JPL PUBLICATION 80-99

DOE/ET-12548-3
Distribution Category UC-88

(NASA-CR-163974) THE ENVIORNMENTAL ASSESSMENT OF A CONTEMPORARY COAL MINING SYSTEM (Jet Propulsion Lab.) 55 p HC A04/MF A01 CSCL 13B

N81-18571

Unclas
G3/45 41576

The Environmental Assessment of a Contemporary Coal Mining System

Elisabeth J. Dutzi
Patrick J. Sullivan
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U.S. Department of Energy
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ABSTRACT

A contemporary underground coal mine in eastern Kentucky was assessed in order to determine potential off-site and on-site environmental impacts associated with the mining system in the given environmental setting. A 4-section, continuous room-and-pillar mine plan was developed for an appropriate site in eastern Kentucky. Potential environmental impacts were identified, and mitigation costs determined, using an environmental assessment methodology for coal extraction systems developed by Sullivan et al., 1980 (JPL Publication 79-82). The major potential environmental impacts were determined to be: (1) acid water drainage from the mine and refuse site, (2) uneven subsidence of the surface as a result of mining activity, and (3) alteration of ground-water aquifers in the subsidence zone. In the specific case examined, the costs of environmental impact mitigation to levels prescribed by regulations would not exceed $1/ton of coal mined, and post-mining land values would not be affected.

FOREWORD

This document is one of a series which describe systems level requirements for advanced underground coal mining equipment. These requirements are summarized in "Overall Requirements for an Advanced Underground Coal Extraction System," JPL Publication 80-39, by Martin Goldsmith and Milton L. Lavin. Five areas of performance are discussed:

(1) Production cost.

(2) Miner safety.

(3) Miner health.

(4) Environmental impact.

(5) Recovery efficiency.

The report which follows illustrates the methodology used to assess compliance with the environmental impact requirements. Details of this methodology may be found in "A Methodology for the Environmental Assessment of Advanced Coal Extraction Systems", JPL Publication 79-82.

This work is part of an effort to define and develop innovative coal extraction systems suitable for the significant resources remaining in the year 2000. Sponsorship is provided by the Office of Mining, United States Department of Energy via an interagency agreement with the National Aeronautics and Space Administration. William B. Schmidt, Director of the Office of Mining, is the Project Officer.

Co-Authors Patrick J. Sullivan and Charles F. Hutchinson are no longer with the Jet Propulsion Laboratory. Sullivan is now with the Department of Natural Resources, Ball State University, Muncie, Indiana, and Hutchinson is with the University of Arizona, Office of Arid Land Studies, Tucson.

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SECTION I

INTRODUCTION

The objectives of the Advanced Coal Extraction Systems Definition Project are to define, develop, and demonstrate advanced systems for underground coal mining. For the purposes of the project, advanced systems are understood to be (1) suitable for the most significant resources remaining in the year 2000, and (2) systems which promise a significant improvement over current systems in production cost and/or miner safety, and are comparable to or better than current systems in terms of miner health, minimization of environmental impact, and resource conservation.

In preparation for systems definition, efforts to date have been directed toward developing tools for evaluating systems and formulating overall systems requirements. Evaluation methodologies have been completed for characterizing systems in five performance areas: production cost, miner safety, miner health, environmental impact, and resource conservation. The evaluation methodology developed for the environmental impact performance area by Sullivan, et al., (1980) is intended as a tool for assessing the environmental impacts associated with advanced underground coal mining systems. In addition, overall systems requirements in the five performance areas have been defined (Goldsmith and Lavin, 1980). The environmental impact systems requirements are specific to the project's target region of Central Appalachia; other areas will be addressed in future work.

The purpose of this document is to demonstrate, on a site-specific basis and using a contemporary underground coal mining system, the environmental impact evaluation methodology developed by Sullivan, et al., (1980). The document includes (1) a statement of the environmental impact systems requirements, as outlined by Goldsmith and Lavin (1980); (2) a discussion of site selection; (3) a description of the mining system chosen for evaluation and the physical site characteristics; (4) an identification of potential environmental impacts following the methodology outlined by Sullivan, et al., (1980); (5) a discussion of generalized costs for mitigating these impacts; and (6) an impact summary.

SECTION II

ENVIRONMENTAL IMPACT REQUIREMENTS

The intent of the environmental impact systems requirements is to develop constraints for new systems to achieve a minimal level of performance in the environmental area. Two factors preclude the formulation of quantitative environmental performance goals for generic systems. First, the environmental impacts associated with coal mining are determined, in large part, by the interaction between the mining system and the specific site being mined. Thus, to develop a specific set of requirements without a specific operating site would be unrealistic. Second, many generic environmental impacts are the result of underground mining activity per se and are independent of the particular system being used; for example, all current underground mining systems will result in generation of refuse and alteration of hydrology. Because the environmental performance of current technology can be quantified only on a site-specific basis, the overall environmental requirements are expressed as constraints on system performance rather than as a set of predictable or unchanging performance goals. Realistically, advanced systems should minimize adverse environmental impacts during mining operations and maintain land suitability for future uses. Two systems requirements were developed which reflect these constraints (Goldsmith and Lavin, 1980).

The first requirement addresses the costs of mitigating potential environmental impacts. Environmental impacts are defined as those consequences of the mining activity that constitute a potential for degradation of off-site environmental quality, and for which environmental law and regulation require mitigation. Both current and advanced underground mining systems will be evaluated in the light of existing mitigation and reclamation technologies. Several assumptions underlie this approach. The first is that all potential adverse environmental impacts can be mitigated to an acceptable level. If impacts cannot be mitigated to levels prescribed by law and regulation, the mining activity would be prohibited and the system would not be evaluated further. A second assumption is that the total cost of mitigating adverse environmental impacts to acceptable levels is a reasonable surrogate for significance of the aggregated impacts. In adopting this approach, the need for assessing the relative importance of individual impacts is precluded. Since required mitigation of potential off-site impacts is not a productive part of the mining enterprise, innovation in system design which proportionally reduces these "non-productive" costs will result in a significant cost advantage over conventional systems if all else is held constant.

The second requirement addresses the range of potential land uses of the mine site following mine closure. The effects of mining upon subsequent land uses are considered on-site impacts which are dealt with during reclamation. In determining the impacts of a mining system upon the site, it is assumed that either a land-use plan exists or that the range of possible uses can be projected for the mining region. In using this approach, the designated or projected land use is assumed to reflect public opinion concerning the most appropriate or most likely use for the land in question. Successful reclamation should at least maintain the value of the land for its previous use.

Statements of the two environmental requirements and the steps by which system performance will be evaluated in relation to the two requirements are outlined in the following sections.

A. REQUIREMENT I

Advanced underground mining systems should not result in higher costs of off-site environmental impact mitigation than those associated with current mining technology. A desirable level of performance is a significant cost reduction over current technology.

As stipulated by law, most mining activities cannot result in significant adverse impacts on their surroundings. Consequently, mitigation measures must be used to prevent environmental quality degradation if penalty is to be avoided. It is assumed that environmental regulations reflect the opinion of the community at large in the determination of impact significance, and that the cost of mitigation reflects the ease of compliance with regulations. Therefore, cost of off-site environmental impact mitigation is used as an indicator of the complexity of off-site environmental problems associated with any system.

In this document, environmental impacts associated with mining systems on specific sites were identified using the approach described in A Methodology for the Environmental Assessment of Advanced Coal Extraction Systems (Sullivan, et al., 1980). After potential impacts were identified, cost figures for their mitigation were determined, based on the figures put forth in Analysis of Pollution Control Costs (Doyle, et al., 1974).

B. REQUIREMENT II

Advanced underground mining systems should maintain the value of mined lands for the pre-mining land use following mine closure, employing current reclamation practices.

The on-site impacts of mining systems are reflected in the cost of reclaiming the land after mining is completed, and potential land use and land value following reclamation. The land use category designated or projected for the land subjected to mining by regional planning authorities or the community at large, if such a plan exists, must be considered and the land value established within that category. If no land-use plan exists, the pre-mining land use and value will be considered.

Costs of reclaiming the land following mine closure and restoring land capabilities for the pre-mining or planned use of the land were determined by using cost figures provided in Doyle, et al., (1974).

The following sections constitute an environmental evaluation of a contemporary coal extraction system on a specific site. The evaluation serves both as a demonstration of the methodology and as a benchmark against which proposed advanced systems could be measured.

SECTION III

SITE SELECTION

Application of the environmental assessment methodology required selection of a mine site and a mining system for analysis. The following sections discuss the constraints that guided site selection, including project direction, data availability, and appropriate site characteristics.

A. PROJECT DIRECTION

Central Appalachia was chosen by the project as a target region to guide the initial development of requirements and designs for advanced underground mining systems. This area includes parts of the states of Kentucky, Tennessee, Virginia, and West Virginia. Lavin and Floyd (1978) point out several reasons for choosing Central Appalachia as the target region: (1) the area exhibits a wide range of physiographic and geologic conditions, resulting in a variety of mining conditions; (2) Central Appalachia is typical of the entire Appalachian region in terms of variety of topography, seam access possibilities, and subsurface conditions; (3) Central Appalachia is likely to remain an important source of coal beyond the year 2000 since the area has over 60 billion tons of total reserves; and (4) the area is close to the population centers of the Atlantic coast and to utilities and industrial users.

Since data on Central Appalachia are typically available for separate states rather than on a regional basis, it was convenient to focus on a particular state in formulating mining system requirements. Eastern Kentucky was chosen as the target resource because it is reasonably representative of the entire Central Appalachian region and because extensive data are available for Kentucky coal resources.

B. SITE SELECTION IN EASTERN KENTUCKY

Selection of a suitable site for location of a mining system and assessment of its associated environmental impacts was predicated upon finding an area within the target region with coal resources appropriate for underground mining and for which data were readily available. The Kentucky Department for Natural Resources and Environmental Protection (DNREP) is currently involved in the development of the Kentucky Natural Resources Information System (KNRIS) as a data base for environmental assessments in Kentucky. DNREP chose the USGS Big Creek 15' topographic quadrangle as a prototype area for the information system, since a considerable amount of data was available for this area. The Big Creek quadrangle is located almost entirely in Clay County in the mountainous region of southeastern Kentucky. Since coal resources appropriate for underground mining exist in the Big Creek area, and the Big Creek data were available from DNREP and its contractors, a site was chosen for the test case within the Big Creek 15' quadrangle.

