

**INTEGRATED MINED-AREA RECLAMATION  
AND LAND USE PLANNING**

**Volume 3D**

**A Case Study of Surface Mining and Reclamation Planning:  
Area Strip Coal Mining,  
Peabody Universal Mine,  
Universal, Indiana**

Prepared for the

Resource and Land Investigations (RALI) Program  
U. S. Department of the Interior  
U. S. Geological Survey

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**ENERGY AND MINERAL RESOURCES**

**ARGONNE NATIONAL LABORATORY**

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9700 South Cass Avenue  
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Peabody Universal Mine,  
Universal, Indiana

by

James L. Guernsey,\* Michael E. Tiller,\*  
and James R. LaFevers

Energy and Environmental Systems Division

February 1977

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## FOREWORD

This report is one in a ten-volume series prepared by the Energy and Environmental Systems Division of Argonne National Laboratory and the Resource and Land Investigations (RALI) Program of the U.S. Department of the Interior under the sponsorship of the U.S. Geological Survey. Because of the close interrelationship of the ten documents in the series, each volume will be most useful only when its relationship to the other products of the program is considered.

The reports in this series are designed primarily to familiarize professional land use and resource planners with the range of possibilities and effective procedures for achieving integrated mining, reclamation, and land use planning. These reports are based on a research program which included an extensive literature review, the compilation and analysis of case study data, and close coordination and interaction with related government programs.

The first volume in the series, *A Guide to Integrated Mined Area Reclamation and Land Use Planning*, summarizes the information in the other volumes and presents conclusions and observations drawn from analyses of that information. Volume 2, *Methods and Criteria for Land Use and Resource Planning in Surface Mined Areas*, examines planning procedures used in several mineral industries and mining regions and discusses problems facing professional planners who must consider surface mine areas in their planning programs.

In Volume 3, *A Guide to Mined Area Reclamation Technology for Reclamation and Land Use Planners*, the methods used to reclaim land in each of several mineral industries are discussed in relation to the physical and cultural constraints that must be considered in planning a reclamation program. Much of the information for this document was obtained from case studies conducted in several mining districts. The case study sites were chosen after consideration of the following: (a) coverage by commodity of those surface mining activities that disturb the greatest acreages; (b) coverage of a variety of cultural and land use settings; (c) evidence of integration of mining, reclamation, and land use planning; (d) cooperation on the part of operating companies and appropriate planning entities; (e) coverage of a variety of surface mining and reclamation methods; and (f) coverage of a variety of physical settings (geology, physiography, climate, hydrology). After the preliminary case study selection, some sites were changed and others dropped because of a lack of company cooperation. The remaining six case studies all meet the criteria listed above. They are not intended to be perfect examples of reclamation and planning procedures. Rather, they illustrate a variety of procedures utilized in different physical and cultural settings to achieve planning goals under a variety of technological, legal, and economic constraints.

Since the case studies are intended to be used as appendices to Volume 3, they are numbered accordingly. The case study reports include:

Volume 3A: *A Case Study of Surface Mining and Reclamation Planning: South Boulder Creek Park Project, Sand and Gravel Operations, Boulder, Colorado.*

Volume 3B: *A Case Study of Surface Mining and Reclamation Planning: International Minerals and Chemical Corporation, Phosphate Operations, Polk County, Florida.*

Volume 3C: *A Case Study of Surface Mining and Reclamation Planning: Georgia Kaolin Company, Clay Mines, Washington County, Georgia.*

Volume 3D: *A Case Study of Surface Mining and Reclamation Planning: Area Strip Coal Mining, Peabody Universal Mine, Universal, Indiana.*

Volume 3E: *A Case Study of Surface Mining and Reclamation Planning: ASARCO Open Pit Copper Mine, Casa Grande, Arizona.*

Volume 3F: *A Case Study of Surface Mining and Reclamation Planning: Cannelton Mountain-Top Removal Coal Mine No. 9-S, Cannelton, West Virginia.*

Volume 4, *A Bibliography of Integrated Mined Area Reclamation and Land Use Planning, With Annotations*, includes primarily references pertinent to reclamation planning and plan implementation.

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Dr. John F. Tschanz, Argonne National Laboratory.  
Dr. Charles E. Wier, Amax Coal Co.

*PROGRAM STAFF*

Dr. James R. LaFevers, Program Manager  
Allen O. Perry  
Leslie R. Lewis  
Jean E. Bogner  
Ralph P. Carter  
William R. Rice (student participant)  
Robert Beck (student participant)

Energy and Environmental Systems Division,  
Argonne National Laboratory

Edgar A. Imhoff, USGS-RALI/ANL Program Coordinator  
Dr. Joseph O'Connor  
Dr. Thomas Friz

Resources and Land Investigations Program,  
U.S. Department of the Interior

Dr. John L. Thames  
Dr. Tika R. Verma

School of Renewable Natural Resources,  
University of Arizona

Dr. J. Lee Guernsey  
Michael E. Tiller

Department of Geography,  
Indiana State University

Dr. Lawrence A. Brown

Troy State University of Fort Rucker, Alabama

Richard Fountain

Fountain and Associates  
Winter Haven, Florida

Dr. Erkan Esmer

Esmer and Associates  
Boomer, West Virginia

*INTEGRATED MINED-AREA RECLAMATION AND LAND-USE PLANNING*

*Volume 3D: A Case Study of Surface Mining and Reclamation  
Planning: Area Strip Coal Mining, Peabody  
Universal Mine, Universal, Indiana*

*by*

*James L. Guernsey, Michael E. Tiller, and James R. LaFevers*

*ABSTRACT*

An integrated surface mining and reclamation program typical of those found at large scale surface coal mining operations in the Midwest and West is examined in this case study, which focuses on Peabody Coal Co.'s Universal Mine in west central Indiana. A high volatile, bituminous coal is extracted and processed at the Universal site, which opened in 1969 and is now one of the largest producing surface mines in the state. Careful planning for effluent control during mining has resulted in a nearly "pollution-free" area stripping operation at Universal, and most of the mined land has been graded for and seeded as pasture. The mine is about 10 miles from the City of Terre Haute; this proximity offers opportunities for developing reclaimed surface mines for higher land uses than those required by the state (forestry, rangeland, pasture, or cropland), due to high demand for housing and recreation sites. Surveys of area residents show such development would be well-received; however, there is no public planning effort underway to promote these types of land use. This situation is representative of many mines, where progressive companies have generated land use strategies without seeking or being offered much input from public planners. While mining companies may be capable of good reclamation planning, public benefit could be maximized by a concerted effort by planners and mining companies to work together in integrating reclamation and land use planning.

*1 INTRODUCTION*

This case study is concerned with land reclamation at Peabody Coal Co.'s Universal Mine, an area stripping operation located about 10 miles north of Terre Haute, Indiana (Fig. 1.1). Physical and cultural factors related to the mine's location are discussed wherever they are considered to affect the reclamation program or reclamation planning at the Universal Mine. Regional factors are also examined in instances in which the information is deemed useful in generalizing data from this site to similar operations.

The Universal Mine was not chosen for this study because of outstanding or unique features. Rather, it possesses many characteristics common to Midwestern and Western area coal mines. The effort involved in the reclamation program and the integrated mining and reclamation planning that permits

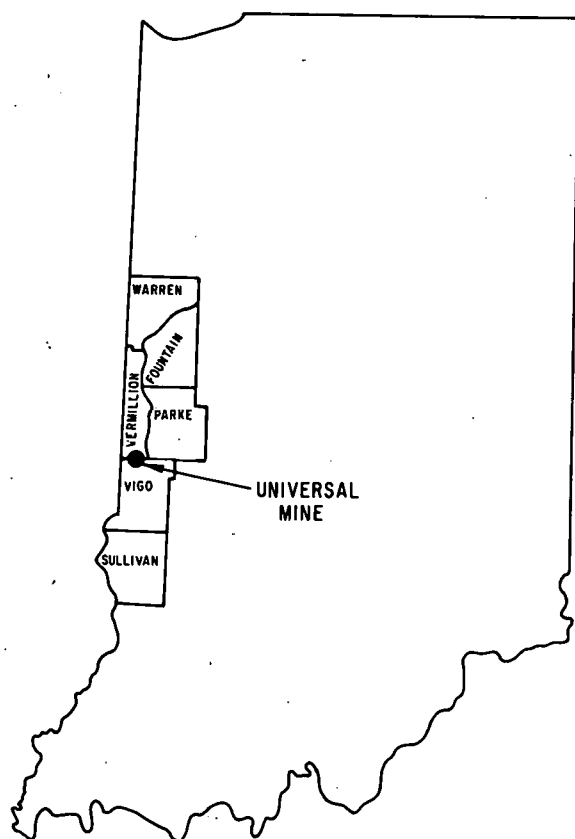


Fig. 1.1. Location of the Universal Mine

concurrent mining and reclamation has become somewhat exemplary of large coal mining corporations' policies. This site constitutes a better example of the various reclamation planning options than do some of the more isolated Western mines, however, because of its proximity to a metropolitan area, Terre Haute. In addition, several studies cited in this report have been conducted in the Terre Haute area to assess the impact of mining and reclamation on the physical and cultural environment. The availability of these data contributed to the selection of this site for a case study.

Some previous investigations have indicated that the Terre Haute area presents an excellent opportunity for mining companies to profit from long-range land use planning. The demand for residential and recreational sites, coupled with past regional experience with reclaiming land to forestry and agricultural uses, indicates that reclamation in this area can be profitable to the mine operator if proper market analyses and reclamation procedures are utilized. Much room remains, however, for improvement in

the relations between mining companies and public planners in the Terre Haute area. This situation is somewhat typical of both planning agencies and mining companies. Since local planners have no mandate to become involved in reclamation planning, they have made little attempt to do so. Conversely, the mining company seems to prefer to handle its planning and marketing strategies in-house without becoming involved with planning officials. Such is the situation in most coal mining areas, and it is well illustrated by this case study.

