in Missouri, Oklahoma, Kansas, Arkansas, and Iowa states.

The available information on properties is not sufficient to identify trends in waste characteristics. Determination of this trend and data analysis to find out the effects of geology or processing method will be carried out after obtaining results of analyses of refuse samples in Phase II.

TABLE 3.1

Set 1, Sheet 1 of 4

PHYSICAL, ENGINEERING, AND OTHER PROPERTIES OF COAL MINE WASTE
IN MIDWESTERN COAL FIELDS, INCLUDING ANALYSES OF EFFLUENT SAMPLES

MINE IDENTIFICATION NUMBER	PARTICLE SIZE PERCENTAGE (Minus 200, 200 to No. 4, No. 4 to 6 inch)	PARTICLE HARDNESS	PERMEABILITY	MOISTURE AND DENSITY (IN-SITU)	MOISTURE AND DENSITY (COMPACTED)	SPECIFIC GRAVITY	ATTERBERG LIMITS	SHEAR STRENGTH		COMPRESSIBILITY
								ϕ	COHESION	
1	2	3	4	5	6	7	8	9	10	11
10060002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10060003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10060004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10060005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10062001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10063006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10060007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10060001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10110002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10112007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10110003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10142003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10230013	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10282014	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10280007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10282024	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10282004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10282012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10282020	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 1, Sheet 2 of 4

MINE IDENTIFICATION NUMBER	ABRASION	SHRINK AND SWELL EXPANSION POTENTIAL	LITHOLOGY AND MINERAL CONTENT (X-RAY DIFF)	HEAVY METAL CONTENT (ATOMIC ABSORPTION SPECTRUM)	SLAKE DURABILITY	ASH CONTENT	CARBON CONTENT	CALORIFIC VALUE (Btu)	SULFUR	pH	TOXICITY
	12	13	14	15	16	17	18	19	20	21	22
10060002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10060003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10060004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10060005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10062001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10060006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10060007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10060001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10110002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10112007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10110003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10142003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10230013	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10282014	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10280007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10282024	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10282004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10282012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10282020	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 1, Sheet 3 of 4

MINE IDENTIFICATION NUMBER	CONDUCTIVITY (Micromhos/cm)	TIT. ACIDITY (meq H ⁺ /100g)	POT. ACIDITY (meq H ⁺ /100g)	Al (ppm)	Fe (ppm)	Mn (ppm)	SO ₄ ⁻² (ppm)	BURNED OR UNBURNED	RECLAIMED OR UNRECLAIMED
1	23	24	25	26	27	28	29	30	31
10060002	82,000 760	40.0 0.1	85 7	710.0 8.9	3,800.0 0.3	86.0 1.8	22,000 750	Unburned Burned	Unreclaimed Unreclaimed
10060003	3,200 1,500	4.1 0.3	25 16	250.0 14.0	1.8 0.2	37.0 1.1	5,300 2,100	Unburned Burned	Unreclaimed Unreclaimed
10060004	4,200 210	4.3 0.1	71 9	160.0 3.0	67.0 0.4	2.2 1.2	5,700 160	Unburned Burned	Unreclaimed Unreclaimed
10060005	6,100	15.0	15	1,200.0	36.0	137.0	13,900	Unburned	Unreclaimed
10062001	2,700 100	1.2 0.1	24 8	76.0 0.9	0.7 0.1	25.0 0.8	4,100 62	Unburned Burned	Unreclaimed Unreclaimed
10060006	300 77	0.1 Tr	0 7	1.1 1.0	0.2 0.3	1.4 0.5	240 74	Unburned Burned	Unreclaimed Unreclaimed
10060007	140	0.1	8	1.6	0.7	0.8	100	Burned	Unreclaimed
10060001	100	0.1	7	11.0	0.4	0.8	61	Burned	Unreclaimed
10110002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10112007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10110003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10142003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10230013	2,800 1,420	1.5 0.7	100 127	53.0 12.0	9.6 1.6	3.3 0.6	3,600 1,400	Unburned Burned	Unreclaimed Unreclaimed
10282014	3,400 1,040	2.7 0.7	144 23	24.0 26.0	170.0 0.9	2.1 7.6	4,900 1,100	Slurry Unburned	Unreclaimed Unreclaimed
10280007	2,800 2,300	1.1 0.4	72 43	28.0 16.0	7.6 0.6	0.4 0.8	3,600 3,200	Unburned Burned	Unreclaimed Unreclaimed
10282024	13,100 4,400	104.0 7.8	127 94	2,600.0 370.0	12,200.0 220.0	18.0 10.0	53,000 6,100	Unburned Slurry	Unreclaimed Unreclaimed
10282004	4,000 2,600	4.9 1.0	45 101	270.0 20.0	19.0 9.8	0.8 3.0	5,200 3,900	Unburned Slurry	Unreclaimed Unreclaimed
10282012	2,500 2,800	0.6 0.9	178 151	10.0 11.0	4.2 13.0	5.6 1.2	3,500 3,900	Unburned Slurry	Unreclaimed Unreclaimed
10282020	160 2,300 3,300	0.1 0.3 2.3	104 7 109	0.2 8.1 81.0	0.3 0.6 44.0	0.4 0.5 3.6	100 3,300 4,400	Unburned Burned Slurry	Unreclaimed Unreclaimed Unreclaimed

TABLE 3.1 (continued)

Set 1, Sheet 4 of 4

MINE IDENTIFICATION NUMBER	G E N E R A L R U N C O E F F								REMARKS
	pH	CONDUCTIVITY (Micromhos/cm)	TOTAL ACIDITY (mg/l as CaCO ₃)	SOL. Al (mg/l)	TOTAL Fe (mg/l)	TOTAL Mn (mg/l)	TOTAL SUSPENDED SOLIDS	SO ₄ ⁻² (mg/l)	
1	33	34	35	36	37	38	39	40	41
10060002	3.5	7,000	480	50.0	23.0	42.0	N/A	10,300	
10060003	3.5	5,200	1,200	150.0	1.4	41.0	N/A	3,000	
10060004	7.1	1,500	28	0.1	0.9	1.2	N/A	720	
10060005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10062001	3.8	2,700	415	62.0	0.9	17.0	N/A	2,600	
10060006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10060007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10060001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10110002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10112007	3.5	25,000	960	120.0	2,400.0	0.0	N/A	2,900	
10110003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10142003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10230013	3.0	3,000	335	37.0	47.0	3.4	N/A	830	
10282014	2.1	9,900	18,100	1,000.0	170.0	40.0	N/A	4,600	
10280007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10282024	1.9	11,500	17,100	1,000.0	270.0	48.0	N/A	16,000	
10282004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10282012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10282020	2.5	8,000	5,100	360.0	780.0	32.0	N/A	4,900	

TABLE 3.1

Set 2, Sheet 1 of 4

PHYSICAL, ENGINEERING, AND OTHER PROPERTIES OF COAL MINE WASTE
IN MIDWESTERN COAL FIELDS, INCLUDING ANALYSES OF EFFLUENT SAMPLES

MINE IDENTIFICATION NUMBER	PARTICLE SIZE PERCENTAGE (Minus 200, No. 4 to 6 inch)	PARTICLE HARDNESS	PERMEABILITY	MOISTURE AND DENSITY (IN-SITU)	MOISTURE AND DENSITY (COMPACTED)	SPECIFIC GRAVITY	ATTERBERG LIMITS	SHEAR STRENGTH		COMPRESSIBILITY
								ϕ	COHESION	
1	2	3	4	5	6	7	8	9	10	11
10292010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10290093	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10290151	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320114	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320115	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10321003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320109	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320089	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320096	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320097	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320098	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320100	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320099	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320102	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320074	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10372002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10371034	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 2, Sheet 2 of 4

MINE IDENTIFICATION NUMBER	ABRASION	SHRINK AND SWELL EXPANSION POTENTIAL	LITHOLOGY AND MINERAL CONTENT (X-RAY DIFF)	HEAVY METAL CONTENT (ATOMIC ABSORPTION SPECTRUM)	SLAKE DURABILITY	ASH CONTENT	CARBON CONTENT	CALORIFIC VALUE (Btu)	SULFUR	pH	TOXICITY
1	12	13	14	15	16	17	18	19	20	21	22
10292010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10290093	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10290151	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320114	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320115	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10321003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320109	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320089	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320096	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320097	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320098	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320100	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320099	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320102	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10320074	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10372002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10371034	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 2, Sheet 3 of 4

MINE IDENTIFICATION NUMBER	CONDUCTIVITY (Microhm/cm)	TIT. ACIDITY (meq H ⁺ /100g)	POT. ACIDITY (meq H ⁺ /100g)	Al (ppm)	Fe (ppm)	Mn (ppm)	SO ₄ ⁻² (ppm)	BURNED OR UNBURNED	RECLAIMED OR UNRECLAIMED
1	23	24	25	26	27	28	29	30	31
10292010	24,000	99.0	258.0	1,200.0	15,900.0	12.0	55,000	Unburned	Unreclaimed
10290093	2,400	0.1	104.0	4.1	0.8	15.0	3,400	Unburned	Unreclaimed
10290151	2,500	Tr	39.0	1.0	0.6	1.3	3,500	Unburned	Unreclaimed
10320114	560	0.2	29.0	5.7	0.3	0.2	530	Unburned	Unreclaimed
	500	Tr	8.0	3.2	Tr	0.5	440	Burned	Unreclaimed
10320115	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10321003	2,600	1.0	16.0	60.0	0.8	12.0	3,800	Unburned	Unreclaimed
	120	Tr	1.3	1.3	0.1	0.1	130	Burned	Unreclaimed
	3,400	1.6	114.0	1.5	41.0	0.5	3,600	Slurry	Unreclaimed
10320109	6,400	19.0	153.0	2,200.0	1,402.0	1.2	9,500	Unburned	Unreclaimed
	5,100	22.0	0.0	96.0	4.3	1.6	13,000	Burned	Unreclaimed
10320089	5,000	12.0	48.0	95.0	90.0	36.0	8,300	Unburned	Unreclaimed
	2,600	1.5	28.0	430.0	0.6	1.7	4,300	Burned	Unreclaimed
10320096	2,400	1.7	13.0	0.2	2.1	35.0	3,500	Unburned	Unreclaimed
	0	Tr	4.0	1.7	Tr	0.2	43	Burned	Unreclaimed
10320097	550	0.1	7.0	370.0	0.1	3.4	480	Unburned	Unreclaimed
	4,100	6.7	37.0	210.0	8.6	101.0	7,700	Burned	Unreclaimed
10320098	2,000	1.7	20.0	92.0	0.9	38.0	2,700	Unburned	Unreclaimed
	1,850	1.1	21.0	0.1	0.8	32.0	2,300	Unburned	Unreclaimed
10320100	1,740	Tr	0.0	54.0	Tr	3.3	2,400	Burned	Unreclaimed
10320099	4,100	4.5	67.0	12.0	22.0	0.1	4,800	Unburned	Unreclaimed
	2,600	0.7	39.0	64.0	0.6	2.0	3,600	Burned	Unreclaimed
	3,000	1.4	92.0	59.0	8.2	2.5	4,000	Slurry	Unreclaimed
10320102	150	0.1	34.0	48.0	0.1	0.3	110	Unburned	Unreclaimed
	2,700	0.8	17.0	0.2	0.2	20.0	3,700	Burned	Unreclaimed
10320074	1,300	0.4	54.0	14.0	0.3	20.0	1,600	Unburned	Unreclaimed
	1,340	0.1	6.0	0.8	0.1	3.5	1,700	Burned	Unreclaimed
10372002	2,700	1.6	12.0	120.0	1.1	1.3	4,000	Unburned	Unreclaimed
10371034	3,400	2.3	344.0	63.0	33.0	0.1	4,200	Unburned	Unreclaimed

TABLE 3.1 (continued)

Set 2, Sheet 4 of 4

MINE IDENTIFICATION NUMBER	G E N E R A L R U N O F F								REMARKS
	PH	CONDUCTIVITY (Microhm/cm)	TOTAL ACIDITY (mg/l as CaCO ₃)	SOL. Al (mg/l)	TOTAL Fe (mg/l)	TOTAL Mn (mg/l)	TOTAL SUSPENDED SOLIDS	SO ₄ ⁻² (mg/l)	
1	33	34	35	36	37	38	39	40	41
10292010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10290093	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10290151	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10320114	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10320115	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10321003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10320109	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10320089	3.4	1,480	80	6.5	74	0.1	N/A	800	
10320096	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10320097	4.4	690	30	1.5	58	2.0	N/A	350	
10320098	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10320100	3.7	500	26	4.8	620	0	N/A	170	
10320099	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10320102	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10320074	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10372002	3.2	1,510	170	14	7.4	2.3	N/A	700	
10371034	3.0	3,000	840	180	150.0	12.0	N/A	2,100	

TABLE 3.1

Set 3, Sheet 1 of 4

PHYSICAL, ENGINEERING, AND OTHER PROPERTIES OF COAL MINE WASTE
IN MIDWESTERN COAL FIELDS, INCLUDING ANALYSES OF EFFLUENT SAMPLES

MINE IDENTIFICATION NUMBER	FARTICLE SIZE PERCENTAGE (Minus 200, 200 to No. 4, No. 4 to 6 inch)	PARTICLE HARDNESS	PERMEABILITY	MOISTURE AND DENSITY (IN-SITU)	MOISTURE AND DENSITY (COMPACTED)	SPECIFIC GRAVITY	ATTERBERG LIMITS	SHEAR STRENGTH		COMPRESSIBILITY
								ϕ	COHESION	
1	2	3	4	5	6	7	8	9	10	11
10392002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10391028	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10390004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10390009	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10481020	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500151	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500086	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500085	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500103	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500102	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500104	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500068	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500070	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500069	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500072	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500076	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500074	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500060	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 3, Sheet 2 of 4

MINE IDENTIFICATION NUMBER	ABRASION	SHRINK AND SWELL EXPANSION POTENTIAL	LITHOLOGY AND MINERAL CONTENT (X-RAY DIFF)	HEAVY METAL CONTENT (ATOMIC ABSORPTION SPECTRUM)	SLAKE DURABILITY	ASH CONTENT	CARBON CONTENT	CALORIFIC VALUE (Btu)	SULFUR	pH	TOXICITY
1	12	13	14	15	16	17	18	19	20	21	22
10392002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10391028	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10390004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10390005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1048102C	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500151	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1050C086	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1050C085	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500103	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500102	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500104	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500068	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500070	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500069	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500072	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500076	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500074	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500060	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 3, Sheet 3 of 4

MINE IDENTIFICATION NUMBER	CONDUCTIVITY (Micromhos/cm)	TIT. ACIDITY (meq H ⁺ /100g)	POT. ACIDITY (meq H ⁺ /100g)	Al (ppm)	Fe (ppm)	Mn (ppm)	SO ₄ ⁻² (ppm)	BURNED OR UNBURNED	RECLAIMED OR UNRECLAIMED
1	23	24	25	26	27	28	29	30	31
10392002	2,700	0.7	98	170.0	11.0	1.8	3,800	Unburned	Unreclaimed
	230	0.1	31	1.7	0.1	0.0	180	Burned	Unreclaimed
	3,000	2.7	138	160.0	1.7	49.0	4,600	Slurry	Unreclaimed
10391028	1,510	1.0	96	61.0	6.4	9.8	2,100	Unburned	Unreclaimed
	2,400	0.8	19	46.0	0.4	1.1	3,600	Burned	Unreclaimed
	2,600	2.8	175	18.0	3.9	0.0	3,500	Slurry	Unreclaimed
10390004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10390009	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10481020	3,000	1.1	155	3.9	11.0	0.0	3,700	Unburned	Unreclaimed
	250	0.1	6	0.2	0.8	0.0	230	Burned	Unreclaimed
10500151	3,000	2.6	27	150.0	0.8	58.0	4,700	Unburned	Unreclaimed
	650	0.1	12	1.2	Tr	0.5	680	Burned	Unreclaimed
10500086	9,400	47.0	180	1,600.0	3,900.0	12.0	22,000	Unburned	Unreclaimed
	140	0.1	13	0.2	0.1	0.1	100	Burned	Unreclaimed
10500085	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10500103	500	0.1	20	1.2	Tr	0.9	450	Burned	Unreclaimed
10500102	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10500104	1,700	1.0	27	39.0	0.2	5.2	2,300	Unburned	Unreclaimed
	1,500	0.1	14	0.8	Tr	0.2	95	Burned	Unreclaimed
10500068	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10500070	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10500069	3,900	4.7	161	270.0	30.0	7.6	5,500	Unburned	Unreclaimed
10500072	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10500076	11,900	22.0	82	3,000.0	9,500.0	12.0	38,000	Unburned	Unreclaimed
10500074	11,900	59.0	48	2,300.0	4,300.0	12.0	2,800	Unburned	Unreclaimed
10500060	2,500	1.3	4	71.0	1.3	32.0	3,200	Unburned	Unreclaimed
	650	0.1	9	0.4	0.1	3.4	660	Burned	Unreclaimed

TABLE 3.1 (continued)

Set 3, Sheet 4 of 4

MINE IDENTIFICATION NUMBER	G E N E R A L R U N O F F								REMARKS
	pH	CONDUCTIVITY (Micromhos/cm)	TOTAL ACIDITY (mg/l as CaCO ₃)	SOL. Al (mg/l)	TOTAL Fe (mg/l)	TOTAL Mn (mg/l)	TOTAL SUSPENDED SOLIDS	SO ₄ ⁻² (mg/l)	
1	33	34	35	36	37	38	39	40	41
10392002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10391028	2.4	5,900	2,800	180	120.0	29.0	N/A	4,800	
10390004	2.8	3,100	360	49	7.9	18.0	N/A	1,800	
10390009	2.1	4,200	1,700	120	170.0	9.6	N/A	2,300	
10481020	3.3	1,250	4,250	63	230.0	1.6	N/A	1,200	
10500151	3.4	7,500	3,000	10	23.0	99.0	N/A	6,200	
10500086	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500085	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500103	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500102	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500104	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500068	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500070	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500069	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500072	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500076	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500074	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500060	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