Selection of a site within the Big Creek quad was based upon several considerations:

(1) Seam access - the coal seam to be mined must outcrop at a low elevation in a valley.

(2) Seam thickness - the coal seam must be approximately 6-ft thick to be consistent with equipment performance projections made in a companion project effort.

(3) Seam extent - the coal seam must cover an adequate area (i.e., relatively continuous) for a 4-section mine.

(4) Adequate and appropriate surface area - the site must have suitable areas for surface facilities and refuse dumps.

(5) Transportation access - the site must be near a major highway, preferably be near secondary roads, and have the potential for railroad spurs.

(6) Water availability - water supplies available at the site must be adequate for mine operations and supporting facilities.

After examining geologic and topographic information on several potential sites, the project chose the northern portion of the Ogle 7 1/2' quadrangle (the southwest quarter of the Big Creek quadrangle) as a site for demonstration of the environmental assessment methodology.

SECTION IV

THE ENVIRONMENTAL ASSESSMENT OF A CONTEMPORARY MINE

A contemporary underground mine was asssessed to determine its environmental impacts. The evaluation was completed using A Methodology for the Environmental Assessment of Advanced Coal Extraction Systems by Sullivan, et al., (1980). The assessment (as outlined by Sullivan, et al., 1980) occurred in four steps: (1) the characterization of the mining system, (2) the characterization of the physical environment where the mining system was implemented, (3) a conceptual evaluation, which identified generic impacts associated with the mining system, and (4) a preliminary evaluation, which quantified the impacts. In addition, a discussion of land use and land value following mine closure and reclamation was included.

The results of the evaluation identified the potential major environmental impacts that could result from implementing the system in the given environmental setting, along with quantitative data necessary to estimate the magnitude of each impact. These data were utilized to calculate the costs associated with (1) mitigation of the identified impacts and (2) reclamation of the land to its original or planned use.

A. THE BASELINE MINING SYSTEM

Once the site in eastern Kentucky was chosen, it was necessary to select a mining system for the site. In order to establish a useful baseline for comparison with proposed advanced systems, the system chosen for evaluation on the site should be "typical" of contemporary underground mining systems operating in this region.

Previous project analysis of baseline technology has focused on three contemporary mine system configurations; continuous room and pillar, longwall, and shortwall (Bickerton, 1980). A continuous room and pillar system is employed in approximately 65% of all U.S underground coal mines, conventional room and pillar methods are used in about 30% of all underground mines, and only a small portion of the resource is mined by longwall and shortwall methods (National Coal Association, 1978-1979). Since the continuous room-and-pillar system is used to extract the greatest portion of the resource mined by underground methods, this system was chosen for the analysis reported here.

A continuous room-and-pillar mining system consists of continuous miner equipment units in a room-and-pillar mine configuration. A 4-section, 5-entry mine, with a planned annual production tonnage of 1.2 million tons, was developed for the site; this mine is designated as the "Fantasy Mine #1". Mine system characteristics are summarized from Bickerton (1979):

(1) Production

There are five main entries, 20-ft wide on 100-ft centers. The seam will be assumed to be 6 ft thick. The planned production over the life of the mine is as follows:

Year	Production (ton/yr)
1	135,000
2	811,800
3 to 22	1,200,000
	Total: 24,950,000 tons

Given this production rate and assuming a 57% recovery rate, one may estimate the total area disturbed as 3940 acres.

(2) Surface facilities

There are the following surface facilities:

(a) One two-lane road from the main highway to the mine site and from the mine site to the refuse dump (surface paved with gravel).

(b) The administrative and operation facilities, including shop, warehouse, bath-house, offices, lamphouse, waiting room, supply yard, and parking lot.

(c) Coal processing facilities, including bulk rock dust bin, conveyor from stockpile to rail spur, stockpile, refuse dump, power lines, and equipment.

(d) Treatment facilities for sewage and water.

(3) Water requirements

Water requirements to support mining operations and surface facilities total approximately 40,000 gal/day.

(4) Refuse production

Refuse production runs approximately 5% of coal production. This is equivalent to about 60,000 cubic yards (yd^3) per year.

B. PHYSICAL SITE CHARACTERIZATION

The Fantasy Mine #1 site is located in the southeastern portion of Clay County in eastern Kentucky (Figure 4-1). This location is in the mountain physiographic region on the western border of the Appalachian plateau. It is an area of narrow flood plains, flanked by long, steep mountainsides extending from long, narrow ridgetops composed of Pennsylvanian shale, siltstone, and sandstone. For details of the mine site location see Figure 4-2.

1. Land Use

In this region over 80% of the land surface is covered by natural vegetation. The mine site is bounded to the west and southwest by broad valley flood plains which are covered with grass, herbaceous plants, and cultivated crops. On the gentle slopes above the flood plain and within the narrow upland stream valleys, the land cover and land use are a mixture of residential (no cities or urbanized areas are within the mine boundary), pasture land, and cropland (approximately 10 to 20% of the mine area). The rest of the mine area is natural woodland. Yellow poplar, white oak, black walnut, and other hardwoods dominate the north and east slopes. Black oak, scarlet oak, and hickory dominate the south and west slopes. Chestnut oaks, together with a few shortleaf and pitch pines, occupy most of the upper slopes and the narrow ridges (ESRI, 1980; McDonald and Blevins, 1965).

2. Uniqueness of Area

There are no known archaeological, paleontological, historical, or ecological critical areas located in or near the mine site (ESRI, 1980).

3. Topography

The physiographic region as well as the mine site are composed of numerous steep ridges and narrow valley floors. The landforms are a combination of ridgetops (20%), sideslopes (60%), and toeslopes (20%) that blend into a complex configuration of concave and convex slopes. Over 70% of the region has a slope gradient between 35% and 50%. Near the ridgetops the slope gradient decreases to a range of 12% to 20%. At the toeslope (where most of the mining activity will occur) the slope gradient ranges from 2% to 6% with local increases to 35% (ESRI, 1980).

The maximum elevation (1686 ft above sea level) occurs in the eastern portion of the mine site and decreases to an elevation of 1185 ft in the west (Figure 4-3). The broad alluvial valleys that occur at the western and southwestern boundary of the mine site range in elevation from 800-to-900 ft. In general, the local relief averages between 300 and 600 ft.