## 2 REGIONAL PERSPECTIVE

### 2.1 PHYSIOGRAPHIC SETTING

To better understand the physical situation of Peabody's Universal Mine, it is necessary to review briefly the physiographic setting of the region. The Universal Mine is located in Vigo and Vermillion counties, Indiana, in the physiographic unit known as the Wabash Lowland, which extends from southeastern Parke County to the Ohio River and includes most of the 16 counties of southwestern Indiana that make up Indiana's coal mining area. The Wabash Lowland reflects the effects of deposition by continental glaciers and is generally level to undulating with a local relief of less than 100 ft. The undulating upland portions are normally covered with wind blown silt deposits (loess), and the more level lowlands are usually characterized by surficial alluvial sediments. The area also possesses deposits of glacial till and valleys that contain extensive outwash and alluvial deposits.

The Universal Mine is situated on a till-covered upland. The original topography of the site was level to gently rolling, with slopes increasing in steepness toward the valleys of Bruillett's Creek to the north and Gin Creek to the south. The mine area is characterized by approximately 100 ft of alluvium and glacial till overburden above the Pennsylvanian age bedrock that includes the minable coal seams. These thick, unconsolidated overburden deposits enable Peabody to revegetate the mined area with a wide variety of plants and crops after mining. No topsoiling of the surface mined lands is required, since the mixture of surficial materials with thick glacial tills provides an excellent base for the growth of grasses, legumes and row crops (Perlar, 1976).

### 2.2 CLIMATE

Precipitation in west central Indiana is extremely variable. The average total for the region is 39.68 in., with the driest year having 28.04 in. and the wettest 63.34 in. Precipitation at the Universal Mine site is fairly evenly distributed throughout the year, with about 60% of the total falling during the growing season.

Heavy precipitation in wet years may adversely affect surface mining operations by eroding materials, flooding, ponding, and causing delays in mining activities and outside work. Intense precipitation especially promotes erosion of surface mine haul roads. Erosion may be severe on the pit entrance roads, which have grades of 6-8% and overall lengths of 500-600 ft. Some stabilization measures, employing existing technology, that are used to reduce erosion at the Universal Mine include: (1) a slope design that reduces runoff and encourages infiltration of water into the spoil, (2) application of soil binders on slopes most subject to severe erosion after final grading, (3) seeding with cover crops until more permanent types of vegetation can gain a foothold, and (4) construction of diversion channels to remove runoff water from mining operations in order to minimize erosion and stream sedimentation.

Of the 39.68 in. of average rainfall received in the Universal Mine area, most returns directly to the atmosphere as water vapor by evapotranspiration.

During the first four months of the year a water surplus exists. By mid-May the period of utilization occurs and plants draw upon the available soil moisture. By late July the available soil moisture is used up and a moisture deficit occurs. By September a period of soil moisture recharge takes place and water becomes available for runoff. In short, the water balance of the Universal Mine area includes the greatest stream discharge between November and May, a low summer availability of moisture, and water deficit from July to September. Time of occurrence, condition of the surface, slope of the land, variation in vegetation cover, and intensity of the rainfall are some of the factors that affect the runoff, groundwater recharge, and evaporation rates. The average annual rainfall in the Wabash Basin is sufficient to meet the total moisture requirements for most crops if properly distributed throughout the growing season. The ideal rainfall pattern seldom occurs, however, and many crops suffer drought effects even in so-called "normal" years.

The area is characterized by a four-season thermal climate. Mean monthly temperatures range from a low of 29.88°F in January to a high of 76.87°F in July. Monthly increments in mean temperatures are greatest during the spring and fall with the largest changes in mean from the preceding month occurring in April (+11.4°F over March) and November (13.6°F cooler than October). By contrast, monthly differences in the summer and winter monthly series vary by some 4°F and 3°F, respectively.

The minimum winter temperatures also affect the depth of frost penetration. The depth to which the soil normally freezes in the Universal Mine area is 18 in. The depth of frost penetration is also affected by several factors other than temperature. Open lands tend to freeze more deeply than lands with a snow cover; snow serves as an insulator for barren unreclaimed lands. Deep, thick frost zones commonly occur in surface mined lands that are frozen after a heavy rain. During periods of frost penetration, the spoils are not subject to erosion but the alternate freezing and thawing of saturated strip mined lands may cause various types of mass movements. A saturated spoil bank subjected to freezing temperatures becomes spongy after thawing and may be subject to slumping. Soils in the area of the Universal Mine are affected moderately to severely by frost heave, indicating a potential for related problems at the mine site. Water infiltration, erosion, slumping, heaving, and runoff all show a marked variation in relation to the amount and depth of the frost penetration (Barton, 1969). Frost penetration depth is thus an important consideration in determining land reclamation practices in the Midwest.

In general, the Universal Mine region has a sufficient margin of growing season to permit the growth of a variety of products on reclaimed mined lands. The length of the growing season fluctuates considerably from year to year but averages 175 days. In reclaiming the surface mined areas for corn, for example, 130 days are required between the last killing frost in the spring and the first one in the fall. Although spring plantings may be delayed by wet, cold soil conditions, the crop still has time to mature within the 175-day period. Occasionally, however, an unexpected frost that occurs during late spring may force farmers to plant row crops a second time.

### 2.3 HYDROLOGY

The Universal Mine area has an excellent supply of groundwater obtained from glacial aquifers. In general, the replaced spoil material is less compacted than the original surficial materials. Thus, surface infiltration rates may be increased by the mining process. This process may be beneficial both in preventing flooding and in maintaining stream flow. Peabody officials have stated, however, that the current state requirement to grade this site to eight percent slopes has caused excessive compaction (Healy, 1977).

Water quality problems characteristic of the region include sedimentation due to surface erosion and consequent pollution of the water resources. Sheet and gully erosion are among the predominant types. Sheet erosion, in which soil is removed by overland runoff, is the most widespread and severe, due to the frequent, intense thunderstorm rainfall occurring on a high percentage of cropland. It is most serious in areas of intensive cultivation. Rill erosion, a form of sheet erosion, forms shallow channels that can be smoothed out by normal cultivation. Gully erosion is very localized in the Universal Mine area and overall is not as serious a problem. Localized, severe erosion tends to lower the value of land adjacent to affected areas.

Sediments transported by erosive processes may cause additional problems. The silting of channels results in their constriction and a decreased capacity to carry runoff water, thus increasing the possibility of flooding. Silting also may block drain tile outlets and surface drainage ditches, causing ponding in adjacent farm lands, which in turn may result in reduced yields. Deposited sediments may disrupt highway and railway drainage systems by accumulating in ditches and culverts and upon roadways.

In most streams, minimum flows provide too little water for adequate dilution of waste materials. A variety of pollutants, both in suspension and in solution, enter streams by direct drainage and by subsurface seepages. However, the Universal Mine has large settling basins designed to prevent the contamination of nearby surface waters. These water impoundments are designed to retain water from the mine pits to prevent acid formation.

### 2.4 SOILS

The soils of Vigo and Vermillion counties vary, depending upon parent materials, topography, vegetation, climate, and duration of development. Glacial till, outwash materials, and wind deposits are the major parent materials. Soils that developed under forest vegetation are thinner and lower in organic content than those developed from grass vegetation. Soils on slopes are normally thinner because of erosion, and soils in depressional or bottomlands are thicker, since they have accumulated runoff deposits. But these lowland soils frequently are poorly drained, especially when the topsoil, subsoil, or parent materials are relatively impervious.

All except 6,434 acres of the total cropland in the two-county area falls into the U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS) Soil Capability Classes I, II, and III, the highest grades of agricultural land (Tables 2.1 and 2.2). Class I soils, which make up 15% of the total cropland, have few limitations that restrict their use and are suited to a wide

Table 2.1. Soil Capability Classes

Capability Class	Acreage in Vermillion and Vigo Counties
I	36,751
IIe	19,818
IIw	111,786
IIs	30,922
IIIe	10,256
IIIw	35,013
IIIs	3,074
IVe	5,907
VIe	527

Source: USDA Soil Conservation Service, *Conservation Needs Inventory* (1967).

range of plants that may be used for cultivated crops. They are deep, generally well drained, and easily worked. Class II soils have some limitations that reduce the choice of plants or require moderate conservation practices. These soils, which make up almost two-thirds of the total cropland, require careful soil management, but may be used for cultivated crops even though the farmer has less latitude in the crop choice. About 20% of the cropland is Class III soils, which although they have some severe restrictions that reduce the choice of plants and require special conservation practices, may be used for cultivated crops, pasture and woodland. The remaining soils in cropland are Class IV and Class VI, and both have very severe limitations for cropland. Limitations of Class IV soils for cultivated crops include steep slopes,

severe erosion, shallow soils, or low moisture-holding capacity. Class VI soils are generally unsuited for crops; however, 527 acres in this classification are used for crops in the two-county area.

Most of the Universal Mine area has soils that were wet in their natural state. Inadequate drainage limits land use to less intensive cropping patterns, reduces crop yields, and results in greater unit costs of production through reduced farming efficiency. Agricultural development of the area has resulted in extensive tiling of such wet soils.

A detailed soils map for the Universal Mine site is given in Fig. 2.1. The two major soil series that occupy the upland portions of the site are the Fincastle and Ragsdale (USDA, 1974). The Fincastle is found on broad level uplands with 0-2% slopes and the Ragsdale, in upland depressions with 0-2% slopes. These series are both silt loams, which have developed in 2-3 ft of loess over glacial till, and are suited to all crops grown in the region if adequate drainage systems are established and maintained. Their capability unit classification is IIw-2, indicating a deep, poorly drained soil. The Ragsdale soil was formed under grass and hardwood tree vegetation, and has a high available water capacity and slow permeability.

The Hennepin and Xenia series comprise the chief soils on slopes adjacent to stream valleys. In total area they are much less important than the Ragsdale or Fincastle series. The Hennepin loam, capability Class VIIe-2, occurs on slopes of 25-50%, which are too steep for cultivation, and needs careful management to control erosion. It is best suited to mixed stands of hardwoods. The Xenia series developed in loess over glacial till and consists of deep, moderately well drained soils on gently sloping uplands. The Xenia silt loam, with slopes of 2-6%, is suited to all types of crop commonly grown in the region, as well as permanent pasture and trees. Its capability unit is IIe-3, and risk of erosion is the major management consideration.