TABLE 3.1

Set 4, Sheet 1 of 4

PHYSICAL, ENGINEERING, AND OTHER PROPERTIES OF COAL MINE WASTE
IN MIDWESTERN COAL FIELDS, INCLUDING ANALYSES OF EFFLUENT SAMPLES

MINE IDENTIFICATION NUMBER	PARTICLE SIZE PERCENTAGE (Minus 200, 200 to No. 4, No. 4 to 6 inch)	PARTICLE HARDNESS	PERMEABILITY	MOISTURE AND DENSITY (IN-SITU)	MOISTURE AND DENSITY (COMPACTED)	SPECIFIC GRAVITY	ATTERBERG LIMITS	SHEAR STRENGTH		COMPRESSIBILITY
								ϕ	COHESION	
1	2	3	4	5	6	7	8	9	10	11
1C500043	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1C500048	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500050	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500051	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10502020	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10502003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500057	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13500059	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13500041	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500040	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10501008	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10530004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10530015	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10530006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10531001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10530051	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10530052	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10562007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10562002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 4, Sheet 2 of 4

MINE IDENTIFICATION NUMBER	ABRASION	SHRINK AND SWELL EXPANSION POTENTIAL	LITHOLOGY AND MINERAL CONTENT (X-RAY DIFF)	HEAVY METAL CONTENT (ATOMIC ABSORPTION SPECTRUM)	SLAKE DURABILITY	ASH CONTENT	CARBON CONTENT	CALORIFIC VALUE (Btu)	SULFUR	pH	TOXICITY
1	12	13	14	15	16	17	18	19	20	21	22
10500043	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500048	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500050	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500051	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10502020	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10502003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500057	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500059	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500041	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10500040	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10501008	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10530004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10530015	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10530006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10531001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10530051	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10530052	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10562007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10562002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 4, Sheet 3 of 4

MINE IDENTIFICATION NUMBER	CONDUCTIVITY (Microhms/cm)	TIT. ACIDITY (meq H ⁺ /100g)	POT. ACIDITY (meq H ⁺ /100g)	Al (ppm)	Fe (ppm)	Mn (ppm)	SO ₄ ⁻² (ppm)	BURNED OR UNBURNED	RECLAIMED OR UNRECLAIMED
1	23	24	25	26	27	28	29	30	31
10500043	4,000	6.5	28.0	450.0	9.9	46.0	7,600	Unburned	Unreclaimed
10500048	730	Tr	7.0	0.2	0	0.6	830	Burned	Unreclaimed
10500050	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10500051	1,770	Tr	6.0	0.3	0.2	0.4	2,300	Burned	Unreclaimed
10502020	4,100 3,100	5.6 1.7	3.7 9.0	150.0 75.0	180.0 0.2	6.3 32.0	4,400 4,900	Unburned Burned	Unreclaimed Unreclaimed
10502003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10500057	2,800 1,140	1.8 0.1	27.0 12.0	110.0 1.2	28.0 0.2	10.0 1.3	4,300 1,400	Unburned Burned	Unreclaimed Unreclaimed
10500059	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10500041	3,000 610	3.5 0.1	20.0 9.0	270.0 1.5	1.0 0.1	41.0 0.6	5,100 620	Unburned Burned	Unreclaimed Unreclaimed
10500040	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10501008	4,500	9.9	17.0	590.0	13.0	36.0	8,600	Unburned	Unreclaimed
10530004	1,010 5,000	0.3 2.3	28.0 23.0	13.0 130.0	0.2 0.8	4.7 48.0	1,100 8,900	Unburned Burned	Unreclaimed Unreclaimed
10530015	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10530006	12,800	53.0	99.0	1,100.0	6,200.0	6.4	24,000	Unburned	Unreclaimed
10531001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unburned	Unreclaimed
10530051	140 2,300	0.1 0.3	54.0 9.0	0.2 13.0	Tr 0.2	0.7 0.4	100 3,400	Burned Burned	Unreclaimed Unreclaimed
10530052	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10562007	6,800	18.3	167.0	670.0	1,100.0	3.0	9,300	Unburned	Unreclaimed
10562002	8,100	19.0	164.0	860.0	530.0	10.0	11,500	Unburned	Unreclaimed

TABLE 3.1 (continued)

Set 4, Sheet 4 of 4

MINE IDENTIFICATION NUMBER	G E N E R A L R U N O F F								REMARKS
	pH	CONDUCTIVITY (Microhos/cm)	TOTAL ACIDITY (mg/l as CaCO ₃)	SOL. Al (mg/l)	TOTAL Fe (mg/l)	TOTAL Mn (mg/l)	TOTAL SUSPENDED SOLIDS	SO ₄ ⁻² (mg/l)	
1	33	34	35	36	37	38	39	40	41
10500043	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500048	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500050	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500051	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10502020	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10502003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500057	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500059	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500041	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10500040	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10501008	3.8	1,520	245	32	3.6	5.8	N/A	960	
10530004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10530015	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10530006	2.0	10,400	13,000	790	2,900	5.7	N/A	15,200	
10531001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10530051	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10530052	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10562007	2.7	7,000	4,200	320	1,800	16.0	N/A	8,400	
10562002	2.1	11,200	13,900	890	250	14.4	N/A	15,100	

TABLE 3.1

Set 5, Sheet 1 of 4

PHYSICAL, ENGINEERING, AND OTHER PROPERTIES OF COAL MINE WASTE
IN MIDWESTERN COAL FIELDS, INCLUDING ANALYSES OF EFFLUENT SAMPLES

MINE IDENTIFICATION NUMBER	PARTICLE SIZE PERCENTAGE (minus 200, 200 to No. 4, No. 4 to 6 inch)	PARTICLE HARDNESS	PERMEABILITY	MOISTURE AND DENSITY (IN-SITU)	MOISTURE AND DENSITY (COMPACTED)	SPECIFIC GRAVITY	ATTERBERG LIMITS	SHEAR STRENGTH		COMPRESSIBILITY
								ϕ	COHESION	
1	2	3	4	5	6	7	8	9	10	11
10562009	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10560086	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10562006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10562003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10562010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10572007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10572004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10570052	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10570069	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10572006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10572003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10590002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10590009	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10590023	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10590022	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10590021	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10590020	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 5, Sheet 2 of 4

MINE IDENTIFICATION NUMBER	ABRASION	SHRINK AND SWELL EXPANSION POTENTIAL	LITHOLOGY AND MINERAL CONTENT (X-RAY DIFF)	HEAVY METAL CONTENT (ATOMIC ABSORPTION SPECTRUM)	SLAKE DURABILITY	ASH CONTENT	CARBON CONTENT	CALORIFIC VALUE (Btu)	SULFUR	pH	TOXICITY
1	12	13	14	15	16	17	18	19	20	21	22
10562009	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10560086	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10562006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10562003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10562010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10572007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10572004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10570052	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10570069	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10572006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10572003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10590002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10590009	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10590023	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10590022	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10590021	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10590020	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 5, Sheet 3 of 4

MINE IDENTIFICATION NUMBER	CONDUCTIVITY (Micromhos/cm)	TIT. ACIDITY (meq H ⁺ /100g)	POT. ACIDITY (meq H ⁺ /100g)	Al (ppm)	Fe (ppm)	Mn (ppm)	SO ₄ ⁻² (ppm)	BURNED OR UNBURNED	RECLAIMED OR UNRECLAIMED
1	23	24	25	26	27	28	29	30	31
10562009	2,600	0.8	69.0	0.7	5.8	0.5	3,400	Unburned	Unreclaimed
10560086	10,900	34.0	373.0	820.0	2,900.0	6.1	18,200	Unburned	Unreclaimed
	4,800	18.0	22.0	888.0	1,200.0	5.8	10,200	Burned	Unreclaimed
10562006	3,300	2.4	115.0	70.0	0.4	0.4	4,100	Unburned	Unreclaimed
	5,300	8.1	167.0	340.0	0.4	0.5	6,600	Burned	Unreclaimed
10562003	15,500	104.0	326.0	2,700.0	5,800.0	1.4	26,000	Unburned	Unreclaimed
	10,800	71.0	141.0	5,000.0	3,400.0	24.0	34,000	Burned	Unreclaimed
	5,400	4.6	205.0	150.0	200.0	3.9	5,200	Slurry	Unreclaimed
10562010	3,200	2.0	147.0	57.0	29.0	2.8	3,800	Unburned	Unreclaimed
10572007	10,000	60.0	146.0	2,400.0	4,200.0	15.0	29,000	Unburned	Unreclaimed
	760	0.3	17.0	19.0	1.0	2.6	760	Burned	Unreclaimed
	2,700	0.1	270.0	6.7	1.0	52.0	3,900	Slurry	Unreclaimed
10572004	350	0.3	278.0	6.0	36.0	0.4	140	Unburned	Unreclaimed
	5,400	16.0	169.0	450.0	1,400.0	24.0	9,400	Burned	Unreclaimed
	5,500	9.3	16.8	600.0	220.0	193.0	10,300	Slurry	Unreclaimed
10570052	16,100	135.0	69.0	5,200.0	12,400.0	28.0	65,000	Unburned	Unreclaimed
	16,900	180.0	30.0	10,300.0	13,900.0	70.0	83,000	Burned	Unreclaimed
10570069	3,100	1.5	262.0	72.0	48.0	0.4	1,200	Unburned	Unreclaimed
	5,600	12.0	72.0	420.0	750.0	2.6	8,400	Burned	Unreclaimed
10572006	4,000	4.8	66.0	230.0	40.0	0.8	5,000	Unburned	Unreclaimed
	3,000	2.0	25.0	78.0	13.0	1.7	4,100	Burned	Unreclaimed
10572003	5,400	7.2	155.0	280.0	290.0	0.4	6,100	Unburned	Unreclaimed
	2,400	0.9	14.0	81.0	1.8	0.5	3,500	Burned	Unreclaimed
	1,510	1.1	186.0	11.0	36.0	2.8	1,100	Slurry	Unreclaimed
10590002	3,000	2.1	42.0	95.0	5.6	8.8	4,300	Unburned	Unreclaimed
10590009	7,900	2.0	3.0	1,800.0	13.0	84.0	15,700	Unburned	Unreclaimed
	800	0.2	11.0	0.9	0.2	0.4	130	Burned	Unreclaimed
10590023	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10590022	1,900	0.7	15.0	30.0	0.5	0.8	3,400	Unburned	Unreclaimed
	55	Tr	7.0	0.1	0.1	0.5	49	Burned	Unreclaimed
10590021	3,000	1.3	13.0	78.0	0.6	37.0	4,600	Unburned	Unreclaimed
	140	0.1	10.0	0.1	0.3	0.7	79	Burned	Unreclaimed
10590020	3,500	0.6	22.0	20.0	0.3	39.0	4,900	Unburned	Unreclaimed
	1,650	0.2	9.0	0.5	0.2	13.0	2,200	Burned	Unreclaimed

TABLE 3.1 (continued)

Set 5, Sheet 4 of 4

MINE IDENTIFICATION NUMBER	G E N E R A L R U N O F F								REMARKS
	pH	CONDUCTIVITY (Microhos/cm)	TOTAL ACIDITY (mg/l as CaCO ₃)	SOL. AL (mg/l)	TOTAL Fe (mg/l)	TOTAL Mn (mg/l)	TOTAL SUSPENDED SOLIDS	SO ₄ ⁻² (mg/l)	
1	33	34	35	36	37	38	39	40	41
10562009	3.1	7,400	1,500	70.0	2.5	22.0	N/A	8,600	
10560086	2.3	11,100	13,800	820.0	480.0	21.0	N/A	17,300	
10562006	4.6	5,700	235	29.0	8.0	7.2	N/A	6,100	
10562003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10562010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10572007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10572004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10570052	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10570069	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10572006	2.3	16,300	11,500	1,100.0	1,000.0	37.0	N/A	19,000	
10572003	2.4	11,200	9,900	730.0	560.0	25.0	N/A	14,100	
10590002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10590009	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10590023	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10590022	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10590021	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10590020	6.4	10,100	22	38.0	0.4	117.0	N/A	8,700	

TABLE 3.1

Set 6, Sheet 1 of 4

PHYSICAL, ENGINEERING, AND OTHER PROPERTIES OF COAL MINE WASTE
IN MIDWESTERN COAL FIELDS, INCLUDING ANALYSES OF EFFLUENT SAMPLES

MINE IDENTIFICATION NUMBER	PARTICLE SIZE PERCENTAGE (Minus 200, 200 to No. 4, No. 4 to 6 inch)	PARTICLE HARDNESS	PERMEABILITY	MOISTURE AND DENSITY (IN-SITU)	MOISTURE AND DENSITY (COMPACTED)	SPECIFIC GRAVITY	ATTERBERG LIMITS	SHEAR STRENGTH		COMPRESSIBILITY
								ϕ	COHESION	
1	2	3	4	5	6	7	8	9	10	11
10640004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10640005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10660040	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10660025	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10680007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10682004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10722001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10720021	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10721001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10721001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10720027	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10730035	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10730103	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10732006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10782001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10780001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10792006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10792005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 6, Sheet 2 of 4

MINE IDENTIFICATION NUMBER	ABRASION	SHRINK AND SWELL EXPANSION POTENTIAL	LITHOLOGY AND MINERAL CONTENT (X-RAY DIFF)	HEAVY METAL CONTENT (ATOMIC ABSORPTION SPECTRUM)	SLAKE DURABILITY	ASH CONTENT	CARBON CONTENT	CALORIFIC VALUE (Btu)	SULFUR	pH	TOXICITY
1	12	13	14	15	16	17	18	19	20	21	22
10640004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10640005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10660040	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10660025	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10680007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10682004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10722001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10720021	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10721001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10721001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10720027	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10730035	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10730103	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10732006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10782001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10780001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10792006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10792005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 6, Sheet 3 of 4

MINE IDENTIFICATION NUMBER	CONDUCTIVITY (Micromhos/cm)	TIT. ACIDITY (meq H ⁺ /100g)	POT. ACIDITY (meq H ⁺ /100g)	Al (ppm)	Fe (ppm)	Mn (ppm)	SO ₄ ⁻² (ppm)	BURNED OR UNBURNED	RECLAIMED OR UNRECLAIMED
1	23	24	25	26	27	28	29	30	31
10640004	750	0.1	17	1.2	0.4	0.9	800	Burned	Unreclaimed
10640005	1,600	2.4	32	170.0	2.9	22.0	2,400	Unburned	Unreclaimed
10660040	2,200	0.1	157	0.6	1.4	4.1	3,300	Unburned	Unreclaimed
10660025	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10680007	10,000	25.0	206	900.0	2,200.0	7.5	14,000	Unburned	Unreclaimed
	2,400	Tr	15	0.1	0.6	6.3	3,200	Burned	Unreclaimed
10682004	10,000	37.0	133	940.0	910.0	12.0	19,600	Unburned	Unreclaimed
10722001	2,400	0.1	50	0.1	0.4	7.0	3,800	Unburned	Unreclaimed
10720021	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10721001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
10720027	2,600	0.1	6	0.4	1.0	7.0	4,400	Burned	Unreclaimed
10730035	2,500	2.6	38	160.0	1.3	10.0	3,800	Unburned	Unreclaimed
	920	0.2	6	4.9	0.1	1.4	1,200	Burned	Unreclaimed
10730103	1,400	0.3	54	5.2	0.9	4.0	1,800	Unburned	Unreclaimed
	300	0.1	31	2.7	0.3	1.1	240	Burned	Unreclaimed
10732006	1,900	0.8	73	31.0	0.9	4.8	2,300	Unburned	Unreclaimed
	1,150	Tr	23	0.2	Tr	2.4	1,600	Burned	Unreclaimed
	2,600	0.5	289	1.0	3.2	9.4	3,600	Slurry	Unreclaimed
10782001	2,800	1.8	15	120.0	0.6	32.0	4,700	Unburned	Unreclaimed
	460	0.1	11	0.4	Tr	2.8	500	Burned	Unreclaimed
10780001	1,500	0.5	11	26.0	0.2	10.0	2,000	Unburned	Unreclaimed
	140	Tr	7	0.4	Tr	0.8	110	Burned	Unreclaimed
10792006	8,200	31.0	264	1,200.0	2,800.0	4.8	17,600	Unburned	Unreclaimed
	2,400	1.3	15	34.0	1.1	0.5	4,000	Burned	Unreclaimed
	3,400	2.4	44	60.0	33.0	8.0	4,800	Slurry	Unreclaimed
10792005	3,600	4.4	92	210.0	58.0	0.6	5,300	Unburned	Unreclaimed
	2,400	1.3	4	110.0	0.4	0.7	4,100	Burned	Unreclaimed
	2,600	0.8	292	21.0	7.5	1.4	4,000	Slurry	Unreclaimed

TABLE 3.1 (continued)

Set 6, Sheet 4 of 4

MINE IDENTIFICATION NUMBER	G E N E R A L R U N O F F								REMARKS
	pH	CONDUCTIVITY (Micromhos/cm)	TOTAL ACIDITY (mg/l as CaCO ₃)	SOL. Al (mg/l)	TOTAL Fe (mg/l)	TOTAL Mn (mg/l)	TOTAL SUSPENDED SOLIDS	SO ₄ ⁻² (mg/l)	
1	33	34	35	36	37	38	39	40	41
10640004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10640005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10660040	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10660025	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10680007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10682004	2.1	19,900	12,900	650.0	1,900.0	0.0	N/A	4,500	
10722001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10720021	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10721001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10720027	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10730035	3.1	1,090	240	35.0	2.6	3.8	N/A	58C	
10730103	2.8	2,900	340	32.0	2.9	1.1	N/A	1,30C	
10732006	2.8	1,330	245	26.0	17.0	0.6	N/A	52C	
10782001	7.8	1,810	165	0.4	29.0	0.0	N/A	49C	
10780001	5.2	890	6	0.9	63.0	1.2	N/A	47	
10792006	2.3	3,900	1,900	150.0	120.0	14.0	N/A	3,20C	
10792005	2.3	5,000	2,000	220.0	110.0	19.0	N/A	3,30C	