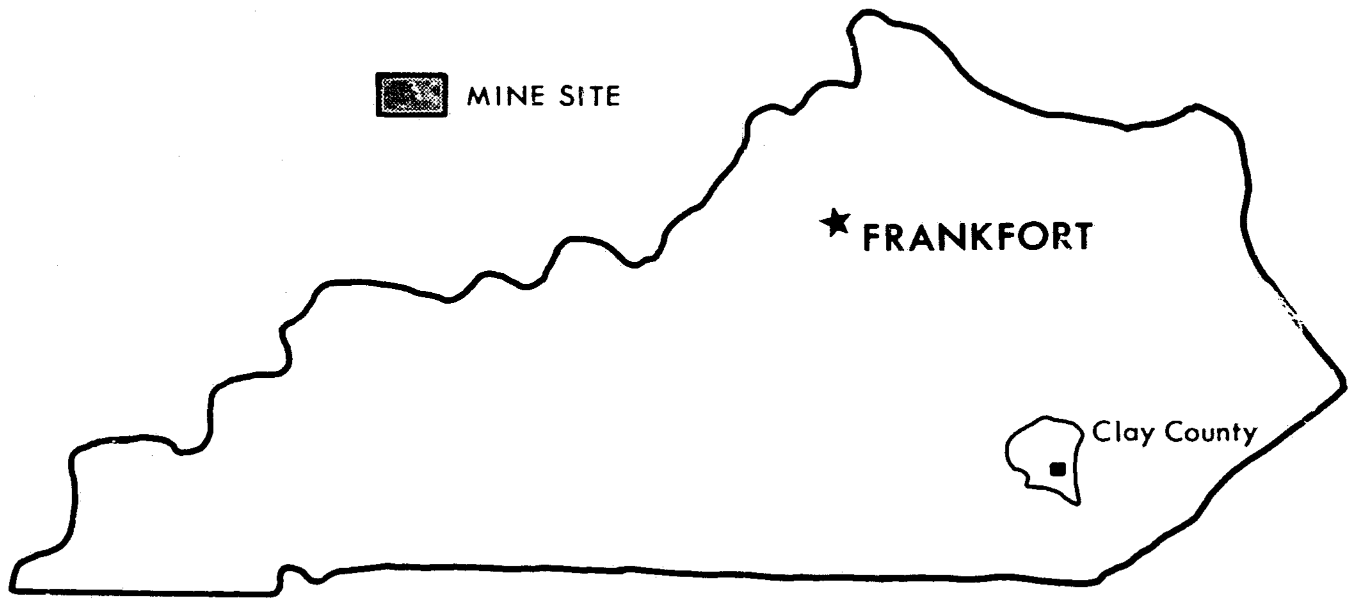

Figure 4-1. Location Map

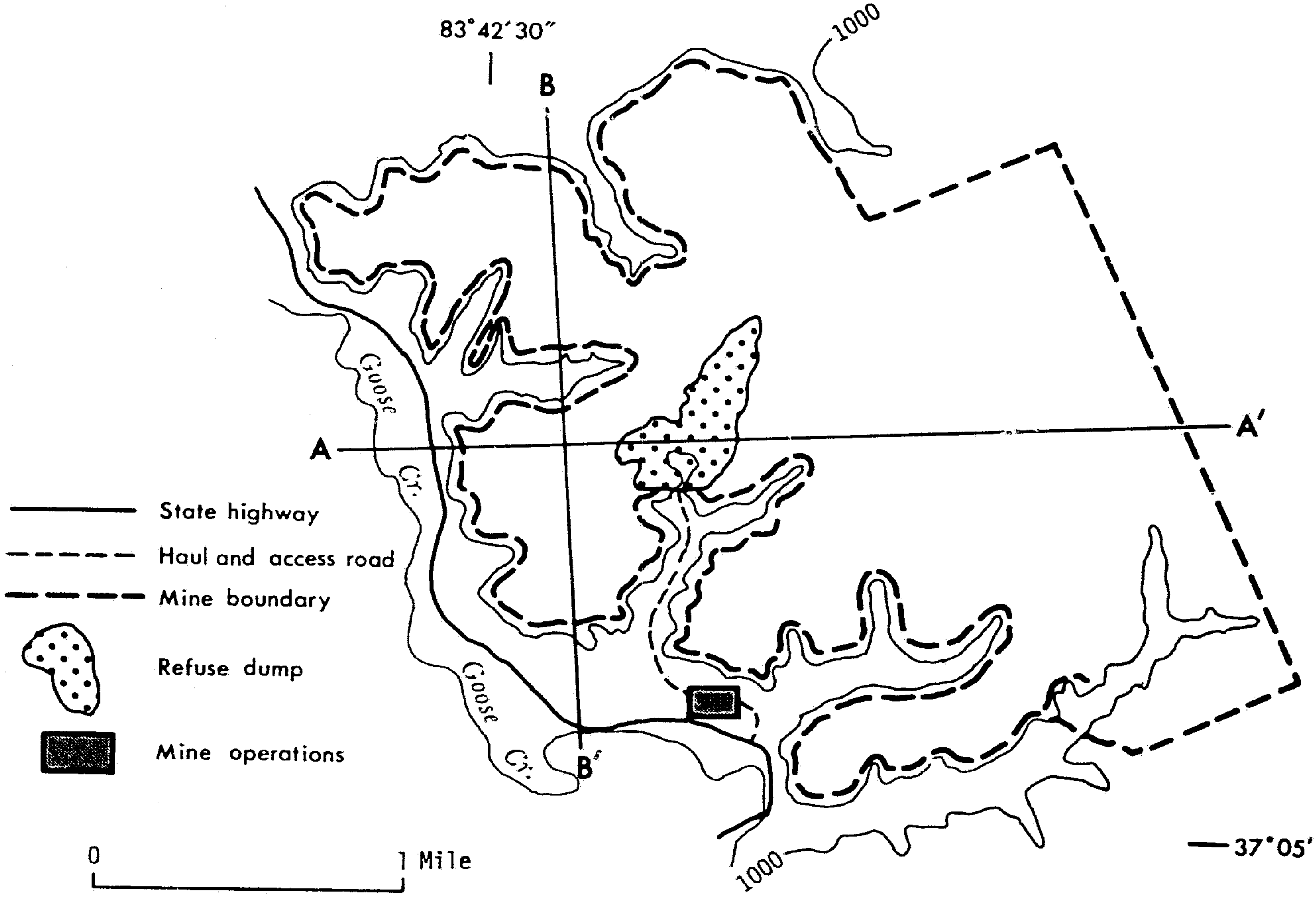

Figure 4-2. Mine Site

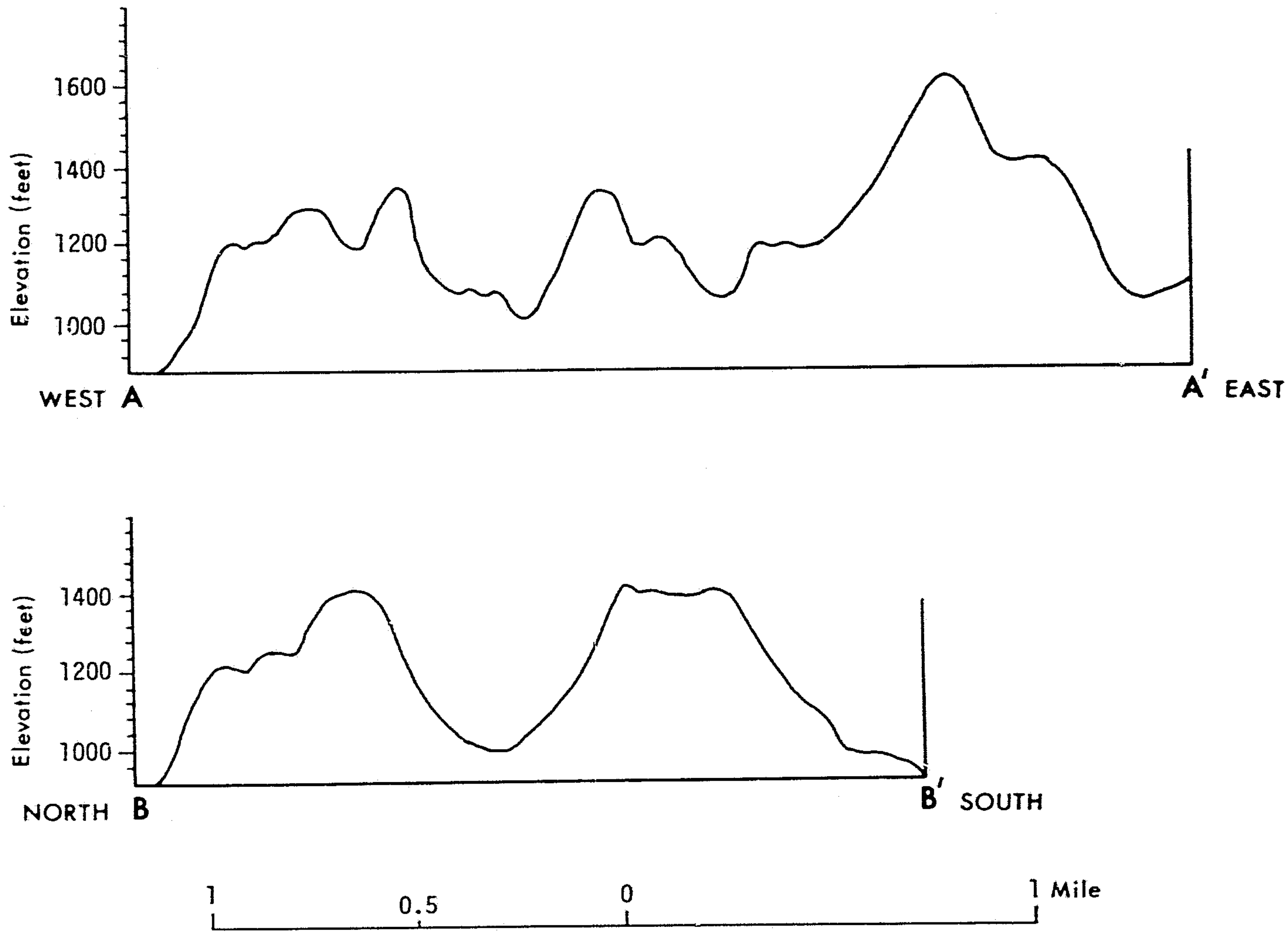

Figure 4-3. Topography of the Mine Site

4. Geology

The major part of the coal in the eastern Kentucky fields and in Clay County occurs in the Breathitt formation (Pennsylvanian period, 280-320 million years ago). The Breathitt formation within the mine site is composed mainly of shales, siltstones, arkosic sandstones, some carbonates (Magoffin member; Pa in Figure 4-4), and minor amounts of ironstone concretions. Within the lower Pennsylvanian of the Breathitt formation (Map symbol Pc in Figure 4-4) is the Jellico coal zone, containing the seams worked by the Fantasy Mine #1.

The Jellico coal zone is up to 25 ft thick and contains as many as three coal beds. Partings between the coal beds contain thin lenses of siderite, shale, and sand. Roof materials are predominantly shale, while the floor is mainly sandstone with some shale. The overburden thickness ranges from 300 ft in the west to over 600 ft in the east; overburden thickness from north to south ranges from 200 to 400 ft (Ping and Sergeant, 1978). A very high probability exists that the overburden and coal materials contain sulfide materials, and thus have the potential for producing acid mine drainage (Sullivan, et al., 1980; McDonald and Blevins, 1965).

5. Climate

Table 4-1 shows the long-term averages of temperature and precipitation for eastern Kentucky. In the summer the temperature may reach 100°F., but rarely for more than a few days. Temperatures below 0°F occur with moderate frequency in December, January, and February, but long cold spells are always broken by intervals of moderate temperatures. The average growing season is 175 to 180 days. Snowfall varies considerably from year to year but annually averages about 20 inches. The ground seldom remains covered with snow for more than a few days after a storm (McDonald and Blevins, 1965).

6. Water Resources

a. Groundwater. The Breathitt Formation supplies very little water from drilled wells in the sideslopes and ridgetops of the mining region, but groundwater is available in adequate amounts for most domestic uses. According to Kilburn, et al., (1962), very few wells have been drilled within the Fantasy Mine #1 region, and no data on yields are available for Clay County. However, some wells drilled in the valley bottoms have been recorded to produce at least 500 gpm.

The water in the Breathitt Formation does contain iron and is moderately hard. Most of the groundwater is fresh, but salty water may be found less than 100 ft below drainage. Nevertheless, Kilburn, et al., (1962), indicate that salty water should not be a concern within or near the mine site.