Table 2.2. Summary Land Capability for Cropland

---

Class I	Soils have few limitations that restrict their use.  Soils are suited to a wide range of plants and may be used safely for cultivated crops, pasture, range, woodland, and wildlife. The soils are nearly level, and erosion hazard (land or water) is low. They are deep, generally well drained, easily worked, hold water well, and are either fairly well supplied with plant nutrients or highly responsive to fertilizer.
Class II	Soils have some limitations that reduce choice of plants or require moderate conservation practices.  Soils require careful soil management, including conservation practices, to prevent deterioration or to improve air and water relations when soils are cultivated. Limitations are few and the practices are easy to apply. The soils may be used for cultivated crops, pasture, range, woodland, or for wildlife food and cover.
Class III	Soils have more restrictions than those in Class II and when used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. They may be used for cultivated crops, pasture, woodland, range, or for wildlife food and cover.
Class IV	Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both.  The restrictions in use for these soils are greater than those in Class III, and the choice of plants is more limited. When these soils are cultivated, more careful management is required and conservation practices are more difficult to apply and maintain. Subclass e (erosion) is made up of soils where the susceptibility to erosion is the dominant problem or hazard in their use; erosion susceptibility and past erosion damage are the major soil factors for placing soils in the subclass. Subclass w (excess water) is made up of soils where excess water is the dominant hazard or limitation in their use. Poor soil drainage, wetness, high water table, and overflow are the criteria for determining which soils belong in this subclass. Subclass s (soil limitations in the root zone) is made up of soils where root-zone limitations are the dominant hazard or limitation in their use. These limitations are the results of such factors as shallow soils, stoniness and low moisture-holding capacity.

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The Orthents, loamy (OrB), with slopes of 0-8%, are nearly level to moderately sloping. These deep, loamy soils are located on disturbed uplands and terraces, adjacent to undisturbed areas of very poorly to well drained, nearly level to very steep soils. They are well to moderately well drained and consist of a mixture of surface soil, subsoil, and substratum that may contain some gravel, shale, or stones. They have moderate available water capacities and are moderately and moderately slowly permeable.

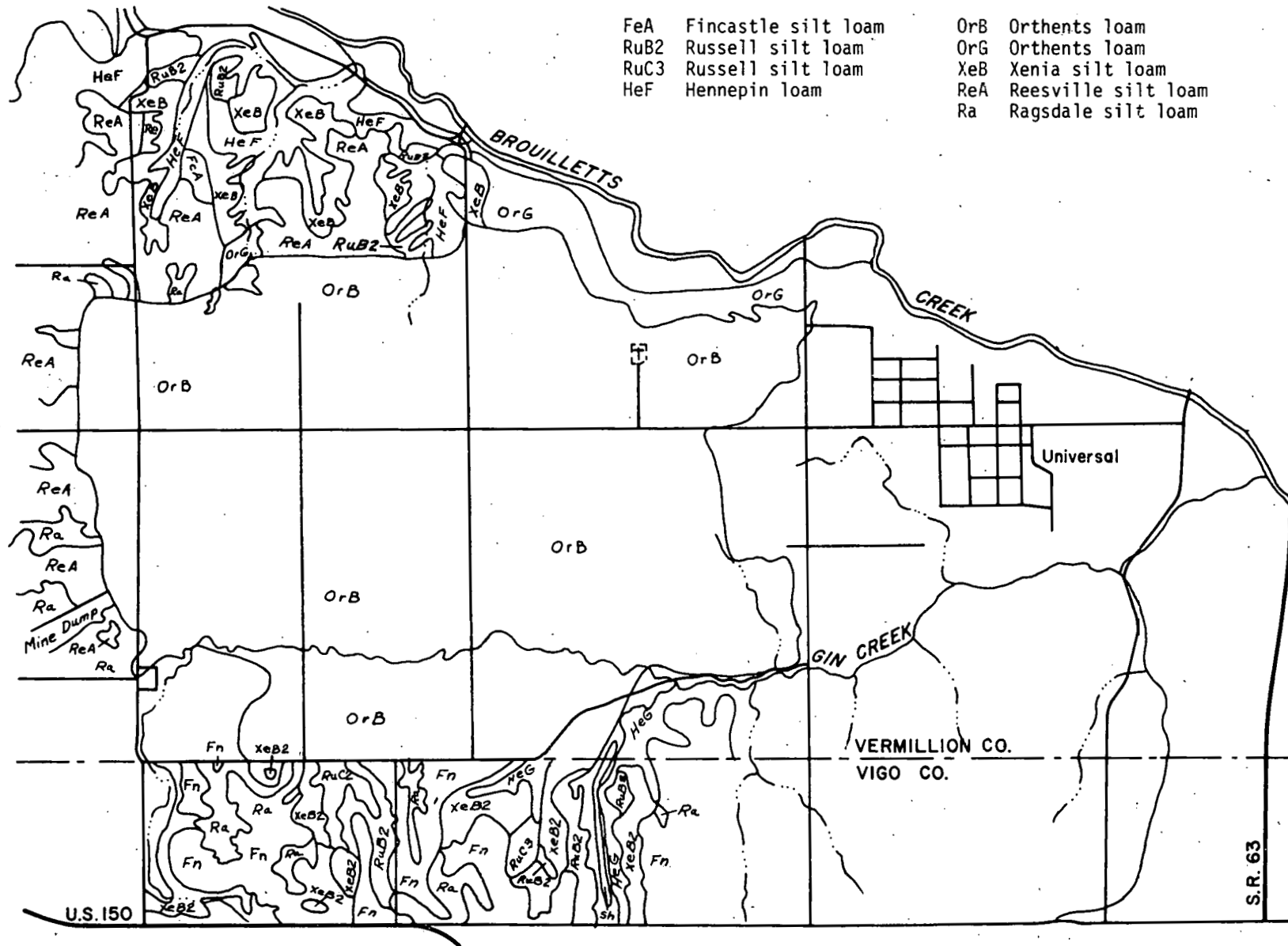


Fig. 2.1. General Soils Map, Universal Mine Area

The Orthents, loamy (OrG), have 33-90% slopes. This very steep, deep, loamy soil is on disturbed uplands and terraces, adjacent to undisturbed areas of very poorly to well drained, nearly level to very steep soils. It is well to moderately well drained and consists of a mixture of surface soil, subsoil, and substratum that may contain some coal, fragments, gravel, shale, or stones. Consisting chiefly of unlevelled strip mine areas, it has moderate available water capacity and is moderately or moderately slowly permeable.

The nearly level Reesville silt loam (0-2% slopes) is a deep, silty soil that occurs on broad flat uplands, adjacent to nearly level to slightly depressional, very poorly drained upland soils. Somewhat poorly drained and formed in loess more than four feet deep, it has high available water capacity and is moderately slowly permeable.

The Russell silt loam (RuB2) has 2-6% slopes and is severely eroded. This gently sloping, deep, fine silty soil occurs on rises and side slopes along drainageways in uplands. Well drained and formed in 20-40 in. of loess over glacial till, it has high available water capacity and is moderately permeable. The Russell silt loam (RuC3) has from 6-12% slopes, and is also characterized by much erosion. This moderately sloping, deep, fine silty soil is on side slopes of drainageways and side slopes adjacent to and intermingled with poorer drained and steeper soils. Well drained and occurring on loess-capped glacial till uplands, it has a high available water capacity and is moderately permeable.

Under improved conditions, the major soil series of the mine site are among the most productive in the region (USDA, 1974). They constitute a high-quality natural resource which is altered by the mining process. A considerable degree of planning and effort in reclamation is necessary to restore the land to its former agricultural potential.

## 2.5 LAND USE

Approximately 80% of the land in Vermillion and Vigo counties, including the Universal Mine, has been identified by the SCS as farm land. Because most areas are suitable for row crops, 56.8% of the land in farms is used as cropland. According to Soil Conservation Service data, the total amount of cropland is 105,726 acres in Vermillion County and 148,328 acres in Vigo County (USDA, 1967). Corn, soybeans, and wheat were produced on about 85% of the acreage used for crops.

The second largest farmland acreage in the two-county region is occupied by timber. Almost one-fourth of the land in farms consists of wooded areas within the farm units. Unfortunately, much of the 75,346 acres are producing weed trees and the trees are sparsely spaced within the forests. Pasture, hay, and grazing compose less than one-fifth of the total farmland in the two-county region.

Urban and other built-up areas occupy about 10% of the land in the two-county region. An increasing population, the suburban sprawl of Terre Haute, and spreading commercial shopping centers represent significant increases in land uses in the region. Considerable expansion of future uses is possible in the two-county region with the possible exception of cropland, of which most of the Class I, II, and III lands have already been used for

crops. Earlier attempts to project future land uses have underestimated production potential and have overestimated the need for higher land uses. In conclusion, land use changes likely to result from surface mining will result more from the need for more appealing aesthetic qualities than from the need for more agricultural output.

Considering the Universal site itself, prior to mining, more than 90% of it (exclusive of the office and processing plant areas) was devoted to farm land; more than 60% of the total acreage was planted in crops. Both of these percentages are larger than the respective figures for the two-county region as a whole. Table 2.3 lists the acreages and percentages of each general category of use that existed before mining.\* The table indicates dominant classes of land: cropland, pasture, and woodland. At the Universal site, these land classes have the following characteristics:

*Cropland.* In any given year the management practices of individual farm operators will vary, resulting in differing "mixes" of crops being cultivated. In general, though, the bulk of cropland has been planted in corn and soybeans, with wheat being a crop of minor importance.

*Pasture.* Pasture, as defined for the purposes of land use calculation, comprises grasslands of varying quality. About half of the pasture in the area was wooded to some degree.

*Woodlands.* Woodlands include mature, mixed hardwood stands as well as areas of dense scrub and small tree growth. Characteristically, woodlands were distributed in steeper slopes, near drainages.

Table 2.3. Pre-Mining Land Uses on Universal Mine Disturbed Areas

Land Use	Acres <sup>a</sup>	% of Disturbed Areas
Cropland	1138	63.4
Pasture	145	8.1
Farmstead	32	1.8
Non-Farm Residence	13	0.7
Woodland	429	23.9
Vacant and Idle	24	1.3
Disturbed (before mining)	11	0.6
Water	1	0.1

Source: Calculated from 1966 USDA air photography, 1:20,000 scale.

<sup>a</sup>Total calculated acreage equals 95% of disturbed acreage reported by Peabody Coal Co.

\*Land uses were classified by photo interpretation and measured, by use of area graph, on a semi-controlled photo mosaic at a scale of 1:20,000. Accuracy is estimated at 94%.