TABLE 3.1

Set 7, Sheet 1 of 4

PHYSICAL, ENGINEERING, AND OTHER PROPERTIES OF COAL MINE WASTE
IN MIDWESTERN COAL FIELDS, INCLUDING ANALYSES OF EFFLUENT SAMPLES

MINE IDENTIFICATION NUMBER	PARTICLE SIZE PERCENTAGE (Minus 200, 200 to No. 4, No. 4 to 6 inch)	PARTICLE HARDNESS	PERMEABILITY	MOISTURE AND DENSITY (IN-SITU)	MOISTURE AND DENSITY (COMPACTED)	SPECIFIC GRAVITY	ATTERBERG LIMITS	SHEAR STRENGTH		COMPRESSIBILITY
								ϕ	COHESION	
1	2	3	4	5	6	7	8	9	10	11
10811001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10822005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10822046	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10832007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10841006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10880182	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10880023	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10882010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10882013	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10920140	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10922002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10922001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10921220	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10990012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10990015	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10990011	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10990032	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 7, Sheet 2 of 4

MINE IDENTIFICATION NUMBER	ABRASION	SHRINK AND SWELL EXPANSION POTENTIAL	LITHOLOGY AND MINERAL CONTENT (X-RAY DIFF)	HEAVY METAL CONTENT (ATOMIC ABSORPTION SPECTRUM)	SLAKE DURABILITY	ASH CONTENT	CARBON CONTENT	CALORIFIC VALUE (Btu)	SULFUR	pH	TOXICITY
1	12	13	14	15	16	17	18	19	20	21	22
10811001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10822005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10822046	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10832007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10841006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10880182	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10880023	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10882010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10882013	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10920140	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10922002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10922001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10921220	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10990012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10990015	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10990011	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10990032	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 7, Sheet 3 of 4

MINE IDENTIFICATION NUMBER	CONDUCTIVITY (Micromhos/cm)	TIT. ACIDITY (meq H ⁺ /100g)	POT. ACIDITY (meq H ⁺ /100g)	Al (ppm)	Fe (ppm)	Mn (ppm)	SO ₄ ⁻² (ppm)	BURNED OR UNBURNED	RECLAIMED OR UNRECLAIMED
1	23	24	25	26	27	28	29	30	31
10811001	6,000	8.4	160	120.0	460.0	0.8	7,400	Unburned	Unreclaimed
10822005	3,000	2.8	50	180.0	30.0	6.6	5,000	Unburned	Unreclaimed
	4,500	2.7	25	20.0	9.4	0.2	4,000	Burned	Unreclaimed
10822046	4,400	13.0	20	960.0	160.0	37.0	10,300	Unburned	Unreclaimed
10832007	2,700	1.3	47	77.0	7.4	0.9	4,300	Unburned	Unreclaimed
10841006	3,100	1.3	366	12.0	23.0	0.5	4,300	Unburned	Unreclaimed
10880182	5,900	1.3	51	600.0	1,700.0	2.0	12,400	Unburned	Unreclaimed
10880023	9,100	18.0	159	2,000.0	2,100.0	23.0	34,000	Unburned	Unreclaimed
	2,300	52.0	44	240.0	120.0	0.7	3,900	Burned	Unreclaimed
10882010	10,000	0.3	315	1,800.0	2,500.0	27.0	32,000	Unburned	Unreclaimed
	2,800	58.0	503	48.0	120.0	10.0	4,000	Burned	Unreclaimed
10882013	3,500	1.5	62	79.0	110.0	0.5	5,000	Unburned	Unreclaimed
	2,300	2.9	207	0.2	Tr	0.9	3,700	Slurry	Unreclaimed
10920140	4,800	Tr	112	630.0	15.0	80.0	9,800	Unburned	Unreclaimed
	2,300	8.4	7	38.0	0.3	0.7	3,900	Burned	Unreclaimed
10922002	2,900	0.6	66	130.0	49.0	14.0	4,200	Unburned	Unreclaimed
	140	2.6	1	0.1	0.2	0.4	120	Burned	Unreclaimed
	3,900	Tr	273	320.0	5.8	153.0	7,700	Slurry	Unreclaimed
10922001	1,900	5.2	82	34.0	7.3	2.8	1,900	Unburned	Unreclaimed
	2,600	0.9	11	93.0	3.3	0.7	4,300	Burned	Unreclaimed
10921220	9,800	1.3	223	380.0	3,600.0	4.5	17,900	Unburned	Unreclaimed
	440	28.0	4	11.0	0.2	1.1	440	Burned	Unreclaimed
10990012	2,200	0.3	7	2.1	0.2	14.0	3,200	Unburned	Unreclaimed
10990015	2,100	0.4	5	17.0	0.2	28.0	3,400	Unburned	Unreclaimed
10990011	2,600	0.8	6	43.0	0.7	73.0	4,200	Unburned	Unreclaimed
	1,550	Tr	3	0.3	0.1	2.9	2,500	Burned	Unreclaimed
10990032	1,000	0.3	10	11.0	1.0	6.6	1,300	Unburned	Unreclaimed
	1,700	0.3	0	8.1	1.0	6.1	2,500	Burned	Unreclaimed

TABLE 3.1 (continued)

Set 7, Sheet 4 of 4

MINE IDENTIFICATION NUMBER	G E N E R A L R U N O F F								REMARKS
	pH	CONDUCTIVITY (Micromhos/cm)	TOTAL ACIDITY (mg/l as CaCO ₃)	SOL. Al (mg/l)	TOTAL Fe (mg/l)	TOTAL Mn (mg/l)	TOTAL SUSPENDED SOLIDS	SO ₄ ⁻² (mg/l)	
1	33	34	35	36	37	38	39	40	41
10811001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10822005	2.3	13,500	14,400	900.0	490.0	115.0	N/A	1,700	
10822046	3.1	1,050	155	19.0	2.3	11.0	N/A	470	
10832007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10841006	7.7	1,420	11	0.2	0.8	0.0	N/A	460	
10880182	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10880023	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10882010	2.4	9,100	6,700	220.0	1,500.0	97.0	N/A	4,800	
10882013	2.3	10,400	9,700	430.0	2,000.0	0.0	N/A	8,300	
10920140	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10922002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10922001	3.7	300	40	0.3	0.6	0.0	N/A	420	
10921220	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10990012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10990015	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10990011	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10990032	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

TABLE 3.1

Set 8, Sheet 1 of 4

PHYSICAL, ENGINEERING, AND OTHER PROPERTIES OF COAL MINE WASTE
IN MIDWESTERN COAL FIELDS, INCLUDING ANALYSES OF EFFLUENT SAMPLES

MINE IDENTIFICATION NUMBER	PARTICLE SIZE PERCENTAGE (Minus 200, 200 to No. 4, No. 4 to 6 inch)	PARTICLE HARDNESS	PERMEABILITY	MOISTURE AND DENSITY (IN-SITU)	MOISTURE AND DENSITY (COMPACTED)	SPECIFIC GRAVITY	ATTERBERG LIMITS	SHEAR STRENGTH		COMPRESSIBILITY
								ϕ	COHESION	
1	2	3	4	5	6	7	8	9	10	11
10990035	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10990007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11002088	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11000184	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11000004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11000035	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11000032	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11000034	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11002093	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11000193	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11002003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11002020	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11000050	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11001150	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11001177	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11002084	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11001032	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 8, Sheet 2 of 4

MINE IDENTIFICATION NUMBER	ABRASION	SHRINK AND SWELL EXPANSION POTENTIAL	LITHOLOGY AND MINERAL CONTENT (X-RAY DIFF)	HEAVY METAL CONTENT (ATOMIC ABSORPTION SPECTRUM)	SLAKE DURABILITY	ASH CONTENT	CARBON CONTENT	CALCRIFIC VALUE (Btu)	SULFUR	pH	TOXICITY
1	12	13	14	15	16	17	18	19	20	21	22
10990035	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10990007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11002088	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11000184	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11000004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11000035	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11000032	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11000034	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11002093	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11000193	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11002003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11002020	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11000050	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11001150	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11001177	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11002084	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11001032	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 8, Sheet 3 of 4

MINE IDENTIFICATION NUMBER	CONDUCTIVITY (Microhos/cm)	TIT. ACIDITY (meg H ⁺ /100g)	POT. ACIDITY (meg H ⁺ /100g)	Al (ppm)	Fe (ppm)	Mn (ppm)	SO ₄ ⁻² (ppm)	BURNED OR UNBURNED	RECLAIMED OR UNRECLAIMED
1	23	24	25	26	27	28	29	30	31
10990035	3,200	1.5	25	77.0	0.8	33.0	5,700	Unburned	Unreclaimed
10990007	1,220	0.3	7	10.0	0.2	7.8	1,600	Unburned	Unreclaimed
11002083	4,600	5.5	56	180.0	460.0	7.3	5,500	Unburned	Unreclaimed
	2,700	0.6	171	8.5	10.0	1.0	3,600	Slurry	Unreclaimed
11000184	2,400	0.3	124	8.4	0.6	0.5	3,700	Unburned	Unreclaimed
11000004	3,000	1.8	157	110.0	7.3	11.0	4,400	Unburned	Unreclaimed
11000035	3,200	2.2	109	110.0	27.0	2.8	4,900	Unburned	Unreclaimed
11000032	3,800	4.2	106	200.0	310.0	19.0	5,500	Unburned	Unreclaimed
11000034	3,500	3.4	39	210.0	32.0	3.0	5,200	Unburned	Unreclaimed
11002093	4,300	6.4	166	240.0	560.0	4.8	6,100	Unburned	Unreclaimed
	2,200	0.1	85	0.7	1.8	7.2	3,400	Burned	Unreclaimed
	5,400	9.9	17	270.0	900.0	1.9	8,300	Slurry	Unreclaimed
11000193	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Unreclaimed
11002003	2,500	0.8	185	44.0	2.2	1.6	3,700	Unburned	Unreclaimed
11002020	300	0.2	300	1.1	1.1	0.2	160	Unburned	Unreclaimed
11000050	7,000	42.0	122	1,100.0	3,300.0	3.3	16,100	Unburned	Unreclaimed
11001150	2,600	0.8	72	32.0	2.1	0.6	3,700	Unburned	Unreclaimed
	540	0.3	198	2.8	4.2	2.9	250	Slurry	Unreclaimed
11001177	3,000	1.2	56	39.0	12.0	0.6	3,800	Unburned	Unreclaimed
	2,100	1.5	256	28.0	20.0	1.1	1,500	Slurry	Unreclaimed
11002084	3,600	2.7	23	110.0	17.0	0.3	4,100	Unburned	Unreclaimed
	4,800	7.0	84	84.0	280.0	3.2	4,200	Slurry	Unreclaimed
11001032	2,600	0.6	123	11.0	3.9	0.6	3,900	Unburned	Unreclaimed

TABLE 3.1 (continued)

Set 8, Sheet 4 of 4

MINE IDENTIFICATION NUMBER	G E N E R A L R U N O F F								REMARKS
	pH	CONDUCTIVITY (Micromhos/cm)	TOTAL ACIDITY (mg/l as CaCO ₃)	SOL. Al (mg/l)	TOTAL Fe (mg/l)	TOTAL Mn (mg/l)	TOTAL SUSPENDED SOLIDS	SO ₄ ⁻² (mg/l)	
1	33	34	35	36	37	38	39	40	41
10990035	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10990007	5.4	1,350	14	0.2	2.0	1.7	N/A	520	
11002088	2.0	4,800	3,800	210.0	1,100.0	12.0	N/A	5,400	
11000184	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
11000004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
11000035	1.6	31,000	19,200	2,200.0	840.0	145.0	N/A	89,000	
11000032	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
11000034	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
11002093	2.2	6,700	7,200	570.0	3,300.0	35.0	N/A	4,900	
11000193	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
11002003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
11002020	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
11000050	2.4	7,700	6,100	400.0	510.0	27.0	N/A	360	
11001150	2.0	13,900	13,200	640.0	3,900.0	113.0	N/A	16,100	
11001177	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
11002084	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
11001032	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

TABLE 3.1

Set 9, Sheet 1 of 4

PHYSICAL, ENGINEERING, AND OTHER PROPERTIES OF COAL MINE WASTE
IN MIDWESTERN COAL FIELDS, INCLUDING ANALYSES OF EFFLUENT SAMPLES

MINE IDENTIFICATION NUMBER	PARTICLE SIZE PERCENTAGE (Minus 200, 200 to No. 4, No. 4 to 6 inch)	PARTICLE HARDNESS	PERMEABILITY	MOISTURE AND DENSITY (IN-SITU)	MOISTURE AND DENSITY (COMPACTED)	SPECIFIC GRAVITY	ATTERBERG LIMITS	SHEAR STRENGTH		COMPRESSIBILITY
								ϕ	COHESION	
1	2	3	4	5	6	7	8	9	10	11
11022001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11022002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11020001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 9, Sheet 2 of 4

MINE IDENTIFICATION NUMBER	ABRASION	SHRINK AND SWELL EXPANSION POTENTIAL	LITHOLOGY AND MINERAL CONTENT (X-RAY DIFF)	HEAVY METAL CONTENT (ATOMIC ABSORPTION SPECTRUM)	SLAKE DURABILITY	ASH CONTENT	CARBON CONTENT	CALORIFIC VALUE (3tu)	SULFUR	pH	TOXICITY
1	12	13	14	15	16	17	18	19	20	21	22
11022001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11022002	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11020001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 9, Sheet 3 of 4

MINE IDENTIFICATION NUMBER	CONDUCTIVITY (Micromhos/cm)	TIT. ACIDITY (meq H ⁺ /100g)	POT. ACIDITY (meq H ⁺ /100g)	Al (ppm)	Fe (ppm)	Mn (ppm)	SO ₄ ⁻² (ppm)	BURNED OR UNBURNED	RECLAIMED OR UNRECLAIMED
1	23	24	25	26	27	28	29	30	31
11022001	760	0.2	27	4.1	1.0	2.9	790	Unburned	Unreclaimed
	960	Tr	5	0.2	0.4	0.3	1,000	Burned	Unreclaimed
11022002	1,450	0.2	21	9.2	1.4	3.3	1,700	Unburned	Unreclaimed
	1,900	0.7	13	4.4	0.3	29.0	2,500	Burned	Unreclaimed
11020001	120	0.1	8	0.2	0.5	0.4	72	Unburned	Unreclaimed

TABLE 3.1 (continued)

Set 9, Sheet 4 of 4

MINE IDENTIFICATION NUMBER	G E N E R A L R U N O F F								REMARKS
	pH	CONDUCTIVITY (Microhmhos/cm)	TOTAL ACIDITY (mg/l as CaCO ₃)	SOL. Al (mg/l)	TOTAL Fe (mg/l)	TOTAL Mn (mg/l)	TOTAL SUSPENDED SOLIDS	SO ₄ ⁻² (mg/l)	
1	33	34	35	36	37	38	39	40	41
11022001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
11022002	5.2	3,900	16	0.9	0.7	19.0	N/A	2,500	
11020001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

TABLE 3.1

Set 10, Sheet 1 of 4

PHYSICAL, ENGINEERING, AND OTHER PROPERTIES OF COAL MINE WASTE
IN MIDWESTERN COAL FIELDS, INCLUDING ANALYSES OF EFFLUENT SAMPLES

MINE IDENTIFICATION NUMBER	PARTICLE SIZE PERCENTAGE (Minus 200, 200 to No. 4, No. 4 to 6 inch)	PARTICLE HARDNESS	PERMEABILITY	MOISTURE AND DENSITY (IN-SITU)	MOISTURE AND DENSITY (COMPACTED)	SPECIFIC GRAVITY	ATTERBERG LIMITS	SHEAR STRENGTH		COMPRESSIBILITY
								ϕ	COHESION	
1	2	3	4	5	6	7	8	9	10	11
Orient No. 3 (Freeman) 10412101	Minus 2 inch to - 200 Mesh	N/A	1.46×10^{-4}	110	N/A	N/A	N/A	30°	400	
Monterey No. 2 (Monterey Coal Co.) 10142101	+ 1-1/2" = 20%	N/A	3.6×10^{-7} (coarse com- pacted) 9.8×10^{-6} (loose slurry solids)	116 Moisture 16.6%	104 60	N/A	LL = 34.3 PL = 19.2 PI = 15.1	25°-33° (coarse)	400-0 (coarse)	
111 Mine No. 1 (Inland) 10282101	Minus 3 inch	N/A	N/A	Moisture 18%	110	N/A	LL = 22 PL = 3	28°	504	
Orient No. 4 (Freeman) 11002101	Minus 3 inch	N/A	N/A	102	N/A	N/A	N/A	32°	500	
Burring Star Mine No. 5 (Consol) 10392101	N/A	N/A	N/A	122	N/A	N/A	N/A	6°	2,251	
Mine No. 4 (Zeigler) 10792101	N/A	N/A	N/A	129.2	N/A	N/A	N/A	10°	385	N/A
Repartee Mine (Midland) 10292101	N/A	N/A	N/A	129.5 Moisture 18.8%	N/A	N/A	LL = 37% PL = 25% PI = 12%	25.7°	1,080	N/A

TABLE 3.1 (continued)

Set 10, Sheet 2 of 4

MINE IDENTIFICATION NUMBER	ABRASION	SHRINK AND SWELL EXPANSION POTENTIAL	LITHOLOGY AND MINERAL CONTENT (X-RAY DIFF)	HEAVY METAL CONTENT (ATOMIC ABSORPTION SPECTRUM)	SLAKE DURABILITY	ASH CONTENT	CARBON CONTENT	CALORIFIC VALUE (Btu)	SULFUR	pH	TOXICITY
1	12	13	14	15	16	17	18	19	20	21	22
10412101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10142101	N/A	N/A	N/A	N/A	N/A	85.4	N/A	N/A	5.6	6.79	N/A
10282101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11002101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10392101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10792101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10292101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1. (continued)