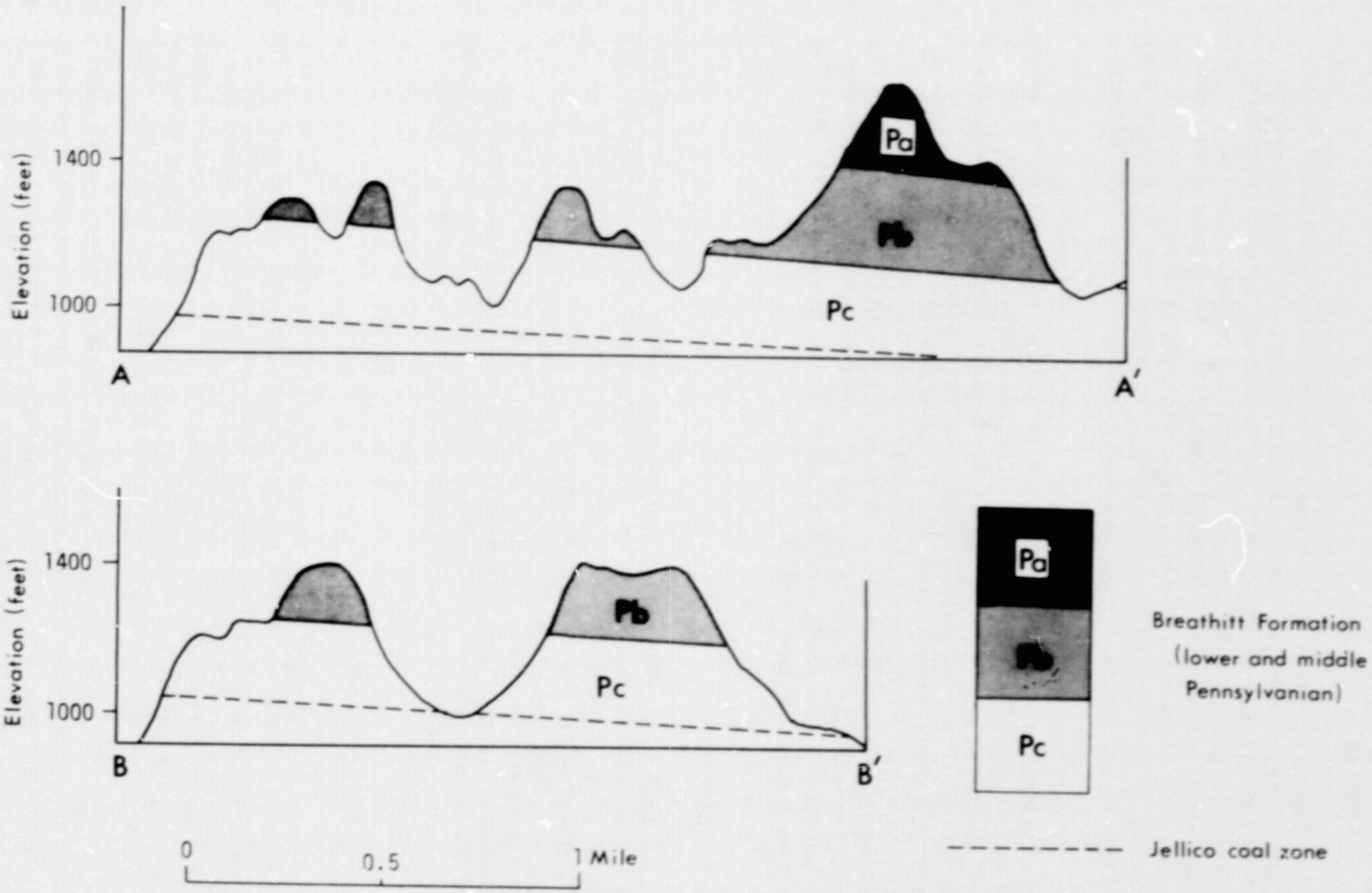

Figure 4-4. Geology of the Mine Site

Table 4-1. Long-Term Averages of Temperature and Precipitation in Eastern Kentucky

Month	Temperature, °F	Precipitation, in.
January	38.6	4.6
February	39.7	3.9
March	46.9	4.9
April	56.6	3.6
May	65.2	4.0
June	73.4	4.2
July	76.4	4.6
August	75.2	3.9
September	69.4	2.6
October	58.3	2.6
November	46.1	3.2
December	38.7	3.6
Average for the Year	56.1	45.3

(Source: McDonald and Blevins, 1965)

b. Surface Water. Goose Creek is the only major stream that occurs adjacent to the mine site. From the data presented by Kirkpatrick, et al., (1963), the discharge rates can be assumed to vary from 89 to 720 gpm for 98% of the year. The rest of the mine site is dissected by numerous first order streams and several second order streams. Surface water from these channels would provide a significant amount of water for the mining operation.

Although the available water resources are not abundant, there are no other competing industrial users for the existing resources. Water quality information for this region was not available.

7. Soils

The majority of the mine site is composed of the Dekalb-Muskingum-Berks soil association (McDonald and Blevins, 1965). This association makes up 96% of the soils that occupy the ridge tops and very steep side slopes. All of these soils are very stony, are shallow to moderately deep, and are derived from acid sandstone and siltstone. Soils that occur between steep uplands and broad stream bottoms (the region of active mine operations) belong to the Jefferson-Muskingum-Holston-Dekalb soil association. The Jefferson soils make up about 32% of the association and occur on the foot slopes below steeper Muskingum and Dekalb soils. The Jefferson soils are generally deep and have a gravelly loam surface layer over a clay loam or loam subsoil. The capability classes of the soils are predominately II to III on the foot slopes and VI to VII on the steeper slopes.

C. CONCEPTUAL ENVIRONMENTAL ASSESSMENT

The conceptual environmental assessment methodology for coal extraction systems, as developed by Sullivan, et al., (1980), produces a descriptive assessment intended to flag potential environmental impacts associated with mining systems at the conceptual design stage. The conceptual environmental assessment consists of (1) a general description of the mining system, (2) an environmental identification checklist and checklist summary, and (3) impact identification sheets which describe the impacts in detail.

1. Description of the Mining System

(1) System: Contemporary room and pillar technology using continuous miners.

(2) Coal resource: Assumed 6-ft coal bed, mostly below drainage.

(3) Mining method: 5 main entries will be utilized for access, coal clearance, and ventilation. The seam will be accessed by a drift driven from a bench.

The coal will be mined by the room and pillar method, with partial extraction of the pillars. Continuous miners are electrically powered and extract the coal by mechanical cutting. Coal is removed from the working face to a processing plant outside the mine by a belt conveyor.

(4) Coal haulage: Coal from the preparation plant will be moved by conveyor to a stockpile. From the stockpile, the coal will be transported a short distance to a rail spur for loading. All outside conveyors are assumed to be covered. The rail haulage will not be considered in the environmental analysis.

(5) Access and support facilities: One two-lane gravel road will be constructed to the site of mining operations. The road will continue beyond the operations site to the refuse dump. All large refuse will be transported by truck to the dump site and stored by the valley fill method. Drainage from the dump site, operation site, and stockpile will be controlled by drainage ditches and sediment ponds. All water generated by the mine will be pumped directly to water treatment facilities.

2. Environmental Identification Checklist

The conceptual environmental assessment methodology identifies potential environmental impacts of systems at the conceptual design stage. These impacts are generic to coal mining processes. Sullivan, et al., (1980), grouped mining activities under 6 general mining processes:

(1) Construction of access and haul roads.

(2) Removal of overburden.

(3) Development of systems access.

(4) Coal cutting.

(5) Coal hauling.

(6) Coal processing.

The environmental identification checklist that follows identifies impacts that are specific to these mining processes. Following the checklist is the checklist summary (Figure 4-5).

ENVIRONMENTAL IDENTIFICATION CHECKLIST

1. **Land - erosion and topographic alteration**

Will the mining system proposed result in the following:

	YES	MAYBE	NO
(a) Road construction because existing access or haul roads are not adequate?	X		
(b) Road construction in a region with steep slope gradient, long slope length, high rainfall intensity and/or low vegetative cover?	X		
(c) Access and haul roads occurring over much of the mine site, not in a localized area?			X
(d) Removal of overburden as the primary means of accessing a coal seam?			X
(e) Any process, except those identified above, that may create erosion problems, or which may produce a large quantity of spoil or tailings?			X
(f) Spoil stored by filling depressions, stream channels, steepening existing slopes, or any other method which may contribute to excess erosion or sedimentation?	X		
(g) Mountain-top removal or any other similar process?			X
(h) Leveling a surface in mountainous regions?			X
(i) Highwalls and benches or any other similar process?	X		

2. <u>Land - subsidence and land use</u>

Will the mining system proposed result in the following:

	YES	MAYBE	NO
(a) Underground cutting and removal of coal?	X		
(b) Incomplete (less than 70-80%) removal of any coal resource?	X		
(c) Absence of backfilling procedures or mechanical structures for roof support after mine closure?	X		
(d) Irregular pattern of coal extraction?			X
(e) Removal of multiple seams?			X
(f) Removal of coal from steeply dipping seams?			X
(g) Uncontrolled subsidence following mine closure?	X		

3. <u>Water - pollution</u>

Will the mining system proposed result in the following:

	YES	MAYBE	NO
(a) Above-ground storage of coal?	X		
(b) Cutting of coal by bench cutting and augering or any similar process?			X
(c) Accessing of coal by any method that will require mine sealing?	X		
(d) Widespread disturbance resulting in drainage alteration?			X
(e) Coal extraction accomplished by hydraulic technologies?			X
(f) Coal extraction accomplished by solvent methods?			X

	YES	MAYBE	NO
(g) Coal extraction accomplished by some other technology which has the potential of degrading water quality?			X
(h) Systems access accomplished by hydraulic technologies?			X
(i) Systems access resulting in thermal discharge?			X
(j) Systems access accomplished by some other technology which has the potential of degrading water quality?			X
(k) Coal processing on-site?	X		
(l) Coal extraction and/or systems access intersecting the regional groundwater table?	X		

4. Water - groundwater alteration

Will the mining system proposed result in the following:

	YES	MAYBE	NO
(a) Shafts or boreholes as the primary method of accessing coal seam?			X
(b) Drilling or excavating a large number of holes?			X
(c) Uncased boreholes or shafts?			X
(d) Pumping of groundwater for dewatering of mine workings?	X		

5. Water Resources

Will the mining system proposed result in the following:

	YES	MAYBE	NO
(a) Insufficient surface and/or groundwater for mining activities?			X

	YES	MAYBE	NO
(b) Water imported and stored at the mine site?			X
(c) Water resources diverted from other uses?			X

6. Air Quality

Will the proposed mining system result in the following:

	YES	MAYBE	NO
(a) Activities that will create fugitive dust?			X
(b) Use of unpaved access or haul roads?	X		