### 3 MINING DATA

#### 3.1 HISTORY OF THE OPERATION

In 1969 Peabody Coal Co. applied to the Indiana Dept. of Natural Resources for a permit to mine coal on 155 acres of land in southern Vermillion County near the town of Universal. From August, 1969, when the permit was granted, to July 31, 1970, 148 acres were strip mined (Peabody, 1969a, b). In 1970, the first full year of production, 926,054 tons of coal were produced (State of Indiana, 1970). The Universal Mine has been in continuous operation since then and has expanded to over 2000 acres; total production through 1975 amounted to over 11 million tons (State of Indiana, 1970-1975).

From the initial area of disturbed land southwest of Universal, the mine has expanded toward the north, west, and south. The mined area extends west for three miles from Universal and south for three miles from the broad valley of Brouillett's Creek. Figure 3.1 indicates the continuous expansion of mining operations toward the north and west between 1970 and 1975 and toward the south beginning in 1972. During 1972, a second pit was opened, and both pits have operated simultaneously since that time, greatly accelerating the rate at which land is disturbed. Note that the upland on both the north and south sides of Gin Creek has been mined; the mined land is being extended south and west into larger areas of this level upland. The mine office, equipment, and processing facilities were constructed in the flood plain of Gin Creek, south of Universal. The town is thus bordered by the activities of coal mining and reclaimed mined land.

#### 3.2 OPERATIONAL DATA

Table 3.1 outlines the expansion of disturbed acres by permit year. The least amount of land, 148 acres, was stripped in the initial permit year, 1969-1970, and the amount of land mined increased through 1974, when 449 acres were disturbed. A 1974-75 decrease to 367 acres may have been a result of work stoppages due to labor problems; 430 acres were supposed to have been mined during that year. An estimate of 377 acres disturbed in 1975-76 can be made on the basis of data in the 1975-76 permit application (Peabody, 1975). In terms of the total amount of disturbed acreage in Indiana resulting from surface mining of coal, clay, and shale, the Universal Mine accounted for 4.1% in 1969-1970, 5.2% in 1970-71, and 7.0% in 1971-72.

The increase in area disturbed between 1971-72 and 1972-73 reflects the opening of the second pit at the mine site, which is south of Gin Creek and south of the area mined in 1969-70. As Table 3.2 indicates, there was a corresponding increase in coal production between 1971 and 1973. A direct comparison of figures on area stripped and production is not possible because the acreage data are reported on the basis of the permit year (July 1 to June 30) and production is reported to the Indiana Bureau of Mines and Mining on the basis of the calendar year (Jan. 1 to Dec. 31). Trends, however, are parallel.

Since the opening of the second pit, the Universal Mine has been one of the largest in the state. At the end of 1970, according to the Indiana

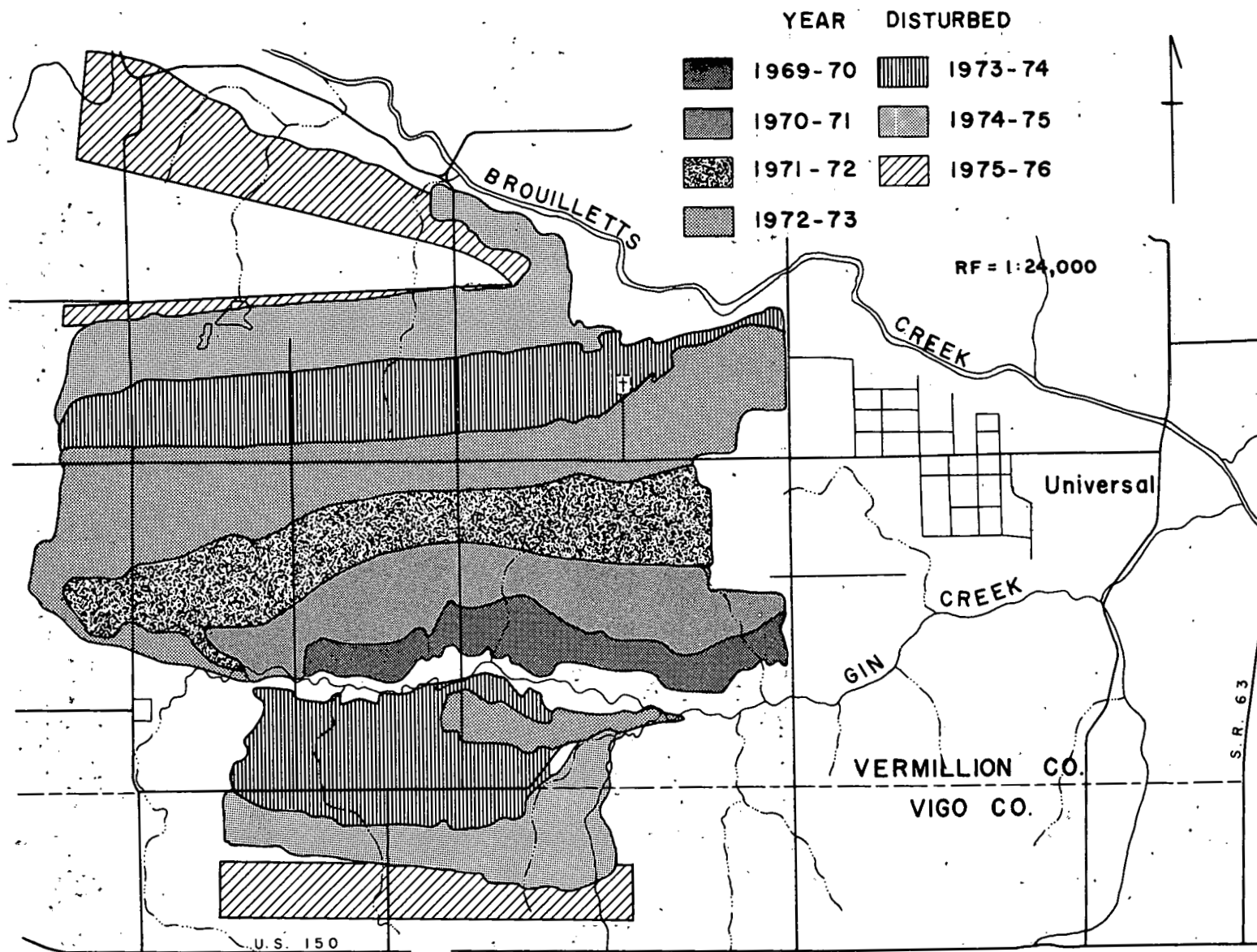


Fig. 3.1. Location and Expansion of Universal Mine Disturbed Area, 1969-1975

Table 3.1. Universal Mine Disturbed Area, 1969-1976

Permit Year	Acres Disturbed	% of Total	Acres Disturbed, Cumulative	% Disturbed, Cumulative
1969-70	148	7.8 <sup>a</sup>	148	7.8 <sup>a</sup>
1970-71	206	10.9	354	18.7
1971-72	275	14.5	629	33.2
1972-73	446	23.6	1,075	56.8
1973-74	449	23.7	1,524	80.5
1974-75	367 <sup>b</sup>	19.4	1,891	99.9
1975-76	400 <sup>b</sup>	-	-	-

Source: Peabody Coal Co., *Form 502, Report of Affected Area*, Div. of Reclamation, Indiana Dept. of Natural Resources (1969-1976).

<sup>a</sup> Percentages do not equal 100.0 due to rounding.

<sup>b</sup> Area planned as indicated in permit application (Peabody, 1975).

Table 3.2. Annual Universal Mine Production, 1970-1975

Calendar Year	Tons
1970	926,054
1971	1,300,094
1972	2,266,567
1973	3,039,321
1974	2,833,348
1975	2,761,649

Source: State of Indiana, Bureau of Mines and Mining, *Annual Reports* (1970-1975).

Bureau of Mines and Mining, the mine was the eleventh largest producing surface mine in the state, and by 1972, with a production of 2.3 million tons, it was the third largest. Because of the Universal Mine, Vermillion County in 1972 ranked fifth out of 10 surface coal mining counties (State of Indiana, 1972). In 1973, Universal's largest production year to date (3 million tons), the mine ranked second out of 36 reporting Indiana surface mines, and of the 10 surface mining counties, Vermillion ranked fourth. In 1975, Universal maintained second place out of 95 reporting mines, and Vermillion County continued to rank fourth in the state.

### 3.3 THE OPERATING COMPANY

Peabody Coal Co., operator of the Universal Mine, is owned by the Kennecott Copper Co., a multi-industry conglomerate that acquired Peabody in 1969. Peabody mines coal in 10 states in the South, Midwest, and West, and is the largest coal producer in both Indiana and the nation (LaFevers, 1974).

According to 1975 figures from the Indiana Bureau of Mines and Mining, Peabody operated five surface mines in five Indiana counties, with a total production of about 8.9 million tons. The number of Peabody mines in operation has remained constant since 1970. However, production reported by all Peabody mines in the state varied by almost 2 million tons between 1971 and 1972. Overall increases and decreases are the result of yearly variations at individual mines rather than of a consistent pattern of change in production across Peabody's Indiana operations. Peabody's relative importance as a surface coal producer in Indiana is illustrated in Table 3.3. In five of the last six years, Peabody has mined more than 40% of the coal produced in the state. Table 3.4 shows the annual production of the state's 10 largest mines, including the Universal.

Table 3.3. Percent of Reported Indiana Surface Coal Mine Production Attributable to Peabody Coal Co., 1970-1975

Year	Peabody Production (10 <sup>6</sup> tons)	Total Ind. Production (10 <sup>6</sup> tons)	% Ind. Prod. by Peabody
1970	9.06	20.2	44.7
1971	8.78	19.5	44.9
1972	10.52	24.4	43.1
1973	10.35	24.5	42.3
1974	9.03	22.3	40.4
1975	8.89	25.0	35.6

Source: State of Indiana, Bureau of Mines and Mining, *Annual Reports* (1970-1975).