Set 10, Sheet 3 of 4

MINE IDENTIFICATION NUMBER	CONDUCTIVITY (Micromhos/cm)	TIT. ACIDITY (meq H ⁺ /100g)	POT. ACIDITY (meq H ⁺ /100g)	Al (ppm)	Fe (ppm)	Mn (ppm)	SO ₄ ⁻² (ppm)	BURNED OR UNBURNED	RECLAIMED OR UNRECLAIMED
1	23	24	25	26	27	28	29	30	31
10412101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10142101	13.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10282101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11002101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10392101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10792101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10292101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 10, Sheet 4 of 4

MINE IDENTIFICATION NUMBER	G E N E R A L R U N O F F								
	pH	CONDUCTIVITY (Microhm/cm)	TOTAL ACIDITY (mg/l as CaCO ₃)	SOL. Al (mg/l)	TOTAL Fe (mg/l)	TOTAL Mn (mg/l)	TOTAL SUSPENDED SOLIDS	SO ₄ ⁻² (mg/l)	REMARKS
1	33	34	35	36	37	38	39	40	41
10412101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A (N)	Standard Penetration Range was 6 to 24
10142101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10282101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
11002101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10392101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10792101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10292101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

TABLE 3.1

Set 11, Sheet 1 of 4

PHYSICAL, ENGINEERING, AND OTHER PROPERTIES OF COAL MINE WASTE
IN MIDWESTERN COAL FIELDS, INCLUDING ANALYSES OF EFFLUENT SAMPLES

MINE IDENTIFICATION NUMBER	PARTICLE SIZE PERCENTAGE (Minus 200, 200 to No. 4, No. 4 to 6 inch)	PARTICLE HARDNESS	PERMEABILITY	MOISTURE AND DENSITY (IN-SITU)	MOISTURE AND DENSITY (COMPACTED)	SPECIFIC GRAVITY	ATTERBERG LIMITS	SHEAR STRENGTH		COMPRESSIBILITY
								ϕ	COHESION	
1	2	3	4	5	6	7	8	9	10	11
IN1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN3c	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN6a	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN6b	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN6p	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
K4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
K5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 11, Sheet 2 of 4

MINE IDENTIFICATION NUMBER	ABRASION	SHRINK AND SWELL EXPANSION POTENTIAL	LITHOLOGY AND MINERAL CONTENT (X-RAY DIFF)	HEAVY METAL CONTENT (ATOMIC ABSORPTION SPECTRUM)	SLAKE DURABILITY	ASH CONTENT	CARBON CONTENT	CALORIFIC VALUE (Btu)	SULFUR	pH	TOXICITY
1	12	13	14	15	16	17	18	19	20	21	22
IN1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN3c	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN6a	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN6b	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN6p	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
K4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
K5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 11, Sheet 3 of 4

MINE IDENTIFICATION NUMBER	CONDUCTIVITY (Micromhos/cm)	TIT. ACIDITY (meq H ⁺ /100g)	POT. ACIDITY (meq H ⁺ /100g)	Al (ppm)	Fe (ppm)	Mn (ppm)	SO ₄ ⁻² (ppm)	BURNED OR UNBURNED	RECLAIMED OR UNRECLAIMED
1	23	24	25	26	27	28	29	30	31
IN1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN3c	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN6a	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN6b	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IN6p	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
K4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
K5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3.1 (continued)

Set 11, Sheet 4 of 4

MINE IDENTIFICATION NUMBER	G E N E R A L R U N O F F								REMARKS
	pH	CONDUCTIVITY (Microhms/cm)	TOTAL ACIDITY (mg/l as CaCO ₃)	SOL. Al (mg/l)	TOTAL Fe (mg/l)	TOTAL Mn (mg/l)	TOTAL SUSPENDED SOLIDS	SO ₄ ⁻² (mg/l)	
1	33	34	35	36	37	38	39	40	41
IN1	3.2	1,480	150	5.6	25.0	11.0	N/A	850	
IN2	2.8	2,500	800	52.0	100.0	25.0	N/A	1,711	
IN2	2.6	2,400	760	50.0	160.0	24.0	N/A	1,700	
IN3	2.4	6,400	6,500	340.0	2,600.0	120.0	N/A	9,512	
IN3c	8.0	2,150	0	10.0	25.0	0.6	N/A	1,456	
IN4	2.5	9,800	10,300	N/A	4,180.0	40.0	N/A	10,400	
IN4	2.2	15,000	16,400	N/A	5,500.0	36.0	N/A	15,200	
IN5	2.3	1,200	13,600	N/A	4,500.0	56.0	N/A	15,000	
IN6	2.5	N/A	7,277	N/A	2,320.0	12.0	N/A	14,282	
IN5a	7.9	N/A	N/A	N/A	0.5	0.03	N/A	564	
IN5b	2.9	N/A	5,660	N/A	2,233.0	16.0	N/A	10,544	
IN6p	2.3	N/A	8,667	N/A	2,147.0	11.0	N/A	16,103	
K4	2.5	6,800	7,020	440.0	3,400.0	72.0	N/A	9,327	
K5	2.4	4,200	2,380	244.0	630.0	26.0	N/A	3,629	

TABLE 3.2

STATISTICAL DATA FOR GENERAL RUNOFF AND SLUDGE SAMPLES
COLLECTED FROM ABANDONED COAL WASTE PILES IN ILLINOIS

GENERAL RUNOFF								
SAMPLE	pH	CONDUCTIVITY (micromhos/cm)	TOTAL ACIDITY (mg/l as CaCO ₃)	SOL. Al (mg/l)	TOTAL Fe (mg/l)	TOTAL Mn (mg/l)	SO ₄ ⁻² (mg/l)	REMARKS
General Runoff (110 Samples)								
Median	3.0	2,900	415.0	37.0	57.0	6.4	1,300	
Mean	3.5	5,100	3,200.0	240.0	510.0	21.0	5,200	
SD	1.54	6,300	6,450.0	513.0	1,260.0	31.1	10,780	
Minimum	1.6	180	4.0	0.1	0.36	0.0	31	
Maximum	7.8	32,000	39,300.0	3,100.0	10,000.0	145.0	89,000	
Sludge Unburned (13 Samples)								
Median	-	-	1.5	76.0	9.6	5.6	4,100	
Mean	-	-	13.7	414.0	1,242.0	25.0	5,333	
SD	-	-	29.0	710.0	3,457.0	43.0	14,426	
Minimum	-	-	0.1	0.2	0.2	0.4	100	
Maximum	-	-	104.0	2,600.0	12,200.0	137.0	53,000	
Sludge Burned (10 Samples)								
Median	-	-	0.3	8.1	0.4	0.8	700	
Mean	-	-	0.31	7.6	0.52	0.92	1,116	
SD	-	-	0.32	5.7	0.42	0.37	1,316	
Minimum	-	-	Tr	0.9	0.1	0.5	61	
Maximum	-	-	1.0	16.0	1.6	1.8	3,300	
Sludge Slurry (5 Samples)								
Median	-	-	2.3	81.0	44.0	3.0	4,400	
Mean	-	-	2.98	113.0	91.0	4.0	4,540	
SD	-	-	2.8	147.0	97.0	3.5	907	
Minimum	-	-	0.9	11.0	9.80	1.2	3,900	
Maximum	-	-	7.8	370.0	220.0	10.0	4,400	

TABLE 3.3

STATISTICAL DATA FOR 21 SAMPLES
COLLECTED FROM ABANDONED SLURRY PONDS IN ILLINOIS

SAMPLE	GENERAL RUNOFF							REMARKS
	pH	CONDUCTIVITY (micromhos/cm)	TOTAL ACIDITY (mg/l as CaCO ₃)	SOL. Al (mg/l)	TOTAL Fe (mg/l)	TOTAL Mn (mg/l)	SO ₄ ⁻² (mg/l)	
Median	2.4	4,100	990	82.0	100.0	8.2	2,400	
Mean	3.0	4,400	2,600	170.0	510.0	14.0	3,500	
SD	1.51	3,030	3,060	300.0	902.0	18.6	2,970	
Minimum	2.0	1,110	6	0.1	0.39	0.0	320	
Maximum	7.6	14,600	9,700	1,300.0	4,000.0	65.0	10,400	

Source: Nawrot, et. al., 1977.

4. IDENTIFICATION OF COAL WASTE AREAS

An inventory and assessment of the quantity of coal waste contained in various disposal areas are prerequisites for characterization of waste properties. In keeping with these objectives, information on significant waste disposal sites associated with abandoned and active underground coal mines and preparation plants was collected from various agencies in the states comprising the midwestern coal fields. The information thus collected was analyzed to pick up significant disposal areas.

This section includes information on 325 significant disposal areas in different states of the midwestern region. These areas represent approximately 80 percent of the quantity of refuse in the midwestern coal fields as of 1978. The information has been suitably tabulated and also, the locations of the disposal areas have been marked on USGS 1:250,000 topographic maps.

Mine identification numbering system has been adopted for the tables to facilitate storing of the information on a computer program if considered desirable subsequently. The system can be used to help retrieval of the information on state, county, and type of mine basis and is given in Appendix A and Appendix B.

Illinois

Following the enactment of the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500), Illinois Pollution Control Board (1976) established general water quality standards for Illinois. Other mine related environmental regulations including planning the location, operation, and abandonment of mining and refuse areas were enacted earlier (Illinois Pollution Control Board, 1972). Since no specific environmental legislation existed, many underground mines abandoned prior to 1972 had received little or no reclamation treatment. Therefore, the Abandoned Mined Lands Reclamation Act of 1975 was enacted to acquire abandoned mined lands and to restore them to productive use (Illinois General Assembly, 1975).

The responsibility for enforcing most of the state environmental regulations pertaining to mines rests with the Illinois Environmental Protection Agency. Recognizing that an inventory and assessment of unreclaimed and associated environmental problems is important for effective enforcement of the various legislations, Illinois Institute for Environmental Quality (IIEQ) funded a program in 1975 to conduct a survey of

Illinois Lands affected by underground mining for coal. The survey was conducted by the Cooperative Wildlife Research Laboratory of Southern Illinois University and includes a detailed inventory of coal mine waste disposal sites associated with abandoned underground mines (Nawrot, et. al., 1977).

Table 4.1 gives information on 159 active and abandoned coal waste disposal areas in Illinois. Approximately one-third of these sites are active, containing about 260 million tons of waste. The waste contained in the remaining abandoned sites is approximately 80 million tons which is about 80 percent of the total refuse contained in approximately 700 disposal sites identified in the above-mentioned survey. All the abandoned disposal areas listed in Table 4.1 contain more than 25,000 cubic yards or approximately 31,000 tons of waste. Figures 4.1 through 4.18 give the locations of these 159 disposal areas. The locations were plotted on USGS 1:250,000 topographic maps, and Figures 4.1 through 4.18 have been reduced from these maps.

Western Kentucky

Information on locations of 45 significant coal waste disposal sites is given in Table 4.2. These locations are shown on Figures 4.19 through 4.23, reduced from USGS 1:250,000 topographic maps. Several disposal sites have two or more refuse piles or other disposal structures. The information on abandoned disposal sites was obtained from Mine Safety and Health Administration's office in Madisonville, Kentucky. The information on active disposal sites was obtained from Kentucky State Department of Mines and Minerals. The information on disposal areas associated with small abandoned underground operations has been omitted because of insignificant quantity of refuse contained in these areas. The quantity of refuse contained in abandoned disposal areas given in Table 4.2 has been estimated to be about 35 million tons and the quantity of refuse accumulated in active waste disposal areas from 1974 through 1978 has been estimated to amount to approximately 26.5 million tons.

Indiana

Table 4.3 gives information on 44 significant abandoned and active coal mine waste disposal sites. Figures 4.24 through 4.27, reduced from USGS 1:250,000 topographic maps, show their locations. The information on locations and accumulated coal production was obtained from Indiana Geological Survey, Department of Natural Resources (Eggert, 1979). The quantity of refuse at each location was estimated based on total

cumulative coal production, duration for which the preparation plant worked, and the average ratio of waste to cleaned coal. These locations are concentrated in ten counties of southwestern Indiana.

Missouri

Sixteen significant coal waste disposal sites have been identified in Missouri. Of these sites, four are active associated with preparation plants attached to strip operations. There are no underground mines in operation at present. These sixteen sites are distributed in ten counties comprising the western and northern regions of the state. The information on these sites was obtained from Missouri Water Quality Report (1978), Missouri Department of Natural Resources, and Keystone Coal Industry Manual. Information on cumulative production of mines attached to the waste disposal sites and quantity of waste was generally not available.

Table 4.4 gives available information on these disposal sites, and Figures 4.28 through 4.34 show their respective locations.

Oklahoma

Table 4.5 gives information on seven significant coal waste disposal areas in the state. Six of them are active disposal areas associated with preparation plants of strip mines. There is one underground mine which is inactive at present. The information on cumulative production and quantity of refuse is not available.

Figures 4.35 through 4.37 show the locations of these seven refuse disposal sites.

Kansas

The entire current production comes from strip mines. The last underground coal mine in Kansas closed in 1963. Presently, four mines have preparation plants with a combined capacity to produce 7,600 tons of cleaned coal per day. The information on accumulative production and quantity of refuse contained in waste disposal areas attached to these four preparation plants is not available. Of the abandoned disposal areas, only two are significant. One of them extends over a 15-acre area and the other one is located on the boundary between Kansas and Missouri. The latter is listed under Missouri. Figures 4.38 and 4.39 show the locations of four active and one abandoned disposal sites in Kansas.

The information on these locations was obtained from Kansas Geological Survey and Keystone Coal Industry Manual.

Arkansas

Table 4.7 gives information on 50 coal mine waste disposal areas in Arkansas. Of these areas, only three are active. The locations of these areas are shown on Figures 4.40 through 4.43, reduced from portions of USGS 1:250,000 topographic maps. Information on locations of these areas was obtained from Arkansas Geological Survey.

The entire current production comes from strip mines. The active disposal areas are associated with preparation plants serving three strip mines. Information on cumulative production and quantity of waste is not available.

TABLE 4.1

Sheet 1 of 18

ESTIMATED QUANTITY AND LOCATION OF SIGNIFICANT DISPOSAL SITES IN MIDWESTERN COAL FIELDS - ILLINOIS

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
1	10060001	Bureau	St. Paul Coal Co.	T17N R11E S27	1906 1933	No	N/A	3,340,000
2	10060003	Bureau	Spring Valley Coal Co.	T16N R11E S18	N/A	No	N/A	1,935,000
3	10060002	Bureau	Illinois 3rd Vein Coal Company	T16N R11E S10	N/A	No	N/A	3,704,000
4	10060005	Bureau	Marquette Third Vein Coal Company	T16N R11E S31	1907 N/A	No	N/A	651,000
5	100620C1	Bureau	Spring Valley Coal Co.	T16N R11E S33	1886 1947	No	N/A	945,000
6	100600C4	Bureau	Spring Valley Coal Co.	T16N R11E S24	N/A 1924	No	N/A	2,782,000
7	10060006	Bureau	Spring Valley Coal Co.	T16N R11E S35	1897 1926	No	N/A	2,090,000
8	10060007	Bureau	Spring Valley Coal Co.	T16N R11E S35	1890 1910	No	N/A	1,200,000
9	10500043	La Salle	Old Caledonia Central Illinois Valley Ind. Co.	T33N R1E S3	N/A 1885	No	N/A	58,000
10	10502020	La Salle	Peru Deep Vein Coal Co.	T33N R1E S16	1879 1942	No	N/A	149,000
11	10500051	La Salle	La Salle County Carbon- Coal Co.	T33N R1E S15	1856 1930	No	N/A	295,000

TABLE 4.1 (continued)

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MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
12	10500048	La Salle	La Salle County Carbon-Coal Co.	T33N R1E S14	N/A	Mc	N/A	214,000
12A	10500050	La Salle	La Salle County Carbon-Coal Co.	T33N R1E S14	N/A 1936	Mc	N/A	1,730,000
13	10500057	La Salle	La Salle County Carbon-Coal Co.	T33N R1E S23	N/A	Mc	N/A	1,140,000
14	10500059	La Salle	Ogelsby Coal Co.	T33N R1E S35	N/A 1926	Mc	N/A	333,000
15	10500041	La Salle	Unknown	T33N R2E S30	N/A	Mc	N/A	77,000
15A	10500040	La Salle	Illinois Clay Products Co.	T33N R2E S30	N/A 1921	Mc	N/A	32,000
16	10782001	Putnam	Prarie State Coal Co.	T32N R1W S8	1905 1935	Mc	N/A	2,364,000
17	10780001	Putnam	B. F. Berry Coal Co.	T32N R1W S11	N/A 1925	Mc	N/A	1,860,000
18	10500060	La Salle	Cedar Point #5	T32N R1W S4	N/A 1935	Mc	N/A	1,240,000
19	10590002	Marshall	Unknown	T12N R9E S2	N/A	Mc	N/A	48,000
20	10590003	Marshall	Fulton Coal Co.	T12N R9E S11	N/A 1915	Mc	N/A	65,000

TABLE 4.1 (continued)

Sheet 3 of 18

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
21	10590020	Marshall	Wenona Coal Co.	T30N R1E S24	N/A 1926	No	N/A	944,000
22	10500086	La Salle	Heenanville Coal Co.	T31N R3E S10	1917 N/A	No	N/A	301,000
22A	10500085	La Salle	Chicago-Wilmington & Vermilion Coal Co.	T31N R3E S21	1890 1912	No	N/A	203,000
23	10500103	La Salle	Star Coal Co.	T31N R3E S21	1890 1900	No	N/A	31,000
23A	10500102	La Salle	Spring Lake Coal Co.	T31N R3E S21	N/A 1918	No	N/A	32,000
24	10500104	La Salle	John Petrotte	T31N R3E S22	1917 1927	No	N/A	103,000
26	10500085	La Salle	Chicago-Wilmington & Vermilion Coal Co.	T31N R4E S19	N/A 1912	No	N/A	464,000
26A	10500070	La Salle	H & M Plumb Coal Co.	T31N R4E S19	1894 1940	No	N/A	45,000
26B	10500069	La Salle	Chicago-Wilmington & Vermilion Coal Co.	T31N R4E S19	N/A	No	N/A	102,000
27	10500072	La Salle	Unknown	T31N R4E S20	N/A	No	N/A	31,000
28	10500076	La Salle	Harrison Coal Company	T31N R4E S31	1915 1916	No	N/A	256,000