7. Ecology

Will the mining system proposed result in the following:

	YES	MAYBE	NO
(a) Removal of vegetation that may result in decreased species diversity?			X
(b) Overburden or refuse dumped off mine site covering originally vegetated areas?	X		
(c) Removal or modification (e.g., diversion of stream flow) of aquatic habitat?			X

8. Reclamation

Will the mining system proposed result in the following:

	YES	MAYBE	NO
(a) Postponement of reclamation procedures until the end of active mining?			X
(b) A high probability of the affected area being mined again in the future (e.g., partial extraction)?	X		

9. Energy

Will the mining system proposed result in the following:

	YES	MAYBE	NO
(a) Removal of less coal than an alternate method (e.g., room and pillar vs. area stripping)?	X		
(b) An energy-intensive system (e.g., use of lasers)?			X
(c) On-site energy generation?			X

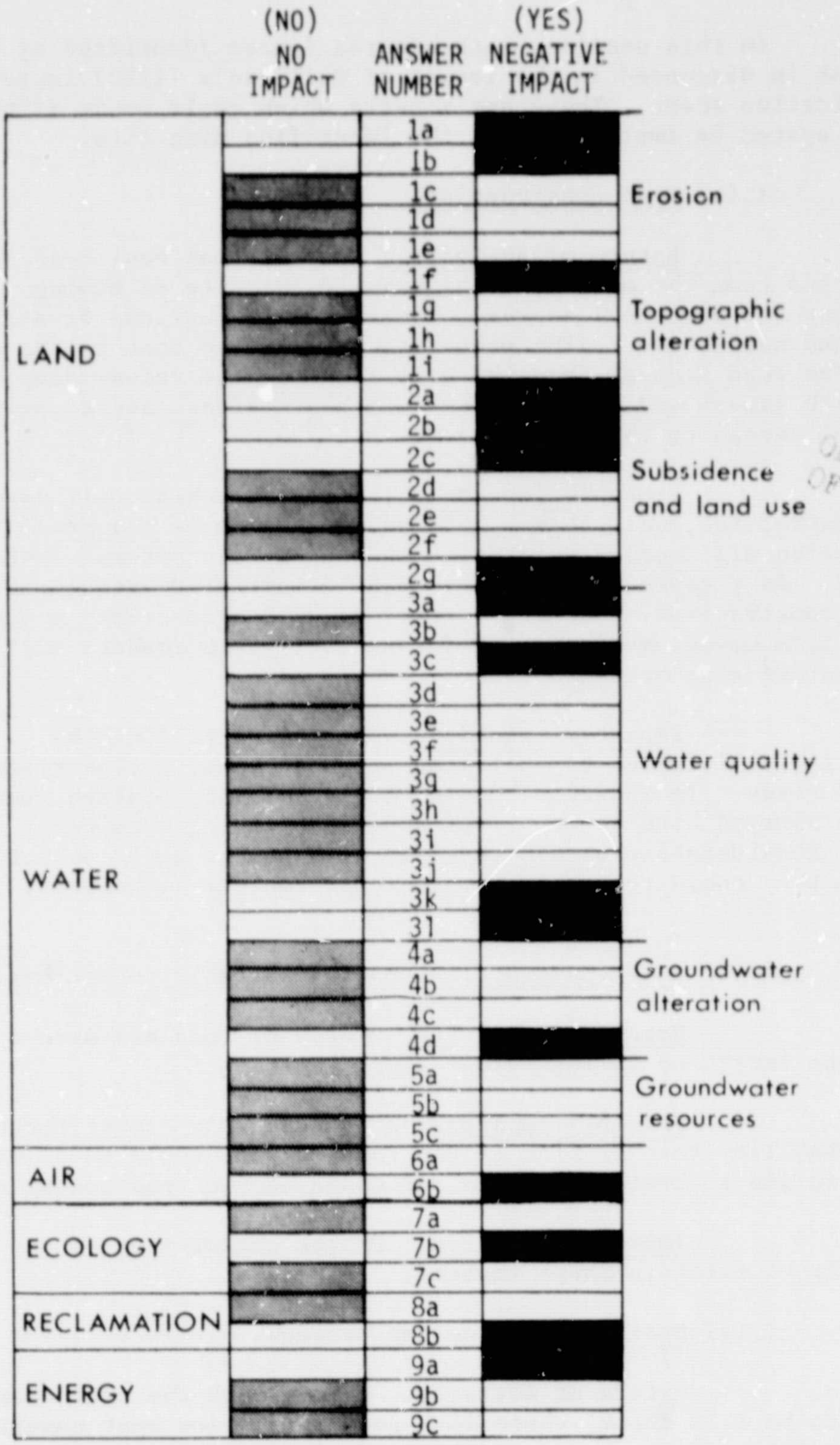

Figure 4-5. Checklist Summary

3. Impact Identification Sheets

In this section, each adverse impact identified by the checklist is discussed in the format of Sullivan's (1980) impact identification sheet. These are impacts which could occur if the defined system is implemented at the identified mine site.

1.(a) Road construction.

Nature of activity. One two-lane haul road will be constructed from the main state highway to the site of mining operations for personnel access. The road will continue from the office and bath-house to the preparation plant and then to the refuse dump. The road segment from the prep plant to the refuse dump will be paved with gravel and used by trucks to haul refuse, and to provide personnel access to the dump area.

Probable impacts. The major impacts will result from construction, maintenance, use and operation of the road. Construction will remove vegetation and change the natural contour of the land. As a consequence, there will be increased erosion from the zone of construction. Haulage operations will also create a dust problem from moving vehicles. Moderate short-term impacts will result during active mine operation.

Impact mitigation. These impacts could be substantially mitigated by following proposed construction criteria for haul roads. In addition, during active mining, haulage roads could be sprayed with water or suitable stabilizing chemicals; however, consideration should be given to possible water pollution problems that could result from these dust control techniques.

1.(b) Road construction under unsuitable conditions.

Nature of activity. The haul road may have a very long slope length up to the refuse dump.

Probable impacts. With such long slopes there is a high probability that erosion on the road surface could be severe. This would add to sediment yields and cause unsafe road conditions.

Impact mitigation. Proper engineering of the road would help to mitigate these impacts.

1.(f) Spoil production and storage.

Nature of activity. Even though the coal seam is assumed to be 6 ft thick, there is a good indication that numerous partings will be encountered. Approximately 5% of run-of-mine coal will be refuse, which will be stored above ground.

Probable impacts. If this spoil is stored above ground there could be a major long-term impact from erosion of the spoil.

Impact mitigation. If the spoil is stored using proper engineering methods and vegetation is established, erosion can be minimized. However, any artificial structure has the potential for structural failure and, hence, major long term impacts from erosion and sedimentation.

1.(i) Highwall and benches.

Nature of activity. A highwall and bench must be cut in order to provide access to the coal seam.

Probable impacts. With creation of a highwall, erosion potential in the area is increased. However, only a small area should be affected as the highwall is cut only for mine access.

Impact mitigation. Backfill area and revegetate following mine closure.

2.(a) Subsidence.

Nature of activity. The extraction of coal by underground methods ultimately leads to the collapse of the overlying strata.

Probable impacts. Subsidence of the overburden will result in slump structures at the earth's surface. As a consequence, land use above the mine will be severely limited. Additionally, the disturbance and breaking of the overlying geologic strata will irreversibly change any aquifers that might be intersected by the collapsed zone.

Impact mitigation. The degree of slumping at the surface can be reduced somewhat by artificial support. Land use, however, will still be restricted.

2.(b) Incomplete removal.

Nature of activity. No more than one-half to two-thirds of the resource will be removed. Moreover, the remaining coal resource will be in coherent blocks, leading to the potential for future removal.

Probable Impact. The fact that a large proportion of coal will remain underground means that there is a possibility that the region could be mined again in the future. This will result in further disturbance of the mine site.

Impact mitigation. None.

2.(c) Backfilling.

Nature of activity. The mined-out areas left by the removal of coal will not be stabilized by backfilling or other mechanical supports.

Probable impacts. Because the mined-out areas will be allowed to cave, differential subsidence will occur at the surface. In addition, no precautions are taken against disruption of aquifers. All of these impacts will be major and long-term.

Impact mitigation. None.

2.(g) Planned subsidence.

Nature of activity. The room and pillar method of mining does not extract the entire coal seam. As a result only portions of the earth's surface undergo subsidence.

Probable impacts. Subsidence will not be uniform, but may take many years to express itself. Thus, utilization of the land on the mine site will be constrained. It is important to note that the land will be limited to only those activities that do not involve urban or agricultural land use. This is not a major problem, nor is it likely to be in the future, since this region will probably remain forested.

Impact mitigation. None.

3.(a) Storage of coal.

Nature of activity. Coal will be stored in a large pile outside of the mine mouth as a ready supply for rail shipment. Coal stored in this fashion is subject to leaching by rain. Discharge of leachate away from the mine site may occur.

Probable impacts. Because this coal has a very high potential for containing acid producing materials, the water that infiltrates the storage pile and runs off of the coal will probably be acidic. This water may contain high concentrations of iron as well as sulfate. The introduction of these materials into aquatic and terrestrial environments can result in major long-term damage to wildlife and vegetation.

Impact mitigation. A leachate and runoff collection system must be constructed to channel polluted waters to an appropriate water treatment plant. Once the water has been treated to comply with standards it may then be released to the environment.

3.(c) Mine sealing.

Nature of activity. After mine operations cease, 4 mine seals will be constructed.

Probable impacts. Mine seals are notoriously unreliable. With 4 mine seals there will be the possibility of a mine seal failure. In this event, the release of acid materials will pollute water supplies and cause widespread ecological destruction to aquatic and terrestrial life.

Impact mitigation. The mitigation of these potential impacts is based upon proper engineering and construction of mine seals and monitoring of mine seal pressures. There will be sufficient mine water to limit oxidative conditions if the seals hold; however, if a seal should fail, a considerable amount of water will be released. As a consequence, there is a potential for major long-term impacts.

3.(k) Processing.

Nature of activity. The extracted coal will be crushed and refuse will be removed outside of the mine.