Table 3.4. Coal Production of the Ten Highest Ranking Surface Mines in Indiana, 1970-1975

Rank	Production (10 <sup>6</sup> tons) <sup>a</sup>					
	1970	1971	1972	1973	1974	1975
1	3.54	3.03	4.17	4.06	3.23	3.23
2	1.89	1.73	2.44	<u>3.04</u>	<u>2.83</u>	<u>2.76</u>
3	1.80	1.58	<u>2.26</u>	<u>2.40</u>	2.40	2.66
4	1.65	1.57	2.14	2.10	2.28	2.52
5	1.62	1.43	2.09	2.01	1.79	2.01
6	1.51	1.40	1.81	1.96	1.79	1.96
7	1.44	<u>1.30</u>	1.51	1.50	1.56	1.41
8	1.42	<u>1.30</u>	1.46	1.23	1.35	1.33
9	1.39	1.28	1.41	1.21	1.28	1.19
10	1.34	1.26	1.34	1.08	0.48	1.02

Source: State of Indiana, Bureau of Mines and Mining, *Annual Reports* (1970-1975).

<sup>a</sup>Rounded to the nearest ten thousand tons; Universal Mine production figures underlined.

The existence of other Peabody operations in the same region may endow Peabody with a certain flexibility in meeting labor and equipment demands at a particular site. Mine inspection reports indicated that when the company needed to speed up the grading of spoils, it was able to respond quickly by transferring equipment to the Universal Mine from another Peabody operation.

### 3.4 LAND USE AND MINERAL OWNERSHIP

Mining companies in Indiana generally prefer outright purchase of land, in fee simple estate, rather than purchase of mineral rights, leasing, or buy-back agreements, although land is also mined on those bases. LaFavers (1974) reports that, in addition, it is "the policy of major coal companies to accumulate land as a resource rather than disposing of it after mining." The recent land ownership patterns in the area of the Universal Mine conform to both of these trends.

In Fayette Township in Vigo County and Clinton Township in Vermillion County, coal mining companies are the single largest group of landholders. In 1974 Peabody owned 5,370.6 acres in the 18 sections that include or are adjacent to the Universal Mine, which represents about 50% of the total land area in the 18 sections. An additional 868 acres of the 18-section tract were owned by another mining interest, Meadow Lark Farms, Inc., a subsidiary of AMAX (Plat Books, 1972-1976).

The bulk of the land required for the Universal Mine was purchased prior to 1972. Between 1972 and 1974, only 97.5 acres were acquired by Peabody in the Vigo County portion of the 18-section area. Between 1974 and 1976 Peabody purchased an additional 135-acre area in Vermillion County sections. Both these recent purchases were close to the area of mine expansion (Plat Books, 1972-1976).

As of 1975, Peabody owned about 85% of the total disturbed land. Mineral ownership on the remaining portion has been held by two other coal companies (AMAX and Ayrshire), a railroad, two private estates, and one individual. Plat books between 1972 and 1976 did not indicate that any land was transferred from Peabody Coal Co. to individual ownership.

### 3.5 COMMODITY DESCRIPTION

In reports to the Indiana Division of Reclamation and the Indiana Bureau of Mining and Minerals, Peabody Coal Co. indicates that the mineral extracted at the Universal Mine is the Hymera or Coal VI in Indiana's numbering system. This identity was confirmed by sources at the mine office in Universal. In compiling information on the geological occurrence, reserves, and composition of Coal VI in the region, Indiana Geological Survey documents and maps were consulted which indicate that the seam mined at Universal could not be Coal VI.

Descriptions of its occurrence and coal distribution maps of Vigo and Vermillion counties fail to verify Coal VI's presence there (Powell, 1968; Shaver, 1970; and Wier, 1958 and 1973). This information was said to be accurate by a representative of the Coal Section, Indiana Geological Survey, who stated that its records show extraction of a different coal member, the Danville member (Coal VII) at the Universal Mine. This conflict is not readily resolvable; therefore, for the purposes of this report, the information on the coal seam supplied by Peabody Coal Co. to the Division of Reclamation will be accepted as correct. This acceptance will, however, limit discussion on the geological occurrence of the coal and preclude any estimation of reserves in the area of the Universal Mine because Coal VI has not been mapped in Vigo or Vermillion counties.

Coal VI is a bright-branded coal, ranked as high volatile, bituminous, Type C. High volatile bituminous coals are common in the Midwest; all coals in Indiana are high volatile bituminous, Types B and C for the most part. Peabody reports the thickness of the seam at the Universal Mine as 72 in. (Peabody, 1975).

Figure 3.2 shows the geologic locations of the major commercial coals of Indiana, including the Hymera, or Coal VI. Coal VI, in terms of energy-producing capability, is third highest in the state (based upon mean values for Btu/lb). It ranks next to lowest in percentage of ash, containing about the same amount as the Springfield Coal (V), which has, historically, been the most widely mined coal in the state. The Hymera Coal falls in the lower half of the range of percent sulfur, Indiana coals having considerably less than the Springfield. The Hymera coal has a lower range of percent sulfur than the majority of the Midwest's coals, but could not be considered a low sulfur coal (Wier, 1973). When compared on the basis of heat content, ash, and sulfur, the Hymera coal maintains a competitive position in relationship to other coals most likely to be produced in the region.

The quality of Coal VI varies over its distribution and with vertical location in the coal seam. The Hoosier Coal survey reports that the lower 12 in. of the seam are made up of an impure bone coal (Indiana Coal Assn., 1972). Where Coal VI has been mined in Sullivan and Greene counties in Indiana, two clay partings occur; in the upper half of the seam these partings are generally less than an inch thick and are separated by about 8 in. of coal (Wier, 1973). Small shale and pyrite partings have also been reported (Shaver, 1970). Mechanical cleaning methods are sometimes used to reduce sulfur levels in the marketed commodity.

According to Wier (1977), the coal mined by Peabody at the Universal Mine is Indiana Coal VII, which is the same as the Danville 7 in Illinois. Indiana Coal VI, or the Hymera Coal, is extensively mined in Sullivan County. However, near the outcrops, it barely extends into the southern part of Vigo County and is not present in the northern part of Vigo County or in Vermillion County. Historically, according to Wier, the coal mined by Peabody has been wrongly called VI simply because it is the first major coal seam above Coal V (Wier, 1977).

*Plans of Reclamation* filed with the state for the Universal Mine do not indicate the existence of clay, shale, or pyrite partings in the seam mined there. However, this information is not specifically required on the application form unless two or more veins of coal are to be mined. The occurrence of partings, and their treatment in the mining process, can be of importance in managing environmental impacts, such as acid mine drainage. Reports by state inspectors on the Universal Mine do not describe such partings, or problems resulting from their existence, as a component of the spoil at that site (State of Indiana, no date given).

### 3.6 PERSONNEL, MINING METHODS, AND EQUIPMENT

A labor force of about 184 union and 30 company employees operates the Universal Mine. Area stripping, the mining method employed at the mine, is commonly practiced in the Midwest and West in relatively level to gently

	SELECTED MEMBERS AND BEDS	LITHOLOGIC SYMBOLS
	Danville Coal Mbr. (VII)	 Shale
	Hymera Coal Mbr. (VI)	 Sandstone
	Coal Vb	 Sandstone
	Springfield Coal Mbr. (V)	 Limestone
	Survant Coal Mbr. (IV)	 Coal
	Colchester Coal Mbr. (IIIa)	
	Seelyville Coal Mbr. (III)	
	Minshall Coal Mbr.	
	Upper Block Coal Mbr.	
	Lower Block Coal Mbr.	

Fig. 3.2. Geologic Location of Major Indiana Coals (Adapted from Powell, *Coal Strip-Mined Land in Indiana*, Special Report No. 6, Indiana Department of Natural Resources, 1972.)

rolling terrain (Powell, 1972). The original topography of the mined area was level to gently rolling, except near the valleys of Gin and Brouillett's Creeks and their larger tributaries. The trenches, or box cuts, made in the process of mining have been generally straight and parallel. While spoil materials have been deposited in the previous cuts rather than cast downslope, it is possible that some overburden materials may have been cast downslope and onto the flood plain of the creek. Stripping has followed the margin of the upland parallel to the creeks' courses. After mining was completed, the spoil slopes adjacent to the two stream valleys, as well as along other sections of the mine perimeter, were graded and terraced. Figure 3.3 illustrates the treatment of the spoil slope along the northern side of Gin Creek and next to Brouillett's Creek. Terraces and diversions are visible in the aerial view.

Figures 3.4 and 3.5 illustrate the mining method as utilized at Universal. During the initial cut the overburden must be cast upon unmined land. The next cut is made parallel to the first, and the overburden is cast into the previous cut. The final cut, unless otherwise treated, leaves an open trench.

In Fig. 3.4, the relative locations of the areas of unmined land, stripping bench, coal seam, spoil, and graded spoil are represented. The dragline rests upon the surface of the bedrock overburden (the stripping bench) and its bucket digs the overburden from the face of the bench, thus exposing the surface of the coal seam. Prior to digging, the overburden has been drilled and blasted to fragment the rock. The overburden is then cast into



Fig. 3.3. Contouring, Terracing, and Diversions on Outer Spoil Slope, North of Gin Creek