TABLE 4.1 (continued)

Sheet 4 of 18

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	REPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
32	10320089	Grundy	Illinois Valley Coal Co.	T32N R8E S5	N/A 1925	No	N/A	55,000
33	10990077	Will	Murphy, Linkskey & Kashev	T33N R9E S32	N/A 1916	No	N/A	45,000
34	10990011	Will	Chicago-Wilmington & Vermilion Coal Co.	T32N R9E S6	N/A 1887	No	N/A	49,000
35	10990012	Will	Chicago-Wilmington & Vermilion Coal Co.	T32N R9E S5	N/A 1880	No	N/A	40,000
35A	10990015	Will	Murphy, Keenan & Co.	T32N R9E S5	1902 N/A	No	N/A	35,000
36	10990032	Will	Chicago-Wilmington & Vermilion Coal Co.	T32N R9E S19	N/A	No	N/A	29,000
37	10990035	Will	Wilmington Coal Mining	T32N R9E S31	1905 1918	No	N/A	45,000
38	10320109	Grundy	Sunlight Coal Company	T32N R6E S23	1921 1931	No	N/A	44,000
39	10320114	Grundy	Chicago-Wilmington & Vermilion Coal Co.	T31N R8E S11	N/A 1911	No	N/A	86,000
39A	10320115	Grundy	Chicago-Wilmington & Vermilion Coal Co.	T31N R8E S14	N/A 1915	Yes	N/A	209,000
40	10321005	Grundy	Chicago-Wilmington & Vermilion Coal Co.	T31N R8E S23	1908 1954	No	N/A	286,000

TABLE 4.1 (continued)

Sheet 5 of 18

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
41	10320098	Grundy	Braceville Coal Co.	T32N R8E S14	N/A 1917	No	N/A	79,000
42	10320096	Grundy	Chicago-Wilmington & Vermilion Coal Co.	T32N R8E S13	1896 1915	No	N/A	28,000
42A	10320097	Grundy	Braceville Coal Co.	T32N R8E S13	N/A 1908	No	N/A	84,000
43	10320100	Grundy	Braceville Coal Co.	T32N R8E S23	1890 1894	No	N/A	106,000
43A	10430099	Grundy	Braceville Coal Co.	T32N R8E S23	1890 1915	Yes	N/A	148,000
44	10430102	Grundy	Braceville Coal Co.	T32N R8E S24	1893 1907	No	N/A	81,000
45	10530051	Livingston	Cardiff Coal Co.	T30N R8E S22	N/A 1913	No	N/A	374,300
46	10530052	Livingston	Cardiff Coal Co.	T30N R8E S23	1900 1907	No	N/A	28,000
47	10320074	Grundy	Big Four Wilmington Coal Co.	T33N R8E S33	N/A 1913	No	N/A	138,000
48	105672006	Madison	Mt. Olive & Stannton Coal Co.	T6N R6W S10	1904 1957	Yes	32,000,000	1,948,000
49	10572003	Madison	Mt. Olive & Livingston Coal Co.	T6N R6W S16	1905 1964	No	19,000,000	66,000

TABLE 4.1 (continued)

Sheet 6 of 18

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
50	10570069	Madison	Madison Coal Co.	T6N R8W S34	N/A 1932	No	N/A	81,000
51	10572007	Madison	Lumagh Coal Co.	T3N R8W S23	1950 1964	No	4,200,000	203,000
54	10882013	St. Clair	St. Louis & O'Fallon Coal Co.	T2N R8W S33	1904 1954	Yes	23,000,000	434,000
55	10882010	St. Clair	Peabody Coal Co.	T2N R8W S26	1903 1960	No	32,000,000	1,860,000
56	1088	St. Clair	Peabody Coal River King V.G. #1	T15 R7W S19	1970 Active	Yes	14,431,597	3,207,000
57	10880182	St. Clair	Belle Valley Coal Co. & Slag Dump	T1N R7W S35	N/A	No	N/A	68,000
58	1014	Clinton	Monterey Coal Co. #2	T1N R5W S11	1977 Active	Yes	461,809	92,000
59	10142003	Clinton	Breese Coal Company Inc.	T2N R4W S23	1905 1957	No	63,000,000	28,000
60	10792006	Randolph	Sparta Coal Company	T4S R5W S10	1900 1950	No	N/A	143,800
61	1079	Randolph	Consolidation Coal Co. Burning Star #3	T5S R5W S6	1966 Active	Yes	16,966,031	3,770,000
62	1079	Randolph	Zeigler Coal Spartan #2	T5S R5W S6	1952 Active	Yes	19,409,439	4,313,000

TABLE 4.1 (continued)

Sheet 7 of 18

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
62A	1079	Randolph	Zeigler Coal #11	T5S R5W S6	1975 Active	No	884,211	265,263
63	10792005	Randolph	Moffat Coal Company	T5S R5W S8	1902 1940	Yes	N/A	903,000
64	1073	Perry	Consolidation Coal Burning Star #4	T6S R4W S5	1973 Active	Yes	11,892,498	2,633,000
65	10730035	Perry	Kanow & Fuel Company	T5S R1W S32	N/A 1922	No	N/A	32,000
66	1073	Perry	Consolidation Coal Burning Star #3	T6S R1W S8	1950 Active	Yes	36,268,572	8,059,000
66A	1073	Perry	Freeman United Coal #11	T6S R1W S8	1929 Active	Yes	3,264,499	725,000
67	1041	Jefferson	Robertson & Assoc. Eads Mine	T2S R3E S29	1970 Active	Yes	5,123,671	1,138,000
68	10282014	Franklin	Old Ben Coal Corporation	T6S R1E S1	1918 1960	Yes	N/A	305,000
69	1028	Franklin	Old Ben Coal #26	T5S R2E S12	1968 Active	Yes	17,354,628	3,856,000
69A	1028	Franklin	Inland Steel #1	T5S R2E S12	1966 Active	Yes	19,201,981	4,266,000
70	1041	Jefferson	Freeman United Coal Orient #3	T4S R2E S6	1951 Active	Yes	79,398,448	17,643,000

TABLE 4.1 (continued)

Sheet 8 of 18

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
70A	1041	Jefferson	Freeman United Coal Orient #6	T4S R2E S6	1968 Active	Yes	14,848,505	3,299,000
71	1038	St. Clair	Peabody Coal Mine #3	T2S R7W S25	1960 Active	Yes	10,488,319	2,319,000
72	10880023	St. Clair	Consolidated Coal Co.	T2N S8W S10	1905 1927	No	N/A	269,000
73	10481020	Knox	Knoxville Mining Company	T11N R2E S25	1936 1954	Yes	N/A	133,000
74	1029	Fulton	Midland Coal Co. Rapatee Mine	T2N R3E E1/2 S1	1936 1954	Yes	N/A	133,000
75	10290093	Fulton	Kickapoo Coal Co.	T8N R4E S3	N/A	No	N/A	29,000
76	10290151	Fulton	Alder Coal Company	T8N R4E S27	N/A 1925	No	N/A	226,000
77	10292010	Fulton	Pschirrer Coal & Asphalt Co.	T7N R4E S3	1936 1961	Yes	16,700,000	34,000
77A	1029	Fulton	Consolidation Coal Norvis Mine	T7N R4E S4	1969 Active	Yes	9,948,437	2,210,000
78	1029	Fulton	Freeman United Coal #17	T7N R8W S27	1962 Active	Yes	49,519,202	11,103,000
79	1029	Fulton	Amax Coal Sunspot Mine	T22N R1E S33	1962 Active	Yes	12,328,664	2,739,000

TABLE 4.1 (continued)

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MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
80	10841006	Shuyler	D & D Coal Co.	T2N R1W S22	1937 1961	No	N/A	68,000
81	1092	Vermilion	Lee Coal Company	T19N R13W S12	1955 Active	No	307,316	68,000
82	10920140	Vermilion	Taylor-English Coal Co.	T18N R12W S3	1918 1931	No	N/A	32,000
83	10922002	Vermilion	Chicago & Harrisburg Coal Co.	T18N R12W S15	1904 1946	Yes	N/A	2,400,000
84	10921220	Vermilion	V-Day Coal Co.	T19N R11W S30	1945 1975	Yes	12,000,000	168,000
85	10371034	Henry	Bill Whippey	T17N R1E S32	1939 1961	No	N/A	169,000
86	10811001	Rock Island	Mielke Brothers	T16N R1W S1	1930 1940	No	N/A	46,000
87	10660025	Mercer	Alden Coal Co.	T15N R2W S27	1910 1925	No	N/A	26,000
88	10660040	Mercer	Coal Valley Mining Co.	T15N R1W S4	N/A 1918	No	N/A	194,000
89	10372002	Henry	Shuler Coal Co.	T14N R1E S33	1923 1965	No	N/A	265,000
90	1043	Knox	Midland Coal Co., Mecca	T12N R4E S18	1956 Active	Yes	3,431,541	762,000

TABLE 4.1 (continued)

Sheet 10 of 18

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION ELABT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
91	10832007	Sangamon	Peabody Coal Co.	T16N R5W S13	1905 1951	N/A	N/A	205,000
92	10562010	Maccoupin	Virden Mining Corp.	T12N R6W S9	1895 1960	No	10,400,000	31,000
93	10682004	Montgomery	Freeman Coal Mining Corp.	T12N R5W S34	1951 1970	No	36,400,000	1,530,000
94	1056	Maccoupin	Monterey Coal #1	T10N R7W S27	1970 Active	Yes	18,816,497	4,180,000
95	10562003	Macoupin	Florida Coal Co.	T8N R7W S13	1919 1968	No	13,000,000	496,000
96	10562006	Macoupin	Superior Coal Co.	T8N R6W S29	1904 1951	No	N/A	28,000
96A	1056C086	Macoupin	Superior Coal Co.	T8N R6W S17	N/A	No	N/A	922,000
97	10562009	Macoupin	Superior Coal Co.	T7N R7W S10	1918 1954	No	24,200,000	1,000,000
98	10562007	Macoupin	Superior Coal Co.	T7N R6W S6	1904 1953	No	33,700,000	203,000
99	10562002	Macoupin	Consolidation Coal Co.	T7N R6W S9	1905 1951	No	N/A	859,000
100	10630007	Montgomery	Corgrove-Moehand Coal Company	T7N R4W S22	1905 1930	No	N/A	103,000

TABLE 4.1 (continued)

Sheet 11 of 18

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
101	10110003	Christian	Assumption Coal and Mining Co.	T12N R1E S2	1887 1917	No	N/A	60,000
102	10110002	Christian	Pana Coal Company	T11N R1E S15	1884 1944	No	N/A	26,000
103	1021	Douglas	Zeigler Coal Murdock Mine	T16N R10E S33	1946 Active	Yes	10,856,710	2,412,000
103A	1021	Douglas	Zeigler Coal #15	T16N R10E S33	1973 Active	No	5,630,569	1,251,000
104	101120007	Cjrostoam	Peabody Coal Company	T11N R1E S28	1949 1957	Yes	N/A	50,000
105	1068	Montgomery	Consolidation Coal Co.	T8N R6W S35	1964 Active	Yes	19,213,075	4,268,000
106	10730035	Perry	Brilliant Coal Co.	T6S R1W S19	N/A 1915	No	N/A	28,000
106A	1073	Perry	Southwestern Illinois Coal Co. - Captain Mine	T6S R4W S16	N/A Active	Yes	N/A	N/A
107	10730103	Perry	Peabody Coal Co.	T6S R1W S23	1904 1954	No	N/A	1,160,000
108	10280007	Franklin	U.S. Fuel Co. U.S. Steel Corp.	T6S R3E S21	1916 1924	No	N/A	63,000
109	10282024	Franklin	Freeman Coal Mining Co.	T6S R3E S34	1960 1962	No	148,000,000	121,000

TABLE 4.1 (continued)

Sheet 12 of 18

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
110	10282012	Franklin	Peabody Coal Co.	T7S R3E S8	1905 1949	Yes	N/A	116,000
111	1028	Franklin	Old Ben Coal #24	T6S R3E S18	1965 Active	Yes	28,843,328	6,408,000
112	10392002	Jackson	Union Colliery Co.	T7S R1W S5	1918 1947	Yes	N/A	467,000
113	10282004	Franklin	Chicago-Wilmington & Franklin Coal Co.	T7S R2E S13	1924 1960	Yes	61,100,000	506,000
114	10391028	Jackson	Elk Coal Company	T7S R1W S20	1936 1966	No	15,500,000	549,000
115	10390004	Jackson	Jackson County Coal	T7S R1W S29	1888 1938	No	N/A	26,000
116	10390009	Jackson	Inland Steel & Washing Co.	T8S R1W S8	N/A 1908	No	N/A	38,000
117	1039	Jackson	Consolidation Coal Co. Burning Star #5	T8S R1W S20	1976 Active	Yes	3,596,922	798,000
118	10282020	Franklin	Old Ben Coal Corp.	T7S R3E S20	1914 1968	Yes	4,260,000	787,000
119	11000004	Williamson	Madison Coal Co.	T8S R1E S20	1921 1931	No	N/A	26,000
120	11002088	Williamson	Bell & Zuller Coal Co.	T8S R1E S11	1948 1967	Yes	1,550,000	48,000

TABLE 4.1 (continued)

Sheet 13 of 18

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
120A	11000184	Williamson	Consolidated Coal Co.	T8S R1E S14	1905 1925	No	N/A	39,000
121	11000035	Williamson	T. G. Wardin Coal Corp.	T8S R1E S25	N/A	No	N/A	107,000
122	11000032	Williamson	R. Dick Coal Co.	T8S R1E S36	N/A	No	N/A	73,000
122A	11000034	Williamson	Hafer Washed Coal Co.	T8S R1E S36	1906 N/A	No	N/A	27,000
123	11000050	Williamson	Taylor Coal Co.	T8S R2E S30	N/A 1924	No	N/A	44,000
123A	1100	Williamson	Riggs Mining Company #2	T8S R2E S30	1978 Active	No	N/A	1,000
123B	1100	Williamson	Coldwater Coal Co.	T8S R2E S30	1972 Active	No	465,100	23,000
124	1100	Williamson	Cranshaw Coal #1	T9S R1E S11	1977 Active	No	30,147	7,000
124A	1100	Williamson	E & B Coal #1	T9S R1E S11	1974 Active	No	183,811	41,000
124B	1100	Williamson	E & B Coal #2	T9S R1E S11	1975 Active	No	61,438	14,000
125	11000193	Williamson	Chicago, Wilmington & Franklin Coal Co.	T8S R2E S17	1907 1923	No	N/A	345,000

TABLE 4.1 (continued)

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MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
126	11002003	Williamson	Consolidation Coal Co.	T8S R2E S20	1897 1940	Yes	N/A	44,000
127	11002020	Williamson	Consolidation Coal Co.	T8S R2E S21	1938 1947	Yes	N/A	29,000
128	11002033	Williamson	Freeman Coal Mining Corp.	T8S R2E S10	1947 1955	Yes	4,100,000	310,000
129	1028	Franklin	Old Ben #25	T7S R3E S19	1977 Active	Yes	1,126,995	250,000
129A	1028	Franklin	Old Ben #27	T7S R3E S19	1978 Active	Yes	120,002	27,000
130	1100	Williamson	Zeigler Coal Co. #4	T8S R3E S3	1943 Active	Yes	265,764,694	5,948,000
132	1100	Williamson	Morris Coal #5 & 7	T8S R3E S34	1977 Active	Yes	252,149	56,000
133	1100	Williamson	Amax Delta	T9S R3E S18	1946 Active	Yes	30,489,221	6,774,000
133A	1100	Williamson	Freeman #4	T9S R3E S18	1952 Active	Yes	28,175,470	6,260,000
133B	1100	Williamson	Arrowhead Coal Co. #1	T9S R3E S18	1973 Active	No	5,307	1,000
133C	1100	Williamson	Illinois Coal & Gas #2	T9S R3E S18	1977 Active	No	7,901	2,000

TABLE 4.1 (continued)

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MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
133D	1100	Williamson	North Side Coal Co.	T9S R3E S18	1977 Active	No	16,596	4,000
133E	1100	Williamson	Exford Construction #4	T9S R3E S18	1977 Active	No	10,540	2,000
134	11001150	Williamson	New Black Diamond Coal Co.	T9S R3E S18	1939 1949	No	N/A	152,000
135	11001177	Williamson	Parson Coal Co.	T9S R4E S17	1947 1969	No	4,320,000	83,000
136	11001032	Williamson	Moore & Sons Coal Co.	T9S R4E S29	1933 1958	No	N/A	38,000
137	11002084	Williamson	Blue Bird Coal Co.	T9S R4E S27	1944 1968	No	1,900,000	38,000
138	1100	Williamson	Peabody Coal Co. - Will Scarlet Mine	T10S R4E S13	1953 Active	Yes	19,134,346	4,251,000
138A	1100	Williamson	D. D. Thomas Coal Co.	T10S R4E S25	1976 Active	No	14,684	3,000
139	10822046	Saline	Peabody Coal Co.	T8S R5E S31	1917 1951	No	2,060,000	37,700
140	108220C5	Saline	Peabody Coal Co.	T8S R5E S27	1949 1954	Yes	N/A	1,890,000
141	1082	Saline	Big Ridge Coal Co. #1	T8S R6E S15	1977 Active	No	50,840	11,000