Probable impacts. On-site processing of coal increases the potential for acid water drainage away from the mine site (see above).

Impact mitigation. The use of drainage diversions so that acid water may be collected and sent to a water treatment plant will effectively mitigate potential impacts.

3.(1) Extraction below drainage.

Nature of activity. The coal bed to be mined is below drainage for almost 95% of the mine site.

Probable impacts. The fact that mining operations will occur below drainage means that the underground openings will certainly produce acid water. In spite of the operator's best efforts to pump this water out of the mine and neutralize the acid, there is a good possibility that a substantial fraction of this water will infiltrate the surrounding geologic strata, and pollute the groundwater which flows through the mine site.

Impact mitigation. Mine sealing may help to alleviate this problem; however, infiltration of polluted water into the surrounding strata may be unavoidable.

4.(d) Pumping.

Nature of activity. Groundwater must be removed by pumping to allow the operation of equipment.

Probable impacts. The pumping of groundwater can increase the yield of groundwater and reduce the base flow of nearby streams. The resulting loss of surface water could have an adverse effect on wildlife using the disturbed water resources. These effects can have a major impact but should lessen somewhat when the pumping ceases.

Impact mitigation. None.

6.(b) Unpaved roads.

Nature of activity. The one road used for transportation to the mine site and the refuse dump will not be paved, but graveled.

Probable impacts. Haulage occurring on unpaved surfaces may result in excessive amounts of dust. Because the mine site is in an attainment region there will be no violation of existing air quality regulations. However, there is a potential health hazard to employees and persons located near the active haul road and service road.

Impact mitigation. These impacts can be mitigated to a very large extent by applications of water or other appropriate chemicals to the road surface. If the road is not maintained properly, however, wind erosion during and after active mining could be severe. Such impacts would be moderate but long-term.

7.(b) Overburden dumping.

Nature of activity. Refuse removed from the mined coal will be put into a valley fill near the mine site.

Probable impacts. In order to install a valley fill, all vegetation must be removed from the fill site, resulting in the destruction of wildlife habitat. However, as most of the region is heavily forested, reestablishment of wildlife habitat should not be a problem. As a result, there should not be a significant impact in this region.

Impact mitigation. At the end of active mining, reestablish vegetation to produce a usable wildlife habitat.

8.(b) <u>Secondary extraction.</u>

<u>Nature of activity.</u> With low extraction efficiency, there will be a high potential for secondary extraction. As a result, once-reclaimed land may be disturbed again.

<u>Probable impacts.</u> The disturbance of previously reclaimed land could have a serious effect on establishing secondary reclamation. As a consequence, there would be a greater potential for long-term erosion and sediment yields.

<u>Impact mitigation.</u> None.

9.(a) <u>Efficiency.</u>

<u>Nature of activity.</u> All the coal resource will not be removed.

<u>Probable impacts.</u> The amount and use of energy required to remove the resource may not be as efficient as when more coal is removed. Additionally, the resource that is left may be unavailable in the future.

<u>Impact mitigation.</u> None.

In summary, the conceptual environmental assessment indicates that the following major impacts could occur if the mining system were implemented at the site: (1) spoil storage above ground, resulting in sediment loss and acid drainage; (2) subsidence, resulting in groundwater alteration; (3) generation of acid water from the mine; and (4) low extraction efficiency.

D. PRELIMINARY ENVIRONMENTAL ASSESSMENT

The objective of the preliminary environmental assessment methodology as developed by Sullivan, et al., (1980) is to quantify the potential impacts of a mining system on a region's natural resources. This preliminary assessment is dependent upon the availability of detailed engineering data on the mining system as well as detailed site-specific information. The preliminary environmental assessment consists of (1) the development of a mine plan, (2) a performance impacts assessment, which deals with impacts that may hinder a system from achieving sustained operation, and (3) an interactive impacts assessment, which deals with impacts that may occur as a result of the interaction of the mining technology with the environmental setting.

Using the preliminary methodology of Sullivan, et al., (1980), the Fantasy Mine #1 was assessed in the following areas:

(1) Performance impacts

- (a) Land resource balance
- (b) Water balance

(2) Interactive impacts

- (a) Erosion and sedimentation
- (b) Resource removal
- (c) Water quality
- (d) Habitat alteration
- (e) Air quality
- (f) Aesthetics
- (g) Reclamation

Not all of the areas outlined by Sullivan, et al., (1980) were be assessed. The energy balance was not completed due to the lack of engineering data on the energy consumption of the mining system.

The resource data and engineering data presented in the previous sections were used in the preliminary assessment. The assessment also required a mine plan. The following mine plan was constructed from information supplied by Bickerton (1979) and engineering principles described by the West Virginia Department of Natural Resources (1975) and Haan and Barfield (1978).

1. The Fantasy Mine #1 Mine Plan

The layout of the Fantasy Mine #1 (in plan view) is illustrated in Figure 4-6. The mine design is based on the following building and engineering requirements:

(1) Mining facilities

(a) Land for mine site

(i) Requirements

Buildings	8,000 ft^2
Yards and parking	10,000 ft^2
Coal and soil storage	9,000 ft^2
Subtotal	27,000 ft^2

Total land allocated = 45,000 ft^2 or 1.03 acres

(ii) Engineering

This site must be cleared and leveled to an approximate 2% slope. The average slope in the area where the buildings will be is 5 degrees. Assuming the slope is constant, 3,596 yd^3 of overburden must be moved. Of this amount, 323 yd^3 of soil (assumed upper one foot of surface) must be stored for future reclamation.

(b) Land for water treatment

(i) Requirements

The water treatment facility will be allocated 0.47 acres (this does not include sediment ponds). It is estimated that 80% of this land will be occupied by the facility.

(ii) Engineering

The site must be cleared and leveled to an approximate 2% slope. This requires removal of 1,147 yd^3 of overburden, including 103 yd^3 of soil. Exposed soil areas will be paved.

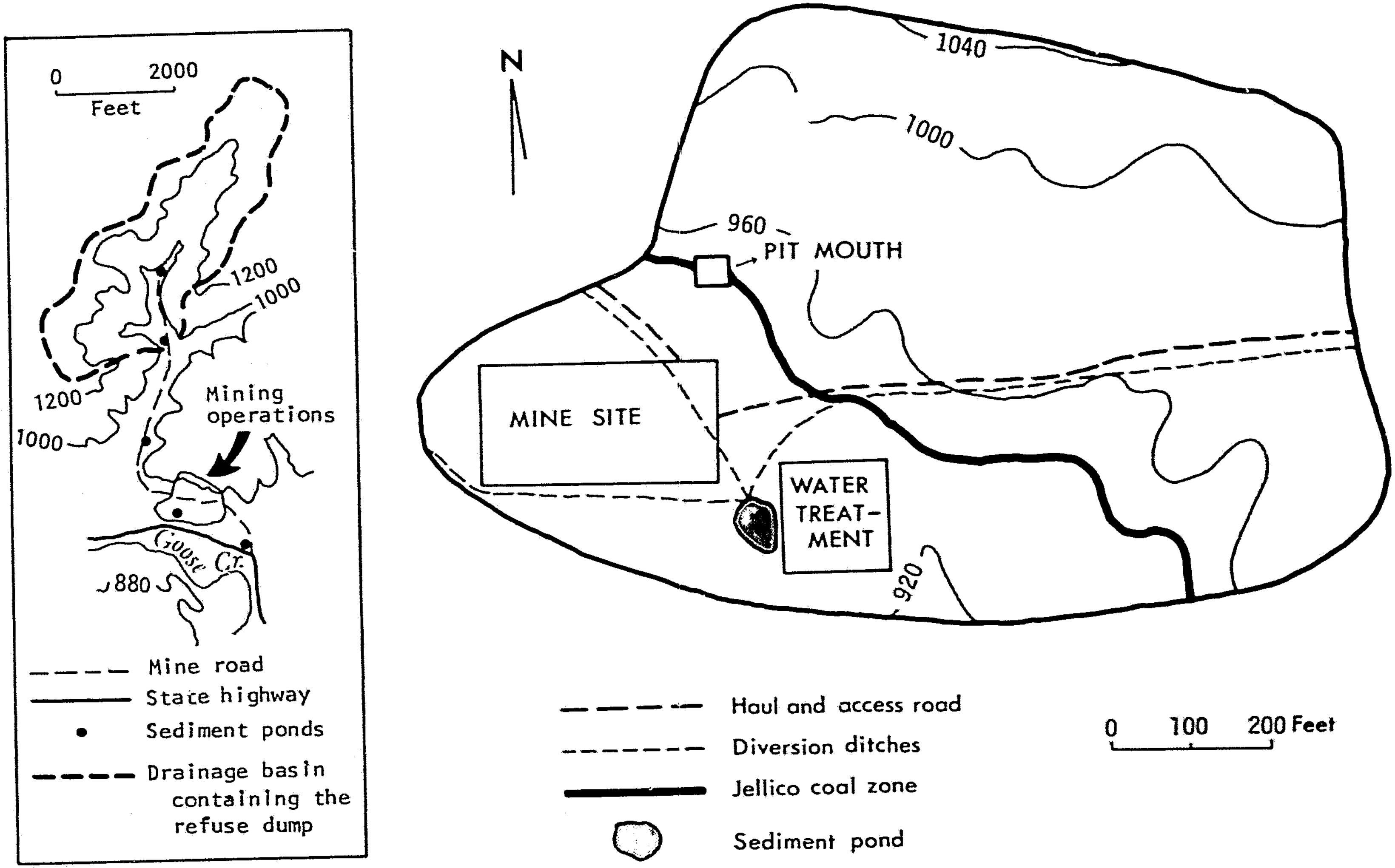

Figure 4-6. Mine Plan

(c) Land for mine mouth haulage

(i) Requirements

A 28-ft corridor will be required for equipment, personnel, and conveyor haulage from the surface facilities to the pit mouth. This corridor will be 100-ft long and should be graded to 3 to 5%. Vegetation removal and leveling must occur on about 0.01 acres.

(ii) Engineering

The amount of material moved will be approximately 145 yd^3, of which 13 yd^3 will be topsoil.