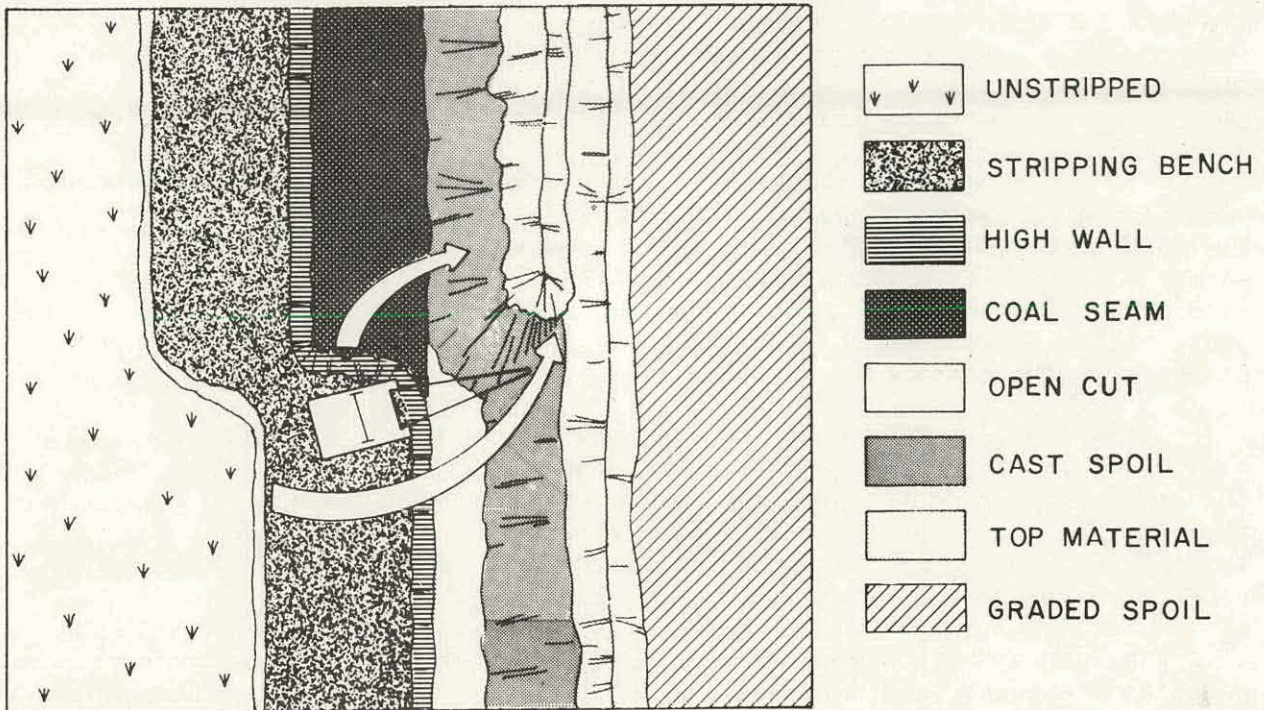


Fig. 3.4. Plan View of Area Stripping Process (showing relative locations of areas of unmined land, stripping bench, coal seam, spoil, and graded spoil at the Universal Mine; not to scale)

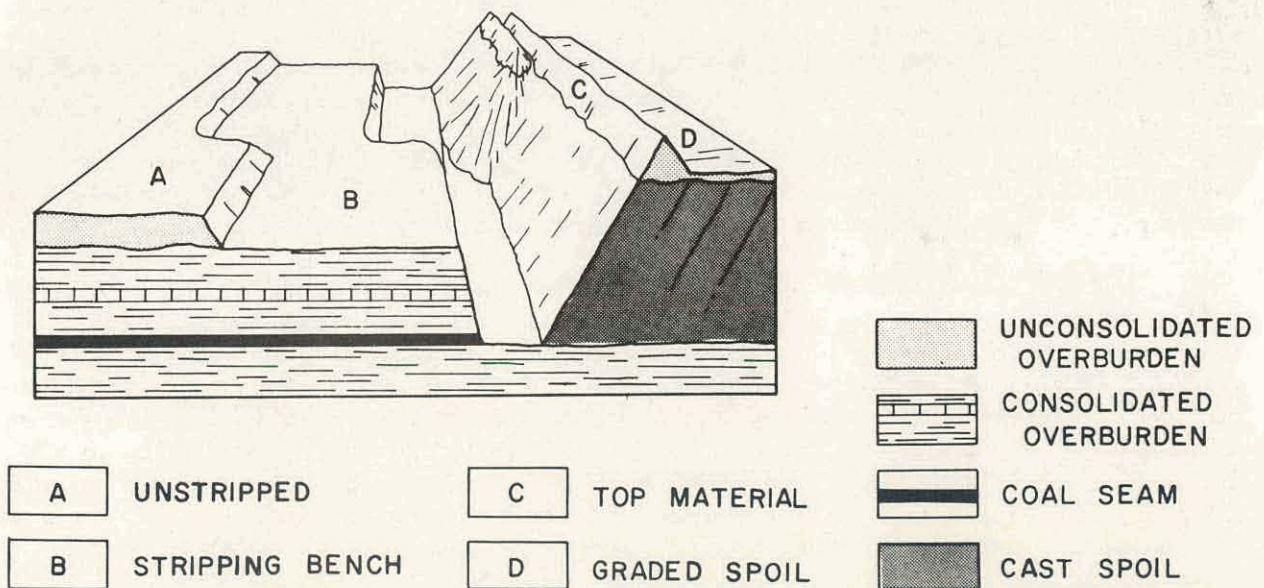


Fig. 3.5. Cross-Sectional View of Area Stripping Process (showing relative vertical relationships between overburden, coal seam, stripping bench, and spoil at the Universal Mine; not to scale)

the open cut made previously in the mining operation. The amount of overburden removed in each cycle brings the spoil ridge to a precalculated height (based upon such factors as the width of the cut, the depth of the coal seam, and the expansion in volume of the material due to fragmentation).

In the next phase of the cycle, the unconsolidated portion of the overburden is stripped from the unmined area adjacent to the bench and cast upon the top of the shale spoil. This operation creates a side bench that will form the stripping bench during the next cut. The dragline distributes the materials stripped from the side bench in such a manner that the peaks of the spoil ridges are made up of the soil and glacial tills that form the upper 25-40 ft of the overburden at the site.

The vertical relationships, in cross section, of the overburden, the coal seam, spoil, and top material are shown in Fig. 3.5. As illustrated, the side benching method of removing the top materials results in their location in the upper layer of the spoil, rather than at the bottom of the pit. If removed in sequence, the unconsolidated materials would have been buried beneath the shale and other rock.

During the process of uncovering the coal seam, the dragline must move, or walk, about its location on the bench. To provide a proper distribution of both the shale and top materials, the operator must move the machine toward or away from the highwall. If sufficient volumes of unconsolidated material are present (normally the case at the Universal Mine), this material will cover the spoil surface after the ridges have been graded down. The chemical and morphological characteristics of the top material provide a more favorable surface for reclamation than the shale and rock overburden. Potential acid-forming materials can be covered, as can large rock fragments, which would impede revegetation and cultivation and increase runoff.

The mining method described above is typical of the large-scale area stripping employed in the state. Figure 3.6 shows the "south" pit, near U.S. Hwy. 150, where overburden removal by the dragline perched upon the unconsolidated material above the highwall has proceeded from west to east along the cut. In the photograph the coal seam has been completely removed from the pit. At this point the grading of spoil for reclamation is less than two ridges behind the open cut, which is well within the limit of two ridges required for compliance with Indiana reclamation law.

During 1976, overburden was being removed in the south pit by a Bucyrus Erie 2560 dragline with a 90 yd<sup>3</sup> bucket and in the north pit by a Marion 8750 dragline with an 115 yd<sup>3</sup> bucket. The draglines used at the Universal Mine are of lower capacity than the largest in operation in the industry (180-220 yd<sup>3</sup>) and smaller than Peabody's own 145 yd<sup>3</sup> bucket used at the Dugger Mine in Sullivan County, Indiana. Two 61-R drills (15-in. diameter) are used for drilling the blast holes to loosen the overburden. In both pits at Universal, a Marion 151 shovel with 10 yd<sup>3</sup> bucket is used to remove the coal. On an average operating day the digging shovel advances 250-300 ft along the floor of the 10,000-ft-long north pit (Perlar, 1976).

Grading equipment on hand for use in the reclamation program in 1976 consisted of three Allis-Chalmers HD 41 and six Caterpillar D9 tractors. Peabody has consistently increased the amount of equipment available on the site



Fig. 3.6. South Pit, Universal Mine near U.S. Highway 150

in order to keep up with the grading necessary for reclamation; a small dragline is part of the equipment used in grading.

### 3.7 PROCESSING, STORAGE, AND EFFLUENTS

Raw coal is processed to remove iron sulfides and other unwanted mineral matter and to produce coal of the right size or mix of sizes to meet the requirements of consumers. The removal of iron sulfides and other impurities is necessary to control emissions of sulfur and particulate matter (fly ash) as air pollutants, and reduce the amount of residue ("clinkers") resulting from the burning of the coal.

Figure 3.7 shows the location of the processing facilities at the Universal Mine, south of the town of Universal and east of the mined area. Trucks that bring the coal from the pits on mine haul roads must cross a public road west of the processing site. For the benefit of local traffic, a stop light has been installed at the intersection.

Figure 3.8 is an aerial view of the processing site of the Universal Mine, showing the processing plant, storage silos, loading areas for rail and truck, and refuse area. Carter et al. (1974) report that a typical Midwestern coal processing plant consists of receiving hopper; rotary breaker; rock bin; crushing, washing and screening apparatus; storage silos; and refuse bin. The Universal plant can process about 1300 tons of raw coal per hour, graded