TABLE 4.1 (continued)

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MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
142	1082	Saline	Sahara Coal Co. #6	T9S R5E S29	1936 Active	Yes	29,491,887	6,553,000
142A	1082	Saline	Sahara Coal Co. #20	T9S R6E S16	1970 Active	Yes	4,233,971	940,000
142B	1082	Saline	Sahara Coal Co. #21	T9S R5E S16	1971 Active	Yes	4,139,481	919,000
142C	1082	Saline	J. J. Trash & Brown Bros. Co. #2	T9S R6E S16	1971 Active	No	436,625	96,000
142D	1082	Saline	Equality #1	T9S R6E S16	1978 Active	No	89,383	20,000
142E	1082	Saline	A & G Coal #1	T9S R6E S16	1978 Active	No	6,063	1,000
143	1030	Gallatin	Peabody Coal Eggal Surf.	T9S R9E S26	1960 Active	Yes	1,595,922	354,000
143A	1030	Gallatin	Peabody #2	T9S R9E S26	1969 Active	Yes	4,632,562	1,028,000
143B	1030	Gallatin	Jorder Fuel Co. #7	T9S R9E S26	1975 Active	No	8,343	2,000
144	1044	Johnson	Energy Exploration Company, Ozark	T13S R3E S5	1978 Active	No	10,417	2,000
145	1076	Pope	Bill V. Martin Mine Co., Rock Mine #1	T13S R6E S25	1978 Active	No	12,514	3,000

TABLE 4.1 (continued)

Sheet 17 of 18

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
146	10720027	Peoria	Elmwood Coal Co.	T9N R5E S17	1890 1906	No	N/A	181,000
147	1072	Peoria	Midland Coal Co. Elm Pit	T8N R5E S12	1968 Active	Yes	9,472,582	2,104,000
148	10721031	Peoria	Edward Mohr & Sons Juc.	T8N R7E S23	1918 1952	No	N/A	35,000
149	10722031	Peoria	Crescent Coal	T7N R7E S8	1887 1957	No	N/A	971,000
149A	10720021	Peoria	Crescent Coal	T7N R7E S8	1901 1925	No	N/A	60,000
150	11022002	Woodford	W. G. Sutter	T28N R2W S6	1898 1936	No	N/A	1,430,000
151	11020001	Woodford	Minonk Coal Company	T28N R2W S7	1905 N/A	No	N/A	349,000
152	10590023	Marshall	Toimco Coal Co.	T29N R1E S8	1894 1908	No	N/A	139,000
152A	10590022	Marshall	Toimca Coal Co.	T29N R1E S8	1894 1908	No	N/A	949,000
152B	10590021	Marshall	Toimca Coal Co.	T29N R1E S8	1894 1924	No	N/A	1,700,000
153	10500151	La Salle	Rutland Coal Co.	T29N R2E S18	1915 1930	No	N/A	619,000

TABLE 4.1 (continued)

Sheet 18 of 18

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
154	11022001	Woodford	Roanoke Coal Co.	T27N R1W S14	1884 1941	No	N/A	750,000
155	10640005	McLean	Easterly Coal & Mining Co.	T26N R4E S1	N/A 1907	No	N/A	27,000
156	10530004	Livingston	Cooperative Coal Co.	T26N R6E S5	1890 1926	No	N/A	73,000
157	10640004	McLean	Colfax Cooperative Coal Co.	T24N R5E S3	N/A	No	N/A	26,000
158	10230013	Edgar	Interstate Coal Co.	T14N R10W S9	N/A	No	N/A	114,000
159	10922001	Vermilion	United States Coal & Coke Co.	T18N R12W S26	1916 1947	No	N/A	565,000

TABLE 4.2

Sheet 1 of 4

ESTIMATED QUANTITY AND LOCATION OF SIGNIFICANT DISPOSAL SITES IN MIDWESTERN COAL FIELDS - WESTERN KENTUCKY

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
1	20072003	Union	Island Creek Coal Ohio #1	Uniontown	N/A	Yes	N/A	N/A
2	20072001	Union	Island Creek Coal Hamilton #1	Morganfield	N/A	Yes	N/A	N/A
3	20072004	Union	Peabody Coal Camp. #11 Mine	Morganfield	N/A	Yes	N/A	N/A
4	20072002	Union	Island Creek Coal Hamilton #2	Morganfield	N/A	Yes	N/A	N/A
5	20082004	Webster	Webster County Coal Datiki Mine	Clay	N/A	Yes	N/A	N/A
6	20082002	Webster	Valley Mining Inc. Diamond Mine	Diamond	N/A	Yes	N/A	N/A
7	20082001	Webster	Island Creek Coal Providence #1	Providence	N/A	Yes	N/A	N/A
8	20042008	Hopkins	Owner: Rex Slaten	87° 35' 26" E 37° 18' 29" N	N/A	Yes	N/A	464,000
9	20042011	Hopkins	Island Creek Coal Co.	87° 33' 17" E 37° 19' 01" N	N/A	Yes	N/A	1,191,000
10	20042001	Hopkins	Cimarron Coal Co. Volunteer Mine	Madisonville	N/A	Yes	N/A	N/A
11	20042010	Hopkins	Island Creek Coal Co.	87° 33' 31" E 37° 18' 30" N	N/A	Yes	N/A	823,000
12	20042004	Hopkins	Pittsburgh & Midway Coal Co. Colonial Mine	Madisonville	N/A	Yes	N/A	N/A
13	20042012	Hopkins	Island Creek Coal Co.	87° 31' 45" E 37° 17' 26" N	N/A	Yes	N/A	451,000
14	20042016	Hopkins	Island Creek Coal Co.	87° 27' 00" E 37° 19' 00" N	N/A	Yes	N/A	270,000

TABLE 4.2 (continued)

Sheet 2 of 4

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
14A	20042017	Hopkins	Island Creek Coal Co.	87° 27' 00" E 37° 18' 50" N	N/A	Yes	N/A	986,000
14B	20042018	Hopkins	Island Creek Coal Co.	87° 27' 00" E 37° 18' 50" N	N/A	Yes	N/A	647,000
14C	20042018	Hopkins	Island Creek Coal Co.	87° 36' 00" E 37° 12' 50" N	N/A	Yes	N/A	493,000
14D	20042018	Hopkins	Island Creek Coal Co.	87° 27' 00" E 37° 18' 40" N	N/A	Yes	N/A	2,514,000
15	20042002	Hopkins	Island Creek Coal Fies Mine	Fies	N/A	Yes	N/A	N/A
16	20042003	Hopkins	Island Creek and Mine #9	Fies	N/A	Yes	N/A	N/A
17	20042023	Hopkins	Peabody Coal Co.	87° 31' 09" E 37° 12' 45" N	N/A	Yes	N/A	N/A
17A	20042024	Hopkins	Peabody Coal Co.	87° 25' 00" E 37° 14' 00" N	N/A	Yes	N/A	N/A
17B	20042025	Hopkins	Peabody Coal Co.	87° 25' 09" E 37° 14' 45" N	N/A	Yes	N/A	N/A
17C	20042025	Hopkins	Peabody Coal Co.	87° 25' 00" E 37° 14' 00" N	N/A	Yes	N/A	N/A
18	20042020	Hopkins	Peabody Coal Co.	87° 31' 39" E 37° 12' 46" N	N/A	Yes	N/A	N/A
19	20042019	Hopkins	Unknown	87° 36' 55" E 37° 12' 30" N	N/A	Yes	N/A	382,000
20	20042007	Hopkins	Unknown	87° 40' 03" E 37° 10' 05" N	N/A	Yes	N/A	57,000
21	20042009	Hopkins	Unknown	87° 33' 05" E 37° 10' 28" N	N/A	Yes	N/A	925,000
22	20042013	Hopkins	Island Creek Coal Co.	87° 30' 00" E 37° 08' 40" N	N/A	Yes	N/A	191,000

TABLE 4.2 (continued)

Sheet 3 of 4

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
22A	20042014	Hopkins	Island Creek Coal Co.	87° 30' 10" E 37° 09' 00" N	N/A	Yes	N/A	449,000
22B	20042015	Hopkins	Island Creek Coal Co.	87° 30' 00" E 37° 09' 00" N	N/A	Yes	N/A	877,000
23	20042006	Hopkins	Norton Coal Company	87° 26' 06" E 37° 11' 51" N	N/A	Yes	N/A	28,000
24	20082003	Webster	Diamond Mine Nortonville Mine	Nortonville	N/A	Yes	N/A	N/A
25	20042005	Hopkins	Pittsburgh & Midway Coal Co. Pleasant Hill Mine	White Plains	N/A	Yes	N/A	N/A
26	20012001	Daviess	Green Coal #K-9	Panther	N/A	Yes	N/A	N/A
27	20062007	Ohio	Peabody Coal Co.	86° 59' 39" E 37° 26' 40" N	N/A	Yes	N/A	N/A
28	20062003	Ohio	Peabody Coal Riverview Mine	Hartford	N/A	Yes	N/A	N/A
29	20062004	Ohio	Peabody Coal Center Prep. Plant	Centertown	N/A	Yes	N/A	N/A
30	20062001	Ohio	Peabody Coal Honestead Mine	Beaver Dam	N/A	Yes	N/A	N/A
31	20062002	Ohio	Peabody Coal Ken Mine	Beaver Dam	N/A	Yes	N/A	N/A
32	20062005	Ohio	Peabody Coal Co.	86° 58' 16" E 37° 20' 00" N	N/A	Yes	N/A	N/A
32A	20062006	Ohio	Peabody Coal Co.	86° 58' 16" E 37° 20' 00" N	N/A	Yes	N/A	N/A
33	20052001	Muhlenberg	Gibraltar Coal Gibraltar Mine	Central City	N/A	Yes	N/A	N/A
34	20052005	Muhlenberg	Peabody Coal Co.	87° 02' 44" E 37° 17' 40" N	N/A	Yes	N/A	N/A

TABLE 4.2 (continued)

Sheet 4 of 4

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
35	20052002	Muhlenberg	Island Creek Coal Crescent Mine	Central City	N/A	Yes	N/A	N/A
36	20052006	Muhlenberg	Peabody Coal Co.	87° 14' 19" E 37° 15' 18" N	N/A	Yes	N/A	N/A
36A	20052007	Muhlenberg	Peabody Coal Co.	87° 14' 19" E 37° 15' 18" N	N/A	Yes	N/A	N/A
37	20052010	Muhlenberg	Peabody Coal Co.	87° 12' 47" E 37° 13' 42" N	N/A	Yes	N/A	N/A
37A	20052011	Muhlenberg	Peabody Coal Co.	87° 12' 47" E 37° 13' 42" N	N/A	Yes	N/A	N/A
38	20052003	Muhlenberg	Peabody Coal River Queen	Greenville	N/A	Yes	N/A	N/A
39	20052004	Muhlenberg	Pittsburgh & Midway Paradise Mine	Crakesboro	N/A	Yes	N/A	N/A
40	20052008	Muhlenberg	Peabody Coal Co.	87° 03' 14" E 37° 12' 41" N	N/A	Yes	N/A	N/A
41	20052009	Muhlenberg	Peabody Coal Co.	87° 02' 12" E 37° 12' 41" N	N/A	Yes	N/A	N/A
42	20032001	Hart	Peabody Coal Co.	85° 02' 12" E 37° 20' 57" N	N/A	Yes	N/A	N/A
43	20022001	Edmonson	Rocky Hill Coal Co.	Rocky Hill	N/A	Yes	N/A	N/A
44	20082005	Webster	Valley Mining Company	87° 28' 08" E 37° 31' 17" N	N/A	Yes	N/A	715,000
44A	20082006	Webster	Valley Mining Company	87° 28' 08" E 37° 31' 17" N	N/A	Yes	N/A	193,000
45	20072005	Union	Pittsburgh & Midway Coal Mining Co.	88° 05' 20" E 37° 35' 24" N	N/A	Yes	N/A	N/A
45A	20072006	Union	Pittsburgh & Midway Coal Mining Co.	88° 05' 20" E 37° 35' 24" N	N/A	Yes	N/A	N/A
45B	20072007	Union	Pittsburgh & Midway Coal Mining Co.	88° 05' 20" E 37° 35' 24" N	N/A	Yes	N/A	N/A

TABLE 4.3

Sheet 1 of 4

ESTIMATED QUANTITY AND LOCATION OF SIGNIFICANT DISPOSAL SITES IN MIDWESTERN COAL FIELDS - INDIANA

MAP. REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
1	30082001	Vermilion	Sunspot	T11N R10W SW-1/4 S14	1953 1959	Yes	6,258,996	497,000
2	30082002	Vermilion	Universal	T14N R10W SW-1/4 S31	1970 Active	Yes	20,000,000	1,729,000
3	30092001	Vigo	Tallydale	T13N R9W SE-1/4 S20	1921 1959	Yes	21,786,653	1,588,000
4	30092002	Vigo	Green Valley - Wabash	T12N R10W SW-1/4 S3	1947 1962	Yes	14,236,652	1,130,000
5	30092003	Vigo	Saxton #1	T13N R9W NW-1/4 S3	1924 1958	Yes	12,660,223	1,005,000
6	30091004	Vigo	Otter Creek	T13N R7W SE-1/4 S7	1953 1958	Yes	149,209	2,000
7	30092005	Vigo	Victory Bobolink	T12N R8W S26	1941 1954	Yes	7,741,613	614,000
8	30092006	Vigo	Dresser	T11N R10W SW-1/4 S11	1936 1953	Yes	7,256,039	576,000
9	30092007	Vigo	Springhill	T11N R9W SW-1/4 S2	1921 1964	Yes	2,400,000	190,000
10	30092008	Vigo	Mt. Pleasant	T11N R9W NW-1/4 S12	1928 1974	Yes	1,854,668	147,000
11	30012001	Clay	Old Chinook	T12N R7W SW-1/4 S22	1938 1974	Yes	26,000,000	2,063,000

TABLE 4.3 (continued)

Sheet 2 of 4

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
12	30012002	Clay	Chinook	T12N R7W NW-1/4 S6	1974 Active	Yes	7,000,000+	1,074,000
13	30092009	Vigo	Chieftan	T11N R9W NW-1/4 S33	1953 1968	Yes	18,839,792	1,495,000
14	30092010	Vigo	Black Hawk	T11N R9W E-1/2 S8	1942 1948	Yes	6,223,000	494,000
15	30072001	Sullivan	Thunderbird	T9N R9W SE-1/4 S21	1958 1972	Yes	12,685,975	1,006,000
16	30072002	Sullivan	Jonay	T8N R9W NW-1/4 S14	1947 1955	N/A	1,496,306	31,000
17	30072003	Sullivan	Pardora	T8N R9W SE-1/4 S36	1937 1967	N/A	1,875,948	149,000
18	30072004	Sullivan	Minnehaha	T8N R8W NW-1/4 S27	1936 Active	Yes	28,000,000+	4,296,000
19	30042001	Greene	Linton-Latta	T6N R7W NE-1/4 S10	1938 Active	Yes	23,000,000+	3,529,000
20	30041002	Greene	Ax	T8N R7W NE-1/4 S28	1955 1957	No	100,000+	2,000
21	30072005	Sullivan	Friar Tuck - New Hope	T8N R8W NW-1/4 S36	1930 1965	Yes	15,000,000+	1,190,000
22	30072006	Sullivan	Regent New Harmony	T7N R8W SW-1/4 S3	1943 1954	Yes	4,018,025	85,000
23	30072007	Sullivan	Allendale	T7N R8W Center S36	1924 1946	Yes	6,632,878	526,000

TABLE 4.3 (continued)

Sheet 3 of 4

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
24	30042003	Greene	Airline	T7N R7N SE-1/4 S34	1938 1965	Yes	20,000,000+	1,587,000
25	30042004	Greene	Peabody Coal Co. Hawthorn	T6N R7W NW-1/4 S30	1966 Active	Yes	19,500,000+	2,992,000
26	30052001	Knox	Shasta	T4N R8W S-1/2 S27	1944 1957	Yes	7,433,536	590,000
27	30052002	Knox	Knox Consolidated #2	T4N R9W S4	1918 1949	Yes	13,112,623	1,041,000
28	30052003	Knox	Eneco-Knox Consolidated #5	T4N R9W S4	1942 1962	Yes	11,879,478	943,000
29	30052004	Knox	Julian	T3N R9W S4	1942 1949	Yes	4,913,558	104,000
30	30052005	Knox	Standard #2	T3N R8W S27	1928 1945	Yes	7,167,146	569,000
31	30022003	Daviess	Maid Marian	T4N R8W S-1/2 S13	1947 1953	Yes	1,496,306	32,000
32	30032001	Gibson	Kings Station	T2S R11W W-1/2 S14	1923 1973	Yes	31,668,921	2,513,000
33	30032002	Gibson	Buckskin	T3S R9W S-1/2 S22	1918 1940	Yes	2,486,000	197,000
34	30062001	Pike	Old Ben #2	T1S R7W SW-1/4 S7	1976 Active	Yes	6,575,376+	1,008,000
35	30063002	Pike	Blackfoot #5	T1S R7W SW-1/4 S20	1959 1977	Yes	16,821,973	1,335,000

TABLE 4.3 (continued)

Sheet 4 of 4

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
36	30062003	Pike	Wick	T2S R8W S-1/2 S28	1929 1940	Yes	1,807,000	38,000
37	30062004	Pike	Blackfoot	T2S R7W Center 51	1941 1964	Yes	14,606,438	1,159,000
38	30062005	Pike	Old Ben #1 - Enos	T4S R8W NW-1/4 S17	1923 Active	Yes	70,891,000	5,626,000
39	30102001	Warrick	Peabody Coal Co. Lynville	T4S R8W W-1/2 S17	1953 Active	Yes	61,000,000+	9,360,000
40	30102002	Warrick	Tecumseh	T4S R7W W-1/2 S17	1940 1965	Yes	20,864,570	1,656,000
41	30102003	Warrick	Buckskin	T4S R8W SW-1/4 S13	1946 1956	Yes	2,387,586	189,000
42	30102004	Warrick	Peabody Coal Co. Sugar Creek	T5S R9W E-1/2 S18	1966 Active	Yes	20,000,000+	1,587,000
43	30102005	Warrick	Ayrshire	T5S R9W SE-1/4 S22	1974 Active	Yes	10,400,000+	1,596,000
44	30102006	Warrick	Sunlight	T5S R8W SW-1/4 S22	1934 1955	Yes	19,600,510	1,556,000