(d) Land for access and haulage

(Note: rail haulage of the coal is outside of the scope of this evaluation.)

(i) Requirements

Over 5,700 ft of haul and access road will be required. Given a 30-ft road width, a total of 3.9 acres of land will be required. Additionally, for each foot of haul or access road there must be an equal length of diversion ditch.

(ii) Engineering

Assuming a constant slope of 5 degrees, a total of 2,638 yd^3 of earth must be moved, including 237 yd^3 of topsoil. In some of the steeper regions, totalling less than 10% of the site area, slightly more earth will be moved.

(e) Summary (for mining facilities)

Total volume of earth moved = 7,526 yd^3

Total area affected = 5.41 acres

Soil storage area (10 ft high) = 5,500 ft^2 or 0.13 acre

(2) Sediment control

(a) Diversion ditches

Over 5,700 ft of diversion ditches are required along access and haul roads, as well as 600 ft within and around the mine site. Total area of ditches will be 0.87 acres, assuming a 6 ft width.

(b) Sediment ponds

There will be two major sediment ponds. The first is located at the base of the refuse dump and will be designed to collect sediment and acid water drainage. The effluent from this pond will be delivered by pipe from the pond to the water treatment plant. The second pond will be constructed near the water treatment plant and will collect sediment and acid water from the mine site and sediment from the access road. Three smaller ponds will be constructed, one at the base of the access road and two at the stream bottom along the haul road (see Figure 4-6). Calculations of the size of the sediment ponds will be completed in the reclamation section, following the calculation of sediment yields.

(3) Refuse dump

(a) Requirements

On the average, 60,000 yd^3/year of refuse must be disposed of in a valley fill. Over the life of the mine, 1.3 million yd^3 of refuse will be generated. This refuse will be stored in the west fork of Rocky Branch (see Figure 4-6).

(b) Engineering

The valley fill will be constructed at the northernmost point of the 1000-ft contour and will fill an area up to the 1200-ft contour. This region has the capacity to hold 1.5 million yd^3. Clearing for the fill will occur one contour interval at a time, in order to minimize the area subject to erosion at any given time. When construction of the valley fill is finished, topsoil will be spread over the entire surface and seeded. Approximately 4.1 acres must be cleared and the total area of the final fill that must be reclaimed is approximately 5.2 acres.

With the mine plan defined, the preliminary assessment will be completed in the order indicated above. The first set of impacts to be estimated are the performance impacts.

2. Performance Impacts

Every mining system has performance requirements for certain amounts of natural resources. Performance impacts are those involved with utilization of natural resources, specifically land, water, and energy, by the mining system operating in a particular region. Before the performance impacts can be calculated, the total area disturbed by the mining system must be determined. It has already been calculated by Bickerton (1979) that the total area of extraction will be 3940 acres. This region is outlined in Figure 2 as the mine boundary. In addition to this area mining operations outside of the mine workings will disturb several more acres. These additional acres must be reclaimed at the end of active mining.

a. Land Resource Balance. The intent of this analysis is to determine any potential conflicts between the mining area and other intensive land uses. In this region, however, there are no conflicts between mining and other intensive land uses. Although there are some structures on several stream valleys, they do not occur above zones of active mining.

b. Water Resource Balance. The mining system will require approximately 40,000 gal/day (assuming 24 hr operation), or on the average 30 gal/min. This amount of water could be supplied without any significant effect on the region's resources. The data presented previously indicate that surface water or one well in the valley floor would supply more than enough water for normal operation.

Additionally, water that has been cycled through the water treatment plant would also be available for use. It should be noted that there are no other competing industries that require a significant amount of the available water resources.

3. Interactive Impacts

Interactive impacts are those environmental impacts that occur as a result of the interaction of the mining system with the environmental setting. The following sections will discuss erosion and sedimentation, resource removal, water quality, air quality, aesthetics, and reclamation.

a. Erosion and Sedimentation. Given the total area disturbed by grading and refuse disposal, the amount of sedimentation can be calculated. These calculations are based on the following information and assumptions:

(1) Soils data

(a) The soil of the mine site is the Jefferson series. The soil is dark grayish brown gravelly loam. The subsoil is yellowish-brown gravelly silt loam or clay loam. This soil has a rapid permeability and surface horizon 10 in. deep (very deep soils).

(b) Soils on the steeper slopes are the Dekalb, Berks, and Muskingum series. Most of the area is covered with Dekalb soil, which has a low organic matter content, rapid permeability, and ranges from a fine sandy loam to a loam. The subsurface is the same as the topsoil, except that it has little or no organic matter. This soil has a thin A horizon (6-8 in.) and is of moderate depth.

All of the soils are covered with dense natural woodland.

(2) Drainage areas

There are 5 drainage areas in the mine region that will contribute sediment, and possibly acid water, to each sediment pond. These areas are as follows:

(a) Area I: This area constitutes the basin which drains into the valley fill, and has a total area of 115.4 acres. During active mining no more than 1.35 acres will be cleared. It is also assumed that there will be very little fine material added to the refuse dump and, thus, no contribution of sediment from the refuse.

(b) Area II: This area is made up primarily of the noseslopes of several ridges along the east facing slope of the west fork of Rocky Branch, and has a total area of 2.8 acres. All drainage from the basin above the haul road will be drained by culverts running under the road into Rocky Branch.

(c) Area III: This area is made up of several noseslopes along the northwest facing slope of Rocky Branch, and has an area of 2.6 acres. All drainage from the basin above the haul road will be drained by culverts running under the road into Rocky Branch.

(d) Area IV: This area is made up of the mine site and several noseslopes along the southwest facing slope near Gooserock. The drainage area is approximately 12 acres. All drainage from the streams upslope of the mine area will be channeled by culverts under the haul roads to Goose Creek.

(e) Area V: This area includes the slope immediately above the access road (see Figure 4-6), and covers approximately 0.8 acres.

(3) Method of calculation

Sediment yields will be determined using the Universal Soil Loss equation. The soil loss equation is:

$$A = RKLSCP$$

where A = sediment yield in tons/acre/year

R = rainfall & runoff factor

K = soil erodibility

L = slope length

S = slope steepness

C = vegetative cover

P = erosion control practice (not used in this analysis)

Table 4-2 contains all the information required to calculate soil loss and the sediment yield/year for each area. All soil factors indicated above were determined using soils data presented previously (McDonald, 1965, USGS 7.5' topographic quadrangle (Ogle, Kentucky), and USDA Agricultural Handbook 537, 1978).

Table 4-2. Sediment Yields by Region

Area		Acreage	R	K	LS	C*	A tons/yr
I	disturbed	1.35	185	0.34	11.0	1	934.1
I	undisturbed	14.05	185	0.27	20.0	0.001	14.0
I	total	115.4	-	-	-		948.1
II	disturbed	1.48	185	0.34	1.0	1	93.1
II	undisturbed	1.32	185	0.27	15.0	0.001	1.0
II	total	2.80	-	-	-		94.1
III	disturbed	1.65	185	0.52	1.0	1	158.7
III	undisturbed	1.04	185	0.18	13.0	0.001	0.5
III	total	2.69	-	-	-		159.2
IV	disturbed	2.72	185	0.52	.38	1	99.4
IV	undisturbed	9.28	185	0.34	5.2	0.001	3.0
IV	total	12.00	-	-	-		102.4
V	disturbed	0.55	185	0.52	1.5	1	79.4
V	undisturbed	0.25	185	0.18	12.0	0.001	0.1
V	total	0.8	-	-	-		79.5

*disturbed = no vegetative cover
undisturbed = natural woodland

b. Resource Removal. From the geologic data of the site, it can be inferred that there are three coal zones, other than Jellico, that could be extracted in the future. These coal resources are:

(1) The Haddix coal zone, a 20-in. seam which underlies 10% of the site, and contains about 1.24 million tons

(2) The Amburgg coal zone, a 20-in. seam which underlies about 80% of the site, and contains about 5.99 million tons

(3) The Elkhorn No. 3 coal bed, a 20-in. seam which underlies about 60% of the site, and contains about 7.46 million tons

Given these data, seam recovery and resource recovery may be calculated as follows:

$$\text{Seam Recovery} = \frac{\text{Tonnage extracted}}{\text{Total tonnage in mined seams}} = \frac{24{,}950{,}000}{43{,}771{,}930} = 0.57$$

$$\text{Resource Recovery} = \frac{\text{Tonnage extracted}}{\text{Aggregated tonnage in all coal resources}} = \frac{24{,}950{,}000}{58{,}490{,}000} = 0.43$$

c. Water Quality. It has been clearly indicated that sediment control must be established so that if excessive erosion occurs, the sediment load of polluted waters can be reduced. In this region drainage water from coal, refuse, and spoil will also be acidic. As a consequence, water from the mine site must be collected and treated to reduce sediment load and acidity before it can be released to the environment.

There are two areas of the site (I and IV) that will produce acid water. The amount of acid water produced in these two areas will be assumed to be natural runoff. Runoff is estimated in these areas using the following equation (EPA, 1976):

R(runoff) = K(runoff coefficient) X P(average precipitation)

The data for Area I indicate the following values for disturbed and undisturbed lands:

K forested (sandy loam-loam), > 30% slope = 0.30

K disturbed (sandy loam-loam), < 30% slope = 0.50

P = 115 cm/yr

Forested area in Area I = 14.05 acres

Disturbed area in Area I = 1.35 acres

Therefore:

$R = 115\ (0.3 \times 14.05 + 0.5 \times 1.35)$

Applying the above expression for runoff separately to the disturbed and undisturbed acreage of Area I using methods described by EPA (1976), one obtains a figure of 16,500 gal/day on the average for Area I.

The data for Area IV indicate the following values for disturbed and undisturbed lands:

K forested (silt loam to loam), slope > 30% = 0.50

K disturbed (silt loam to clay), slope < 5% = 0.60

P = 115 cm/yr

Forested area in Area IV = 9.28 acres

Disturbed area in Area IV = 2.72 acres

Therefore:

$R = 115\ (0.5 \times 9.28 + 0.6 \times 2.72)$

A figure of 21,000 gal/day on the average is obtained for Area IV. The total water that must be treated daily from Areas I and IV is, on the average, 37,600 gallons.