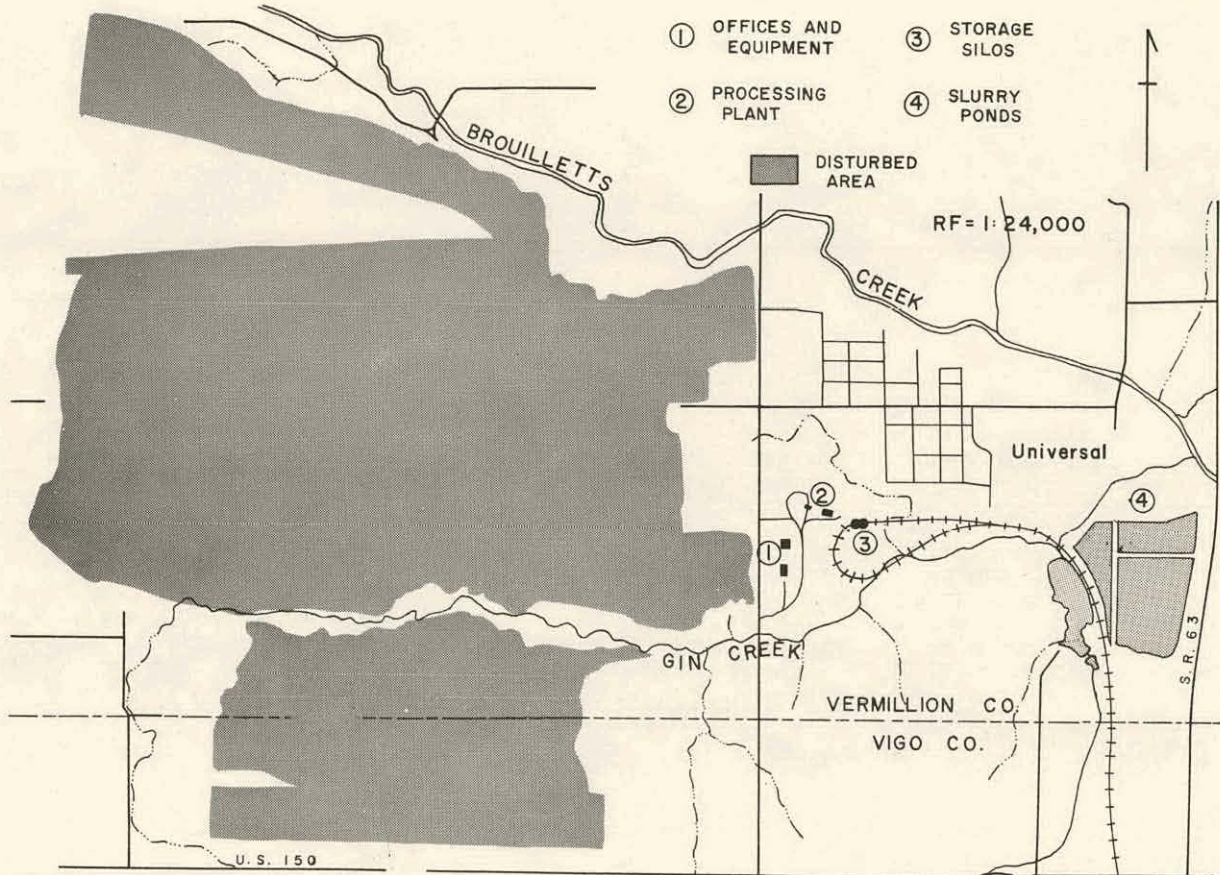


Fig. 3.7. Location of Universal Mine Processing Facilities

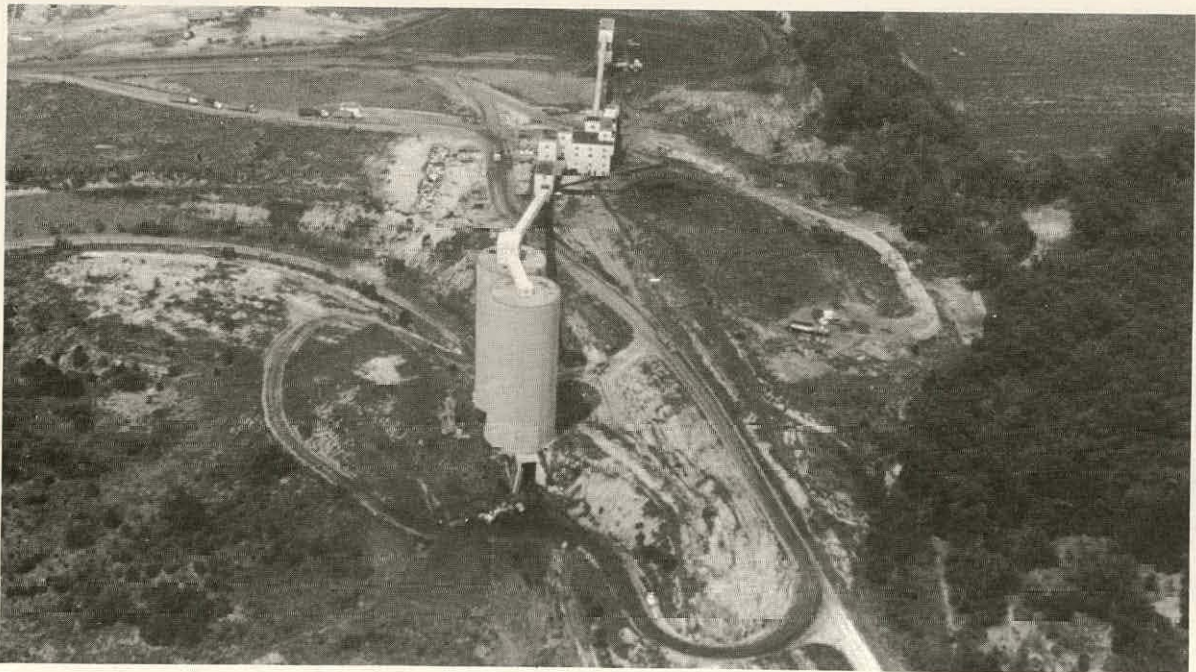


Fig. 3.8. Universal Mine Processing Plant, Storage Silos and Rail Connection

to 1 1/4-1 1/2 in. in diameter in accordance with the requirements of the consumer. Washed and graded coal is stored at the plant site in the two silos visible in Fig. 3.8, each of which has a capacity of 12,500 tons. The intermediate storage of the prepared coal by silo at the Universal Mine is Peabody Coal Co.'s method for both offsetting demand fluctuations and reducing the deterioration of stored coal. The two large storage silos at the mine provide a relatively efficient and inexpensive storage and loading capability.

Two types of waste are produced as part of the processing of raw coal. The first is solid waste that is removed mechanically, loaded into trucks at a site adjacent to the processing plant, and hauled to the mine pits where it is buried during the filling of cuts or grading of spoil. The second type of waste is wastewater from coal washing, an effluent that contains coal and various other solids in suspension. It is pumped into a settling basin, and when sufficient material has settled, the water can be pumped into a fresh water reservoir and reused in the washing process. Most of the water required for processing consists of recycled wastewater, which reduces the impact of the mine operation on local water resources.

### 3.8 TRANSPORTATION AND MARKETS

Coal is an energy source of considerable weight and bulk. Since it must be moved in large quantities, the transportation costs vary directly with the distance hauled and inversely with the unit size of the carrier. The Universal Mine is an ideal mine from the standpoint of transportation, because it has its own railhead at the preparation plant. In this way, the cost of transportation is reduced and problems of general traffic congestion and road maintenance are eliminated.

The Peabody Coal Co. has reduced its transportation costs by the use of the unit-train haulage. Stored coal at the Universal site awaits shipment by unit train or truck to nearby power plants. According to Perlar (1976), 98% of the coal is transported by unit train. Coal is loaded directly beneath the silos as trains pass under them. In Fig. 3.8, the track can be seen at the base of the silos. Trucks can reach the same loading point by means of a road that enters from north of the plant.

At present, coal mined and processed at the Universal site has a single consumer, Public Service of Indiana, which burns it in the Cayuga Power Plant. The unit trains carry coal the 21 miles to the power plant and return, intact, for another load. This method significantly reduces both the energy and dollar costs of shipping the coal to market.

Nearly all of Indiana's coal is used to generate electricity, for space heating, or in industry. Therefore, the coal's heating value, measured in Btu/lb, is its most important characteristic. The percentage of ash is important because ash must be disposed of after combustion of the coal and may also contribute to particulate air pollution. The percentage of sulfur in a coal is often a critical measure of its quality, in terms of marketability, because of environmental regulations limiting emissions of sulfur dioxide.

Indiana ranked 11th among the 50 states in electric utility sales in 1975. Virtually all the electricity (98%) used in Indiana is generated by

the consumption of coal. Increased demand for electricity since World War II has resulted in the tripling of coal consumption by electric utilities in Indiana. From all market projections, and in keeping with regional and state economic trends, the demand for electricity will continue to accelerate, at least through 2000.

Electric power plants were initially located close to potential markets in order to minimize the costs and energy losses associated with distribution. Technological developments have radically reduced the costs and energy losses of long-distance power transmission; thus, modern coal-fired power plants can be located farther from consumers. As a result, more attention is now centered on the generation of electrical energy near coal fields.

Indiana's electric utility industry has generally had little or no difficulty in obtaining adequate amounts of coal. The demand for coal to generate electricity in west central Indiana is a function of availability and price. Unlike natural gas and petroleum, coal is not regulated in either quantity or price, and the amount of user demand is the primary factor that controls the coal markets. When the yardstick of "heat value per unit cost" is applied to energy extracted from all fossil fuels, coal is the most economical. The annual energy unit costs from coal in Indiana are only about one-half those of natural gas and fuel oil.

#### 4 DESCRIPTION OF DISTURBED AREAS AND POLLUTION CONTROL PROCEDURES

##### 4.1 DISTURBED AREAS

Approaching the Universal Mine from the south, the mined area forms a plateau above the surrounding farm land. There is an abrupt change from the undisturbed landscape to the Universal Mine open cut and the ridges of ungraded spoil immediately behind it. This effect is illustrated in Fig. 4.1, an aerial view from south of U.S. Hwy. 150.

At the Universal site, spoil is made up of a combination of soil, unconsolidated material that consists mostly of glacial till, and bedrock. The unconsolidated materials are basically clay and sand; the bedrock materials generally consist of shale, with some sandstone and limestone. Permit applications in 1974 and 1975 indicate the depth and character of the overburden. The area to be mined in permit year 1974-75 had 75 ft of material overlying the coal seam; 46% of this was composed of unconsolidated materials, 46% of shale, and 8% of other rock. The area mined in permit year 1975-76 had overburden that averaged 80-ft thick with 48% unconsolidated material, 44% shale, and 8% other rock. The amount of unconsolidated material near stream valleys decreases with the depth to bedrock.