TABLE 4.4

Sheet 1 of 2

ESTIMATED QUANTITY AND LOCATION OF SIGNIFICANT DISPOSAL SITES IN MIDWESTERN COAL FIELDS - MISSOURI

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
1	4072001	Putnam	Missouri Mining Inc. Evamaria Bluebell Mine	T65N R19W S2	Active	Yes	N/A	N/A
2	40052001	Henry- Johnson	Windsor Coal Co.	T44N R25W S36	N/A	No	N/A	N/A
3	40052002	Henry	Windsor Coal Co.	T44N R25W S35	N/A	No	N/A	N/A
4	40042001	Henry	Peabody Coal Tebo Mine	T43N R25W S11	Active	Yes	N/A	N/A
5	40042002	Henry	Peabody Coal Reliance Shop Mine	T42N R27W S11	N/A	No	N/A	N/A
6	40032001	Callaway- Boone	Cedar Creek	T48N R11W S10 & 11	N/A	No	N/A	N/A
7	40012001	Barton	D.S.L. Mining #1	T31N R33W SW-1/4 S18	Active	Yes	N/A	N/A
8	40102001	Vernon	Walker Ared	T36N R30W S10	N/A	No	N/A	N/A
9	40062001	Macon	Keota Mine	T57N R15W S33	N/A	No	N/A	N/A
10	40062001	Macon	Peabody Coal Bee Veer Mine	T57N R14W S20	Active	Yes	N/A	N/A
11	40082001	Randolph	Peabody Coal Mark Twain Mine	T55N R14W S23	N/A	No	N/A	N/A

TABLE 4.4 (continued)

Sheet 2 of 2

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
12	40082002	Randolph	Peabody Coal #530	T54N R14W S29	N/A	No	N/A	N/A
13	40082003	Randolph	Peabody Coal #531	T54N R14W S31	N/A	No	N/A	N/A
14	4022001	Bates	Tiger Coal	T39N R33W S18	N/A	No	N/A	N/A
15	40042003	Henry	Peabody Coal Gerrantown	T41N R28W S27	N/A	No	N/A	N/A
16	40092001	St. Clair	Pioneer Mine	T39N R28W S4	N/A	No	N/A	N/A

TABLE 4.5

ESTIMATED QUANTITY AND LOCATION OF SIGNIFICANT DISPOSAL SITES IN MIDWESTERN COAL FIELDS - OKLAHOMA

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
1	50052001	Rogers	Fuel Dynamics Inc. Black Diamond Mine	T24N R17E S24	Active	Yes	N/A	N/A
2	50012C01	Craig	Leon's Coal Co. Bluejacket Mine	T27N R21E S28	Active	Yes	N/A	N/A
3	50012C02	Craig	Cherokee Coal Co. Welch Mine	T26N R21E S30	Active	Yes	N/A	N/A
4	50042001	Okmulgee	Peltron Mine #1	T14N R13E S7	Active	Yes	N/A	N/A
5	50032001	Muskogee	Carbonex Coal Pcsum Mine	T9E R19E S2	Active	Yes	N/A	N/A
6	50022001	Haskell	Kerr-McGee Croctaw Mine	T9N R21E S17	Active	Yes	N/A	N/A
7	50022C02	Haskell	Lone Star Street McCurtain Mine	T8N R22E S14	Active	Yes	N/A	N/A

TABLE 4.6

ESTIMATED QUANTITY AND LOCATION OF SIGNIFICANT DISPOSAL SITES IN MIDWESTERN COAL FIELDS - KANSAS

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
1	60012001	Bourbon	Cherokee Coal Co. Ft. Scott Mine	T25S R24E S25	Active	Yes	N/A	N/A
2	60032001	Crawford	Fuel Dynamics Inc. Golden Eagle Mine	T31S R24E S18	Active	Yes	N/A	N/A
3	60022001	Cherokee	Missouri, Kansas & Texas Ry. Co. #15	T32S R23E SW-1/4 S4	N/A	Yes	N/A	N/A
4	60042001	Labette	Bill's Coal Co. Chetopa Mine	T34S R21E S34	Active	Yes	N/A	N/A
5	60032002	Crawford	Clemens Coal Co. Mine #25	T30S T25E	Active	Yes	N/A	N/A

TABLE 4.7

Sheet 1 of 5

ESTIMATED QUANTITY AND LOCATION OF SIGNIFICANT DISPOSAL SITES IN MIDWESTERN COAL FIELDS - ARKANSAS

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
1	70010001	Franklin	N/A	T7N R28W S18	N/A	No	N/A	N/A
2	70060001	Sebastian	N/A	T7N R31W S22	N/A	No	N/A	N/A
3	70060002	Sebastian	N/A	T7N R31W S28	N/A	No	N/A	N/A
4	70060003	Sebastian	N/A	T7N R31W S31	N/A	No	N/A	N/A
5	70060004	Sebastian	N/A	T7N R32W S33	N/A	No	N/A	N/A
6	70060005	Sebastian	N/A	T7N R32W S34	N/A	No	N/A	N/A
7	70060006	Sebastian	N/A	T6N R32W S14	N/A	No	N/A	N/A
8	70060007	Sebastian	N/A	T6N R32W S14	N/A	No	N/A	N/A
9	70060008	Sebastian	N/A	T6N R31W S18	N/A	No	N/A	N/A
10	70060009	Sebastian	N/A	T6N R32W S26	N/A	No	N/A	N/A
11	70060010	Sebastian	N/A	T5N R31W S7	N/A	No	N/A	N/A

TABLE 4.7 (continued)

Sheet 2 of 5

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREAFICATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
12	70060011	Sebastian	N/A	T5N R31W S19	N/A	No	N/A	N/A
13	70060012	Sebastian	N/A	T5N R31W S32	N/A	No	N/A	N/A
14	70060014	Sebastian	N/A	T5N R31W S27	N/A	No	N/A	N/A
15	70060015	Sebastian	N/A	T5N R31W S26	N/A	No	N/A	N/A
16	70060016	Sebastian	N/A	T4N R32W S16	N/A	No	N/A	N/A
17	70060017	Sebastian	N/A	T4N R32W S23	N/A	No	N/A	N/A
18	70060018	Sebastian	National Mines Sugarloaf Mine	T8N R32W S7	Active	Yes	N/A	N/A
19	70020001	Johnson	N/A	T10N R25W S20	N/A	No	N/A	N/A
20	70010002	Franklin	N/A	T9N R26W S28	N/A	No	N/A	N/A
21	70010003	Franklin	N/A	T9N R26W S28	N/A	No	N/A	N/A
22	70010003	Franklin	N/A	T9N R26W S13	N/A	No	N/A	N/A

TABLE 4.7 (continued)

Sheet 3 of 5

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
23	700200C2	Johnson	N/A	T9N R25W S30	N/A	No	N/A	N/A
24	700200C3	Johnson	N/A	T9N R24W S18	N/A	No	N/A	N/A
25	70020004	Johnson	N/A	T9N R24W S17	N/A	No	N/A	N/A
26	70020005	Johnson	N/A	T9N R24W S10	N/A	No	N/A	N/A
27	70020006	Johnson	N/A	T9N R24W S3	N/A	No	N/A	N/A
28	70020007	Johnson	N/A	T9N R24W S10	N/A	No	N/A	N/A
29	70020008	Johnson	N/A	T9N R23W S18	N/A	No	N/A	N/A
30	70020009	Johnson	N/A	T9N R23W S17	N/A	No	N/A	N/A
31	70030001	Logan	N/A	T8N R24W S23	N/A	No	N/A	N/A
32	70010004	Franklin	N/A	T7N R28W S3	N/A	No	N/A	N/A
33	70030002	Logan	N/A	T7N R27W S3	N/A	No	N/A	N/A

TABLE 4.7 (continued)

Sheet 4 of 5

MAP REFERENCE NUMBER	MINE IDENTIFICATION CCODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
34	70030003	Logan	N/A	T7N R27W S12	N/A	No	N/A	N/A
35	70030004	Logan	N/A	T8N R26W S30	N/A	No	N/A	N/A
36	70030005	Logan	N/A	T8N R26W S28	N/A	No	N/A	N/A
37	70030006	Logan	N/A	T8N R26W S26	N/A	No	N/A	N/A
38	70030076	Logan	N/A	T8N R26W S28	N/A	No	N/A	N/A
39	70030008	Logan	N/A	T7N R26W S3	N/A	No	N/A	N/A
40	70030009	Logan	N/A	T8N R26W S36	N/A	No	N/A	N/A
41	70030010	Logan	N/A	T7N R26W S8	N/A	No	N/A	N/A
42	70030011	Logan	N/A	T8N R26W S28	N/A	No	N/A	N/A
43	70030008	Pope	N/A	T8N R20W S15	N/A	No	N/A	N/A
44	70040002	Pope	N/A	T7N R20W S21	N/A	No	N/A	N/A

TABLE 4.7 (continued)

Sheet 5 of 5

MAP REFERENCE NUMBER	MINE IDENTIFICATION CODE NUMBER	COUNTY	MINE NAME AND COMPANY	LOCATION REFERENCE	OPENING AND CLOSING DATES	PREPARATION PLANT	TOTAL CUMULATIVE PRODUCTION (tons)	TOTAL REFUSE QUANTITY (cubic yards)
45	70040003	Pope	N/A	T7N R20W S22	N/A	No	N/A	N/A
46	70070C01	Yell	N/A	T6N R21W S34	N/A	No	N/A	N/A
47	70022010	Johnson	Titan Mining Co. Lamar Mine	T9N R24W S10	Active	Yes	N/A	N/A
48	70032012	Logan	Titan Mining Co. Scranton Mine	T8N R24W S10	Active	Yes	N/A	N/A
49	7006C018	Sebastian	N/A	T3N R32W S6	N/A	No	N/A	N/A
50	70050001	Scott	N/A	T3N R32W S28	N/A	No	N/A	N/A

- SLURRY POND INTACT
- ◐ SLURRY PARTLY REMOVED
- ⊗ SLURRY ENTIRELY REMOVED
- ◉ SLURRY INCORPORATED WITH GOB
- ⊖ SITE USED AS A SANITARY LAND FILL
- SOIL COVERED BY SOIL
- ▲ ACTIVE PREPARATION PLANT
- △ ABANDONED PREPARATION PLANT
- ABANDONED COAL MINE WASTE DISPOSAL SITE
ASSOCIATED WITH UNDERGROUND MINES
- S INDICATES A SURFACE MINE
- U INDICATES AN UNDERGROUND MINE
- P INDICATES PREPARATION PLANT ONLY
- A TWO SEPARATE DISPOSAL AREAS AT ONE LOCATION
- B THREE SEPARATE DISPOSAL AREAS AT ONE
LOCATION AND SO ON

FIGURE 4.0
EXPLANATION OF SYMBOLS
ON TOPOGRAPHIC MAPS

BASE MAP REFERENCE:
 PREPARED FROM A PORTION OF THE AURORA,
 ILLINOIS U.S.G.S. QUADRANGLE DATED 1971,
 SCALE 1:250,000.

FIGURE 4.1
 MAP SHOWING LOCATIONS OF SIGNIFICANT
 COAL MINE REFUSE DISPOSAL SITES
 161 IN ILLINOIS

BASE MAP REFERENCE:
 PREPARED FROM A PORTION OF THE AURORA,
 ILLINOIS U.S.G.S. QUADRANGLE DATED 1971,
 SCALE 1:250,000.

FIGURE 4.2
 MAP SHOWING LOCATIONS OF SIGNIFICANT
 COAL MINE REFUSE DISPOSAL SITES
 IN ILLINOIS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE BELLEVILLE,
ILLINOIS & INDIANA U.S.G.S. QUADRANGLE
DATED 1977, SCALE 1:250,000.

FIGURE 4.3
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
IN ILLINOIS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE BELLEVILLE,
ILLINOIS & INDIANA U.S.G.S. QUADRANGLE
DATED 1977, SCALE 1:250,000.

FIGURE 4.4
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
IN ILLINOIS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE BELLEVILLE,
ILLINOIS & INDIANA U.S.G.S. QUADRANGLE
DATED 1977, SCALE 1:250,000.

FIGURE 4.5
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
165 IN ILLINOIS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE BURLINGTON,
ILLINOIS; IOWA; & MISSOURI U.S.G.S. QUADRANGLE
DATED 1958, SCALE 1:250,000.

FIGURE 4.6
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
IN ILLINOIS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE BURLINGTON,
ILLINOIS; IOWA; & MISSOURI U.S.G.S. QUADRANGLE
DATED 1958, SCALE 1:250,000.

FIGURE 4.7
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
IN ILLINOIS

BASE MAP REFERENCE:
 PREPARED FROM A PORTION OF THE DANVILLE,
 ILLINOIS & INDIANA U.S.G.S. QUADRANGLE
 DATED 1971, SCALE 1:250,000.

FIGURE 4.8

MAP SHOWING LOCATIONS OF SIGNIFICANT
 COAL MINE REFUSE DISPOSAL SITES
 168 IN ILLINOIS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE DAVENPORT,
IOWA & ILLINOIS U.S.G.S. QUADRANGLE DATED 1968,
SCALE 1:250,000.

FIGURE 4.9
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
IN ILLINOIS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE DECATUR,
ILLINOIS U.S.G.S. QUADRANGLE DATED 1969,
SCALE 1:250,000.

FIGURE 4.10
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
IN ILLINOIS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE DECATUR,
ILLINOIS U.S.G.S. QUADRANGLE DATED 1969,
SCALE 1:250,000.

FIGURE 4.11
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
IN ILLINOIS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE DECATUR,
ILLINOIS U.S.G.S. QUADRANGLE DATED 1969,
SCALE 1:250,000.

FIGURE 4.12
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
IN ILLINOIS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE PADUCAH, KENTUCKY;
ILLINOIS; MISSOURI; & INDIANA U.S.G.S. QUADRANGLE
DATED 1969, SCALE 1:250,000.

FIGURE 4.13
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
173
IN ILLINOIS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE PADUCAH, KENTUCKY;
ILLINOIS; MISSOURI; & INDIANA U.S.G.S. QUADRANGLE
DATED 1969, SCALE 1:250,000.

FIGURE 4.14
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
174 IN ILLINOIS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE PADUCAH, KENTUCKY;
ILLINOIS; MISSOURI; & INDIANA U.S.G.S. QUADRANGLE
DATED 1969, SCALE 1:250,000.

FIGURE 4.15
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
IN ILLINOIS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE PEORIA,
ILLINOIS U.S.G.S. QUADRANGLE DATED 1971,
SCALE 1:250,000.

FIGURE 4.16
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
IN ILLINOIS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE PEORIA,
ILLINOIS U.S.G.S. QUADRANGLE DATED 1971,
SCALE 1:250,000.

FIGURE 4.17
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
177 IN ILLINOIS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE INDIANAPOLIS,
INDIANA & ILLINOIS U.S.G.S. QUADRANGLE DATED
1974, SCALE 1:250,000.

FIGURE 4.18
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
178
IN ILLINOIS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE EVANSVILLE,
INDIANA & KENTUCKY U.S.G.S. QUADRANGLE DATED 1974,
SCALE 1:250,000.

FIGURE 4.19
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
179
IN KENTUCKY

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE EVANSVILLE,
INDIANA & KENTUCKY U.S.G.S. QUADRANGLE DATED 1974,
SCALE 1:250,000.

FIGURE 4.20
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
180
IN KENTUCKY

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE EVANSVILLE,
INDIANA & KENTUCKY U.S.G.S. QUADRANGLE DATED 1974,
SCALE 1:250,000.

FIGURE 4.21
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
181
IN KENTUCKY

BASE MAP REFERENCE:
 PREPARED FROM A PORTION OF THE EVANSVILLE,
 INDIANA & KENTUCKY U.S.G.S. QUADRANGLE DATED 1974,
 SCALE 1:250,000.

FIGURE 4.22
 MAP SHOWING LOCATIONS OF SIGNIFICANT
 COAL MINE REFUSE DISPOSAL SITES
 182
 IN KENTUCKY

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE PADUCAH, KENTUCKY;
ILLINOIS; MISSOURI; & INDIANA U.S.G.S. QUADRANGLE
DATED 1969, SCALE 1:250,000.

FIGURE 4.23
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
183 IN KENTUCKY

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE INDIANAPOLIS,
INDIANA & ILLINOIS U.S.G.S. QUADRANGLE DATED
1974, SCALE 1:250,000.

FIGURE 4.24

MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
184 IN INDIANA

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE INDIANAPOLIS,
INDIANA & ILLINOIS U.S.G.S. QUADRANGLE DATED
1974, SCALE 1:250,000.

FIGURE 4.25
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
IN INDIANA

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE VINCENNES,
INDIANA; ILLINOIS; & KENTUCKY U.S.G.S.
QUADRANGLE DATED 1969, SCALE 1:250,000.

FIGURE 4.27
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
187
IN INDIANA

BASE MAP REFERENCE:
 PREPARED FROM A PORTION OF THE CENTERVILLE,
 IOWA & MISSOURI U.S.G.S. QUADRANGLE DATED 1977,
 SCALE 1:250,000.

FIGURE 4.28
 MAP SHOWING LOCATIONS OF SIGNIFICANT
 COAL MINE REFUSE DISPOSAL SITES
 188 IN MISSOURI

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE JEFFERSON CITY,
MISSOURI U.S.G.S. QUADRANGLE DATED 1970,
SCALE 1:250,000.