In addition to the acid water produced at the earth's surface, acid water will also be produced from the mine. Bickerton (1979) estimated that after the first year of mining 107,400 gal/day would be produced by the mine. The drainage would increase to 214,800 gal/day by year 3 and would continue this increase until the close of the mine when the production would reach 2.37 million gal/day.

These waters, both surface and mine, must be treated before their release to the environment. For the size of the treatment facilities and costs, see the reclamation section.

d. Habitat Alteration. Although wildlife habitat will be lost as a result of mining, this loss is minor when compared to the large acreage of similar habitat in this part of Kentucky. Additionally, there are no known critical habitats or endangered species within or near the affected areas. Road kills will increase along the added roadways but other than this there are no unusual hazards.

e. Air Quality. With this mining system, the road haulage of coal is minimal. All coal is transported by conveyor (covered) directly to storage and then to waiting rail cars. As a consequence there should be few off-site impacts from road use or from coal dust generated by the above ground handling of coal. In addition, the mine site is located in an attainment area.

f. Aesthetics. By their nature, underground mines do not result in the same degree of aesthetic impact as surface mines. With the Fantasy Mine #1, however, the mine site as well as the water treatment facilities will be highly visible along several miles of Goose Creek. One positive aspect is that the disturbance occurs fairly low on the hill slope and does not intersect the natural ridgeline. Additionally, post-mining reclamation should mitigate the aesthetic impact substantially.

g. Reclamation. This section deals not only with final reclamation, but also those activities that are necessary for mitigation of off-site environmental impacts. These activites along with their associated costs, as determined by Doyle, et al., (1974), will be calculated separately and then combined to give a total cost of environmental impact mitigation. Costs in 1974 dollars will be used for all calculations.

4. Environmental Impact Mitigation During Active Mining

Sediment ponds. Sediment ponds must be constructed for each of the areas described above. Ponds receiving water with particle sizes 0.001 mm or larger should be able to effectively remove the suspended solids without having to use a coagulent. Because most of the soils in this region are sandy loams, loams, and silt loams, it is assumed that no coagulants will be required. Sediment pond size is determined using the following equation (EPA, 1976):

$$A = \frac{Q}{Vs}$$

where A = basin size (acres, 1 ft deep)

Q = water flux

Vs = settling velocity of particle

Detailed calculations will be shown only for Area I.

Settling velocity (Vs). Assuming a particle specific gravity of 2.65, the settling velocity will be 50.2×10^{-4} cm/sec for particles larger than 0.001 mm.

Water flux (Q). Is a function of runoff and storm duration and is expressed as:

$$Q = R/T$$

The calculation of R is identical to that in the Water Quality section except that the established 10-year, 24-h precipitation event is used (EPA, 1976). In Kentucky, this figure is 9 cm. For Area I, R is calculated as follows:

$$R = 9(0.3 \times 14.05 + 0.5 \times 1.35)$$

$$R = 178 m^3$$

T is calculated from:

$$E_s = \frac{T}{100} + 0.20$$

where E_s = Excessive storm, inches of precipitation, and

T = storm duration, minutes

For the region E_s = 9cm or 3.5 inches and, thus:

$$T = (9 - .20)\ 100$$

$$T = 330 \text{ minutes} = 19{,}800 \text{ sec.}$$

Basin size can now be calculated:

$$A = Q/V_s$$

Where:

$$Q = 1781\ m^3/19800\ sec = 0.089\ m^3/sec$$

$$V_s = 50.2 \times 10^{-4}\ cm/sec\ (0.01\ m/cm) = 0.5 \times 10^{-4}\ m/sec$$

$$A = \frac{0.089\ m^3/sec}{0.5 \times 10^{-4} m/sec} = 1780\ m^2$$

This area must be corrected to take into account non-ideal settling factors. Thus, A is multiplied by 1.2 to correct possible errors.

The basin area corrected for non-ideal settling is then:

$$A = 1780 \times 1.2 = 2136\ m^2$$

Assuming that the basin depth will be at least 1 meter, the total volume of the basin will be 2136 m^3.

Using the EPA sediment storage volume requirement (EPA, 1976), the pond must be cleared of excess sediment when 60% of the pond volume is filled. For this pond, 60% of the volume is 1281 m^3. Given that 948.1 tons of sediment is 0.85 g/cm^3, the volume of sediment produced in this region will be 1015 m^3. With this rate of sediment production, the pond must be cleaned out every 1.3 years and will produce approximately 17,225 m^3 of sediment that must be removed. The data for all regions occurs in Table 4-3. It must be realized, however, that it is unlikely that only one sediment pond would be constructed. It is more likely that several smaller ponds would be utilized.

Table 4-3. Sediment Basin Design and Sediment Removal

Area	Basin Volume (m^3)	Sediment Volume Removal (m^3)/Mine Life
I	2136	9,135
II	502	2,107
III	508	3,310
IV	702	2,150
V	155	1,790

Also, some of the ponds would probably be constructed by placing a dam across a creek and would not require massive earth removal. However, for the purpose of this document it will be assumed that all sediment ponds will be constructed by earth removal.

Cost of sediment control. Given the previous assumptions and using unit cost information from Doyle, et al., (1974), the following costs are estimated for sediment control:

Diversion ditches:	11,812
Sediment ponds:	36,610
Sediment removal:	145,050
Sediment haulage:	7,252
Total:	$200,724

Cost of water treatment. Assuming limestone treatment and installed capital cost to eventually handle 2.37 million gals/day, the capital cost will be:

Installed Capital Cost:	$\$350,000\ (2.37)^{.72} =$ $651.459
Operating costs:	$.20/1000 gal X 4,403,400 gal = $880
Total Water Treatment:	$652,339

Reclamation After Active Mining.

Cost of Mine Sealing. According to Bickerton (1979), four of the five main entries must be sealed. Using grouted double bulkhead seals, the cost of mine sealing will be:

4 X $20,520 = $82,080

Cost of General Reclamation.

Removal of access roads: 5,700 ft of roads X $2.75/ft = $15,675

Backfilling all disturbed areas to original contour:
6.4 acres disturbed X $1250 = $8,000

Soil cover: (6.4 acres disturbed + 3.9 acres of roads) x $2,500/acre = $25,814

Refuse bank grading and soil cover: 5.2 acres X $3,500 = $18,200

Revegetation: 15.5 acres X $375/acre = $5,813

Total: $73,502

Summary of Reclamation Costs. All reclamation costs incurred both during active mining and after mine close are summarized in Table 4-4. For this mine, the cost of environmental impact mitigation per ton of coal mined is less than $1/ton.

Table 4-4. Summary of Reclamation Costs

Activity	Cost
Sediment Control	$ 200,700
Water Treatment	652,300
Mine Sealing	82,100
General Reclamation	73,500
Total	$1,008,600

E. LAND USE IMPACTS

The Fantasy Mine is located in a part of eastern Kentucky where over 80% of the land is in commercial forest and wood-based industries are important (Karan and Mather, 1977). The Fantasy Mine site itself is covered with natural hardwood deciducus forest; most of the site is privately owned land, but includes a small portion of the Daniel Boone National Forest (ESRI, 1980). The region of the mine site is rural, sparsely populated, and poor (more than one-half of the population of Clay County was below the poverty level in 1977) (Karan and Mather, 1977). Rural land values are extremely low in the eastern mountain region of Kentucky. Natural timber land in this part of Kentucky is worth from \$150 to \$250/acre without mineral rights, depending on the quality of the timber. Land value including mineral rights can range from \$250-\$1000/acre, depending on the amount of mineable coal present (Sizemore, 1979, and Reynolds, 1980). The mine site is not valuable for agriculture, not located near any large urban centers, and not noted for scenic or aesthetic values.

The impacts of underground coal mining upon subsequent potential land uses are minimal for this site. Further, no general land-use plan exists for the area; there is no projected use for the land other than its pre-mining use as timber land. Environmental regulations require that after mine closure, the land must be restored to a condition capable of supporting the uses which existed prior to mining. All surface areas disturbed by mining operations must be reclaimed. Reclamation actions include removal of access and haul roads, regrading of disturbed areas to approximate original contour, soil replacement, and revegetation. As pointed out in the previous section, the cost of such general reclamation for the Fantasy Mine site came to \$73,500 in 1974 dollars. The reclaimed mine site would be less valuable than the undisturbed site, because the newly planted vegetation would be worth less than mature timber; however, the value of the land should increase with time as the trees mature.

SECTION V

IMPACT SUMMARY

The environmental assessment of the Fantasy Mine #1 identified the following potential environmental impacts.

(1) The refuse removed from the mined coal will be stored above ground in a valley fill. The refuse has the potential for acid water drainage, thus creating the potential for long-term pollution of the region's water resources. Even though the refuse site will be reclaimed, the possibility for erosion and structural damage in the future will present a continuing environmental hazard.

(2) In addition to the potential for acid water drainage from refuse storage, there will also be acid water production from the mine workings. Although the mine will be sealed following mine closure, water may still leave the mine from fractures in weak rock. In addition, there is also the possibility of mine seal failure. A failure of just 1 of the 4 seals would release millions of gallons of acid water directly into Goose Creek. This would not only damage aquatic life, but would also cause flood damage in the immediate vicinity of the mine and possibly downstream.

(3) The future land use of the mine site will be affected. Some areas will be deforested as a result of the mining operations, resulting in a loss of mature timber land; however, the cleared land will be revegetated following mine closure. Uneven subsidence will probably occur as a result of mining activity, although impacts on land use will be minimal since no urban or agricultural uses are planned for the land. Aquifers in the subsidence zone will be altered; this could result in a loss of needed ground water to local residents.

(4) The cost of environmental impact mitigation to levels prescribed by law and regulation came to less than $1/ton of coal mined. However, there will probably be long-term environmental impacts due to subsidence of the surface, acid mine drainage leaking from the mine, and possible erosion of the stored refuse.

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