FIGURE 4.29
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
IN MISSOURI

BASE MAP REFERENCE:
 PREPARED FROM A PORTION OF THE JEFFERSON CITY,
 MISSOURI U.S.G.S. QUADRANGLE DATED 1970,
 SCALE 1:250,000.

FIGURE 4.30
 MAP SHOWING LOCATIONS OF SIGNIFICANT
 COAL MINE REFUSE DISPOSAL SITES
 190 IN MISSOURI

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE JOPLIN,
MISSOURI & KANSAS U.S.G.S. QUADRANGLE
DATED 1974, SCALE 1:250,000.

FIGURE 4.31
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
191
IN MISSOURI

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE JOPLIN,
MISSOURI & KANSAS U.S.G.S. QUADRANGLE
DATED 1974, SCALE 1:250,000.

FIGURE 4.32
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
IN MISSOURI

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE MOBERLY,
MISSOURI U.S.G.S. QUADRANGLE DATED 1970,
SCALE 1:250,000.

FIGURE 4.33
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
IN MISSOURI

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE LAWRENCE,
KANSAS & MISSOURI U.S.G.S. QUADRANGLE
DATED 1974, SCALE 1:250,000.

FIGURE 4.34
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
194 IN MISSOURI

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE TULSA,
OKLAHOMA; ARKANSAS; MISSOURI; & KANSAS
U.S.G.S. QUADRANGLE DATED 1973, SCALE
1:250,000.

FIGURE 4.35
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
195 IN OKLAHOMA

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE FORT SMITH,
ARKANSAS & OKLAHOMA U.S.G.S. QUADRANGLE
DATED 1949, SCALE 1:250,000.

FIGURE 4.36
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
196
IN OKLAHOMA

BASE MAP REFERENCE:
 PREPARED FROM A PORTION OF THE FORT SMITH,
 ARKANSAS & OKLAHOMA U.S.G.S. QUADRANGLE
 DATED 1949, SCALE 1:250,000.

FIGURE 4.37
 MAP SHOWING LOCATIONS OF SIGNIFICANT
 COAL MINE REFUSE DISPOSAL SITES
 197 IN OKLAHOMA

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE JOPLIN,
MISSOURI & KANSAS U.S.G.S. QUADRANGLE
DATED 1974, SCALE 1:250,000.

FIGURE 4.38
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
198
IN KANSAS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE FORT SMITH,
ARKANSAS & OKLAHOMA U.S.G.S. QUADRANGLE
DATED 1949, SCALE 1:250,000.

FIGURE 4.40
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
IN ARKANSAS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE RUSSELLVILLE,
ARKANSAS U.S.G.S. QUADRANGLE DATED 1954,
SCALE 1:250,000.

FIGURE 4.41
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
201
IN ARKANSAS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE RUSSELLVILLE,
ARKANSAS U.S.G.S. QUADRANGLE DATED 1954,
SCALE 1:250,000.

FIGURE 4.42
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
202
IN ARKANSAS

BASE MAP REFERENCE:
PREPARED FROM A PORTION OF THE McALESTER,
ARKANSAS & OKLAHOMA U.S.G.S. QUADRANGLE
DATED 1948, SCALE 1:250,000.

FIGURE 4.43
MAP SHOWING LOCATIONS OF SIGNIFICANT
COAL MINE REFUSE DISPOSAL SITES
203 IN ARKANSAS

5. DATA COLLECTION PLAN

As discussed in the previous sections, available information on physical, chemical, and engineering properties of the coal wastes in the Midwestern coal fields is meagre. Consequently, a meaningful characterization of the properties depending on the geology, geography, amount of existing volume of the waste, and projected waste production cannot be performed on the basis of the available information. Therefore, the following program has been planned to fill the gaps in information on various properties:

- Identification of properties needing further investigation;
- Selection of suitable number of sampling sites; and
- Drilling and sampling program.

Twenty of the various physical, chemical, and engineering properties pertinent to design of safe, economical, and environmentally acceptable disposal systems; underground disposal of coal waste; and secondary use of waste have been identified and presented in Section 1. These twenty properties will be investigated in detail at twenty candidate sites located in different coal fields of the Midwestern region.

From the inventory of significant coal waste disposal areas in the Midwestern region presented in Section 4, it is revealed that most of the quantity of refuse associated with abandoned sites is placed in piles, whereas most of the waste associated with the active disposal areas is contained in slurry ponds. The disposal areas given in the inventory contain over 80 percent of the total existing waste in the Midwestern region.

Twenty candidate sites have been selected for drilling and sampling in order to generate sufficient information on the selected properties to enable meaningful characterization of waste materials in the Midwestern coal fields. Selection of the sites was based on the following considerations:

- Quality of existing waste distribution;
- Projected future waste production;
- Geographical distribution;
- Geology;
- Age of the waste;

- Availability of existing data; and
- Site accessibility.

Table 5.1 gives the estimated quantities of the existing accumulated waste at the end of 1978 and also the projected quantities of waste production from 1980 through 2000 in different states of the Midwestern region. The quantity of existing refuse in Illinois is about 60 percent of the total quantity in the Midwestern region. The trend of future waste production indicates that about 44 percent of the total waste production in the entire Midwestern region will be in Illinois. Accordingly, about half of the sites for drilling and sampling should be located in Illinois.

Based on the availability of remaining coal reserves in different regions and geographical considerations, the following sites have been selected for the drilling and sampling program:

LOCATION	ESTIMATED NUMBER OF SITES
Southern Illinois	5
Remaining Illinois	5
Western Kentucky	4
Southwestern Indiana	4
Missouri-Kansas	2

Particulars of the selected sites are given in Table 5.2. Sixty-five percent of the sites are active disposal areas, as against 35 percent abandoned sites. As may be seen from the table, some of the abandoned sites are 50 to 80 years old.

Locations of the selected sites are shown on Figures 5.1 through 5.4. These figures also show the concentration of available coal reserves in different areas.

Access permission has been obtained for all the sites except four sites in western Kentucky. Negotiations with the mine operators are at an advanced stage.

Field visits have been made to eight sites. Drilling plans with respect to these sites, taken from the field notes, are shown on Figures 5.5 through 5.12.

The drilling program given in Dames & Moore's proposal has been changed somewhat because of lack of availability of suitable drilling and sampling sites in Oklahoma, Kansas, Arkansas, and Iowa. Iowa has no preparation plants, and there are only two active underground mines that are relatively small

in size. Contacts with operators in Oklahoma revealed that the quantity of refuse in the active disposal sites was rather small, and most of them were being actively reclaimed. A drilling site selected in Missouri runs along the state boundary line between Missouri and Kansas, which is also representative of the northeastern coal-bearing area of Kansas state. All individual disposal sites in Arkansas have generally low volumes and, therefore, are not suitable for drilling.

As may be seen from the drilling plans, an average of 200 linear feet of drilling will be carried out at each candidate site. The number of borings will vary according to the height of the piles and depth of the slurry ponds. The borings have been located in a manner that will enable determination of the horizontal and vertical variability of coal waste properties. Truck-mounted or all-terrain vehicle drills will be used, depending on the accessibility of each site. Augers will be used to advance the borings. Samples will be taken at a maximum interval of 5 feet using a Dames & Moore Type U sampler, shown on Figure 5.13. An experienced engineer or geologist will supervise the collection of samples and prepare a field log for each boring. In addition to the borings, bulk samples will be collected at each site. In addition, undisturbed samples of coarse refuse will be collected from different sites. Standard penetration tests will also be performed where warranted as a supplement to the undisturbed sampling program. The samples will be suitably packed, labeled, and shipped to Dames & Moore's soils laboratory in Chicago or to other qualified laboratories for specialized testing.

No change is anticipated in the laboratory testing program to be carried out in Phase II at this time.

TABLE 5.1

ESTIMATED ACCUMULATED QUANTITY OF COAL WASTE
AND ITS PROJECTED PRODUCTION
IN DIFFERENT STATES OF MIDWESTERN COAL FIELDS

STATE	ACCUMULATED QUANTITY OF WASTE (tons)	PROJECTED QUANTITY OF WASTE PRODUCTION FROM 1980 THROUGH 2000 (tons)
Illinois	362,000,000	658,000,000
Western Kentucky	+ 61,500,000	319,000,000
Indiana	114,000,000	319,000,000
Missouri	N/A	55,000,000
Oklahoma	N/A	56,000,000
Kansas	N/A	33,500,000
Iowa	N/A	25,000,000
Arkansas	N/A	22,000,000
Total Midwest	+537,500,000	1,487,500,000

TABLE 5.2

Sheet 1 of 2

LOCATION AND OTHER PARTICULARS
OF SITES SELECTED FOR DETAILED DRILLING AND SAMPLING

CONDITION	STATE AND COUNTY	MINE IDENTIFICATION CODE NUMBER	MINE NAME AND COMPANY	SEAMS MINED	MINE TYPE	DATES	CUMULATIVE PRODUCTION (tons)	REFUSE VOLUME (cubic yards)	PREPARATION PLANT
unburned	ILLINOIS Montgomery	10682004	Freeman-United	N/A	U	1951 1970	36,400,000	1,530,000	no
burned	Grundy	10321005	Eugene Paulsen	N/A	U	1908 1954	N/A	286,000	no
burned	Putnam	10782001	Village of Mark, Ill..	N/A	U	1905 1935	N/A	2,364,000	no
unburned	Madison	10572004	Belleville Titar, Inc. c/o Atty. Robt. Eggmann	N/A	U	1901 1950	N/A	1,800,000	no
partly burned	Vermilion	10922002	CGC Corp. c/o Scott Campbell	N/A	U	1904 1946	N/A	2,400,000	yes
unburned	Macoupin	10562500	Monterey No. 1	No. 6	U	1970 active	13,816,497	5,644,000	yes
unburned	Clinton	10142550	Monterey No. 2	No. 6	U	1977 active	461,809	125,043	yes
unburned	Perry	10732503	Southwestern Illinois Coal Co. - Captain Mine	Nos. 5 & 6	S	N/A active	6,300,000*	N/A	yes
unburned	Williamson	11002505	Zeigler Coal Co. Mine No. 4	No. 6	U	N/A active	702,000*	N/A	yes
unburned	Saline	10922501	Sahara Coal Co. Mine No. 6	No. 6	S	1936 active	29,492,000	8,847,566	yes
unburned (secondary recovery)	INDIANA Knox	30052002	Banner Energy of Indiana Inc. Knox-Consolidated No. 2 (American)	No. 5 (Springfield)	U	1918 1949	13,113,000	N/A	yes
unburned (secondary recovery)	Vigo	30092002	Mineral Resources Green Valley-Wabash	Nos. 3 & 5 (Seeleyville)	U	1947 1962	14,237,000	N/A	yes

*Total for 1977 and 1978.

TABLE 5.2 (continued)

Sheet 2 of 2

CONDITION	STATE AND COUNTY	MINE IDENTIFICATION CODE NUMBER	MINE NAME AND COMPANY	SEAMS MINED	MINE TYPE	DATES	CUMULATIVE PRODUCTION (tons)	REFUSE VOLUME (cubic yards)	PREPARATION PLANT
unburned	INDIANA (cont'd) Sullivan	30072004	AMAX: Minnehaha	Nos. 5, 6, & 7 (Danville)	S, U	1936 active	28,000,000+	N/A	yes
unburned	Clay	30012001	AMAX: Old Chinock	No. 3	S	1938- 1974	26,000,000+	2,063,000	yes
unburned	MISSOURI Bates	40022001	Peabody: Tiger Mine	Mulberry	S	N/A abandoned	N/A	N/A	yes
unburned	Randolph	40082002	Walter Funk: Huntsville East Mine	Bevier	S	N/A abandoned	N/A	N/A	yes
unburned	KENTUCKY Union	20072001	Island Creek Coal Co. Hamilton No. 1	No. 9	U	N/A active	2,750,000*	N/A	yes
unburned	Hopkins	20042002	Island Creek: Fies Mine	No. 11	U	N/A active*	1,192,000*	N/A	yes
unburned	Muhlenberg	20052003 Central City (U)	Peabody: River Queen	Nos. 11, 12, & 9	S, U	N/A active	4,457,000(S)* 1,535,000(U)*	N/A	yes
unburned	Ohio	20062004	Peabody: Center Preparation Plant (Coal from Alston Nos. 3 & 4, Alston Surface Mine and River Queen Mine)	No. 9	S, U	1973 active	N/A	N/A	yes

Billions of tons

FIGURE 5.1
SITE LOCATIONS
IN ILLINOIS

- Coal producing area
- Coal bearing rocks
- Non coal bearing rock

FIGURE 5.2
SITE LOCATIONS IN
SOUTHWESTERN INDIANA

RESOURCES IN BILLIONS OF TONS

FIGURE 5.3
SITE LOCATIONS
IN KENTUCKY

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EXPLANATION.

- AREA UNDERLAID WITH COAL DEPOSITS
- MAJOR COAL FIELDS

**FIGURE 5.4
SITE LOCATIONS
IN MISSOURI**

FIGURE 5.5
PLAN VIEW OF REFUSE PILE AND
SLURRY POND

MINE IDENTIFICATION
NO. 40022001

FIGURE 5.6
MAP SHOWING APPROXIMATE LOCATIONS
OF PROPOSED BORINGS

PLAN VIEW

FIGURE 5.7
MAP SHOWING LOCATIONS
OF PROPOSED BORINGS AND
THEIR APPROXIMATE DEPTH

FIGURE 5.8
MAP SHOWING LOCATIONS
OF PROPOSED BORINGS AND
THEIR APPROXIMATE DEPTH

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FIGURE 5.9
MAP SHOWING LOCATIONS
OF PROPOSED BORINGS AND
THEIR APPROXIMATE DEPTH

FIGURE 5.10
MAP SHOWING LOCATIONS
OF PROPOSED BORINGS AND
THEIR APPROXIMATE DEPTH

MINE IDENTIFICATION
NO. 10142500

220

MINE IDENTIFICATION
NO. 10562500

FIGURE 5.12
MAP SHOWING LOCATIONS
OF PROPOSED BORINGS

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ALTERNATE ATTACHMENTS

FIGURE 5.13
SOIL SAMPLER TYPE U

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APPENDIX A

MINE IDENTIFICATION CODE NUMBER SYSTEM FOR LOCATIONS OF MINE WASTE DISPOSAL SITES IN MIDWESTERN COAL FIELDS

VARIABLE	CODE	DEFINITION
State	1-9	State Number
	1 -	Illinois
	2 -	Western Kentucky
	3 -	Indiana
	4 -	Missouri
	5 -	Oklahoma
	6 -	Kansas
	7 -	Arkansas
	8 -	Iowa
	9 -	Nebraska
County	See Appendix B	
Mine Classification (Based on Illinois Department of Mines & Minerals)	0 -	Unclassified
	1 -	Local
	2 -	Shipping
Mine Identification Number	001-999	Countywide

APPENDIX B

CODE IDENTIFICATIONS FOR COUNTIES OF ILLINOIS, WESTERN KENTUCKY, INDIANA, MISSOURI, OKLAHOMA, KANSAS, ARKANSAS, IOWA, AND NEBRASKA IN WHICH COAL MINE WASTE SITES WERE IDENTIFIED

Illinois

<u>CODE</u>	<u>COUNTY</u>	<u>CODE</u>	<u>COUNTY</u>
001	Adams	056	Macoupin
003	Bond	057	Madison
005	Brown	058	Marion
006	Bureau	059	Marshall
007	Calhoun	062	McDonough
009	Cass	064	McLean
010	Champaign	065	Menard
011	Christian	066	Mercer
012	Clark	068	Montgomery
014	Clinton	069	Morgan
015	Coles	070	Moultrie
017	Crawford	072	Peoria
018	Cumberland	073	Perry
021	Douglas	075	Pike
023	Edgar	076	Pope
024	Edwards	078	Putnam
028	Franklin	079	Randolph
029	Fulton	080	Richland
030	Gallatin	081	Rock Island
031	Greene	082	Saline
032	Grundy	083	Sangamon
034	Hancock	084	Schuyler
035	Hardin	085	Scott
037	Henry	086	Shelby
039	Jackson	087	Stark
040	Jasper	088	St. Clair
041	Jefferson	090	Tazewell
042	Jersey	092	Vermilion
044	Johnson	093	Wabash
046	Kankakee	094	Warren
048	Knox	095	Washington
050	La Salle	097	White
051	Lawrence	099	Will
053	Livingston	100	Williamson
054	Logan	102	Woodford
055	Macon		

APPENDIX B (continued)

Western Kentucky

<u>CODE</u>	<u>COUNTY</u>	<u>CODE</u>	<u>COUNTY</u>
001	Daviess	005	Muhlenberg
002	Edmonson	006	Ohio
003	Hart	007	Union
004	Hopkins	008	Webster

Indiana

<u>CODE</u>	<u>COUNTY</u>	<u>CODE</u>	<u>COUNTY</u>
001	Clay	006	Pike
002	Daviess	007	Sullivan
003	Gibson	008	Vermillion
004	Greene	009	Vigo
005	Knox	010	Warrick

Missouri

<u>CODE</u>	<u>COUNTY</u>	<u>CODE</u>	<u>COUNTY</u>
001	Barton	006	Macon
002	Bates	007	Putnam
003	Callaway-Boone	008	Randolph
004	Henry	009	St. Clair
005	Henry-Johnson	010	Vernon

Oklahoma

<u>CODE</u>	<u>COUNTY</u>	<u>CODE</u>	<u>COUNTY</u>
001	Craig	004	Okmulgee
002	Haskell	005	Rogers
003	Muskogee		

Kansas

<u>CODE</u>	<u>COUNTY</u>	<u>CODE</u>	<u>COUNTY</u>
001	Bourbon	003	Crawford
002	Cherokee	004	Labette

APPENDIX B (continued)

Arkansas

<u>CODE</u>	<u>COUNTY</u>	<u>CODE</u>	<u>COUNTY</u>
001	Franklin	005	Scott
002	Johnson	006	Sebastian
003	Logan	007	Yell
004	Pope		