State inspectors report on the surface conditions and acidity of the spoil, including the amount, type, and size of rock. In general, the amount of rock present at the surface of the graded spoil at Universal is low. The

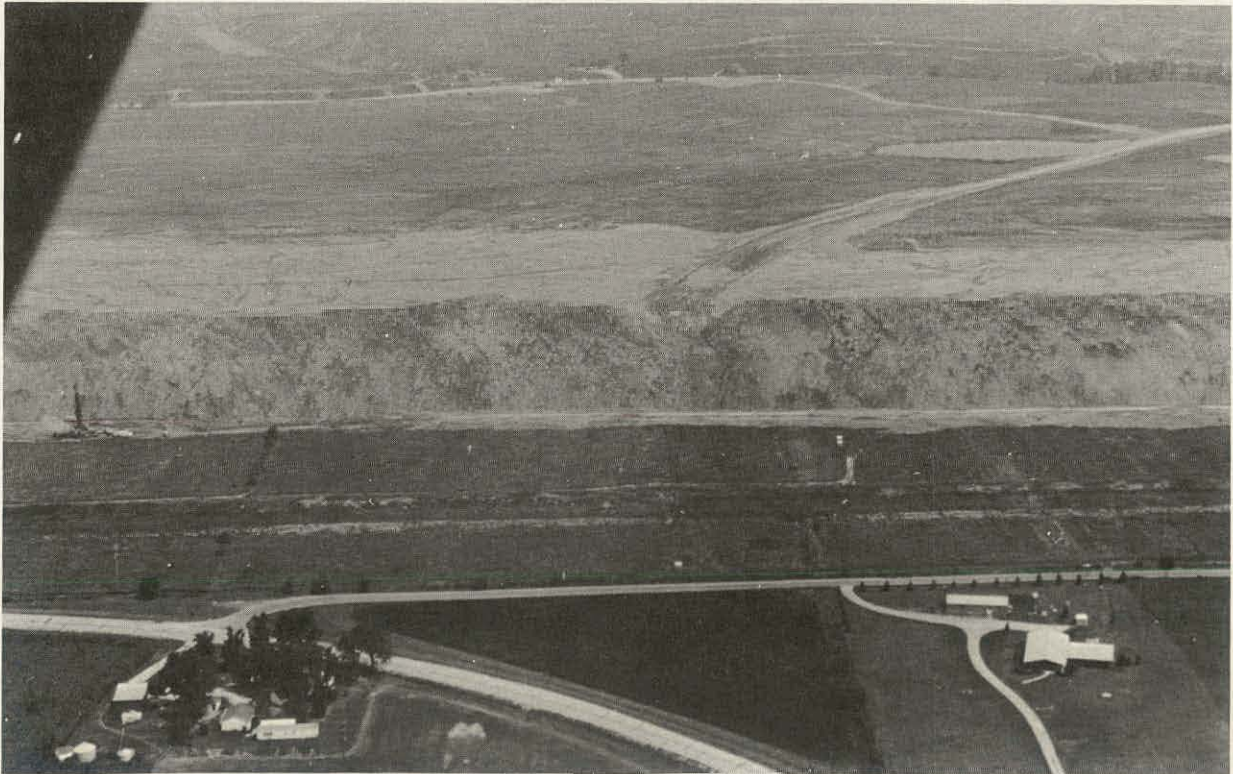


Fig. 4.1. Aerial View Approaching the Universal Mine from the South

fragments measure 6 in. or less in diameter for the most part, and are usually a mix of shale and limestone, or of shale, limestone, and sandstone. On occasion, rocks from 6-18 in. in size are found at the surface. These rock problems have become evident in and near natural ravines where overburden was thin.

The graded spoils are usually neutral to slightly acidic, with pH ranges of 7.0-6.2 being typical. The pH is dependent upon the nature of the spoil. The unconsolidated material is predominantly calcareous glacial till. Acidic areas, in which the pH ranges from 5.4-6.0, are reported where shale is exposed at the surface, and a pH as low as 3.4 has been observed in some areas (Healy, 1977).

In an Ohio study, three factors were cited as important in determining strip mine spoil bank stability: steepness of the slope, excessive soil moisture in the spoil bank, and reduction in resistance to shearing due to severe weathering and freeze/thaw cycles (Hoffman et al., 1964).

Data on the engineering properties of the spoil material are not available. Inspection reports merely indicate the relative moisture, compaction, and surface texture of the spoil. Spoils at the Universal Mine are typically moist, firm and smooth. Severe moisture conditions such as standing water often restrict work.

Poor drainage characterizes the two major soil series that originally covered the mine area. This factor is due, in part, to the characteristics of the underlying material, which now forms a major component of the spoil. Frost heave, due to freezing and thawing, may also be a problem associated with these soils. These two characteristics of the spoil material might result in some form of slope failure.

On the other hand, slope was determined to be the major contributing factor to instability by Hoffman et al. (1964); slopes of less than 1.5 horizontal to 1 vertical (67%) showed little evidence of failure. Prior to mining, slopes in the disturbed area ranged from less than 1% to over 4% near the local stream valleys and up to 18% at the valley walls. All slopes on graded areas of the Universal Mine will be less than 67%. Steepest slopes appear to occur at the margin of the disturbed area where it descends to the level of the floodplain of Brouillett's Creek. In general, low slope angles and proper compaction of the spoil will mitigate tendencies for slope failure.

Mine inspection reports do not mention problems associated with slope failure on the ungraded or graded spoil. No evidence of slumping or any form of mass wasting have been observed in the mine site or in air photographs of the site. Failure due to excessive slope or seepage has never been a problem at the Universal Mine, according to Perlar (1976).

The Universal Mine has affected the natural drainage system by destroying all the tributaries of Gin and Brouillett's Creeks, which formerly flowed across the area now disturbed. The drainageway of Gin Creek has also been altered in sections of its course. Runoff is now accommodated by special measures designed to prevent soil erosion on reclaimed land and to protect the water quality of nearby streams.

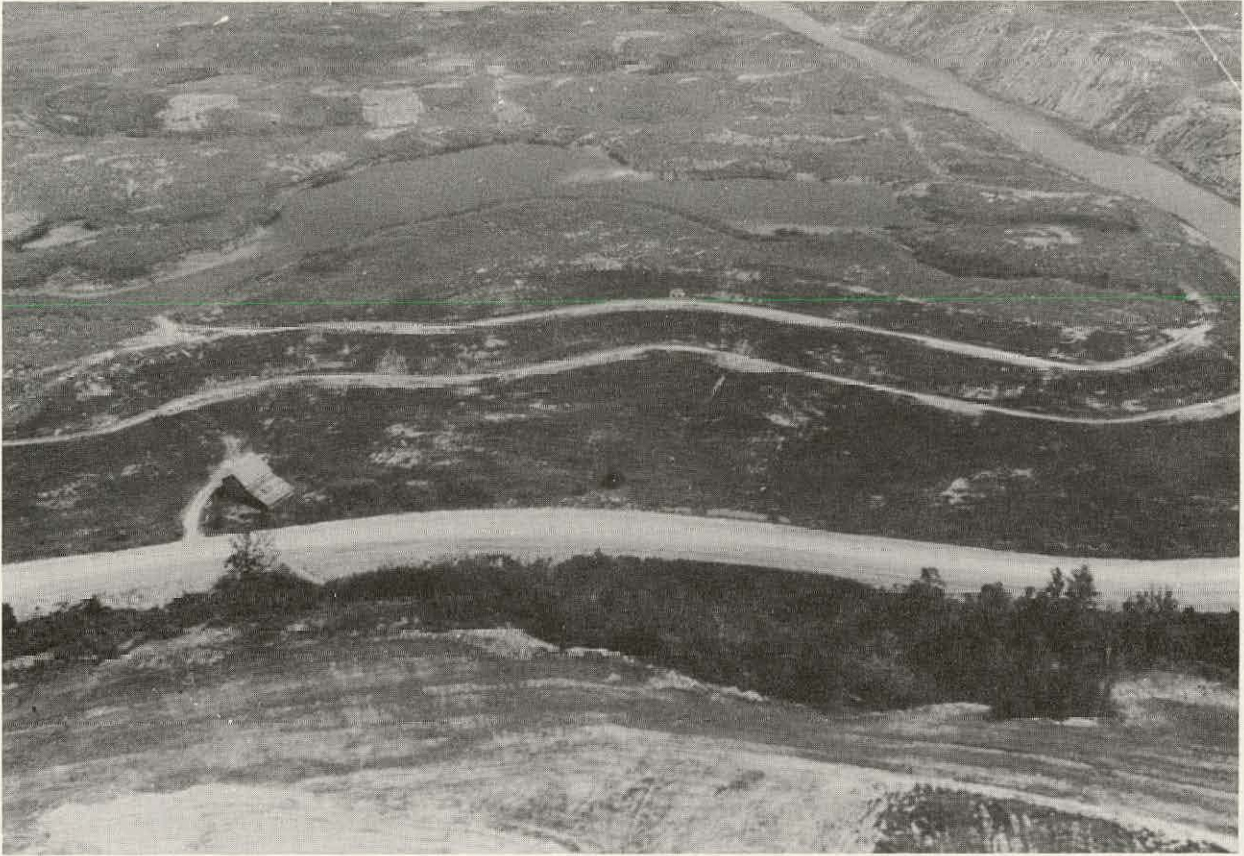


Fig. 4.2. Ponding on the Graded Spoil Surface (also note terraced slope with drainage diversions)

These two objectives are accomplished by a combination of grading and construction. Grading to minimize slope steepness decreases both the amount and velocity of runoff; grading to create a drainage pattern internal to the mine area prevents discharge of sediment-laden water into area streams. The ponding evident in Fig. 4.2 is a result of grading to a gently rolling topography. A large volume of water is thus "stored" on the surface of the mined land.

Five catchment ponds behind earthen dams capture surface runoff and prevent or delay its discharge into Gin and Brouillett's Creeks. These ponds also trap sediments before water is discharged, thereby preventing increases in the sediment load of area streams. As a further precaution, spillways into Brouillett's Creek are armored with crushed stone riprap. Construction of diversion ditches and terraces on outer slopes also are used to impede and direct runoff. According to Perlar (1976), great care has been taken in the design and construction of the surface drainage system at the Universal Mine in order to prevent erosion and water pollution. Inquiries to the Water Pollution Control and Stream Monitoring Divisions of the Indiana State Board of Health did not reveal any serious water quality problems in Brouillett's Creek.

#### 4.2 POLLUTION CONTROL

Environmental problems most often associated with surface coal mining are soil erosion and acid mine drainage, both of which can become major sources of water pollution in a given region. Sedimentation is also a common water quality problem in the Midwest. Surface coal mining has the potential of aggravating an already undesirable situation when large areas of barren, steeply sloping land have toxic materials exposed at the surface.

Slope is the most significant factor contributing to runoff and, hence, soil erosion. As slope increases, the volume of runoff and the amount of erosion increases. Surface conditions, such as rockiness and finely compacted material, add to the volume of runoff by retarding infiltration. Soil erosion is evident at the Universal Mine where surface conditions include relatively steep and/or long slopes, vegetation is lacking or sparse, or clay material forms a relatively impervious surface. Sheet erosion has been observed on areas with a clayey soil that are planted in row crops. Although a considerable amount of the disturbed land has been reclaimed in slopes of up to 25%, the state currently requires that all slopes at this mine be graded to 8% or less.

Possible sources of acid and other chemical contamination of surface water and groundwater at the Universal Mine are erosion and leaching of acid-forming materials in the spoil exposed at the surface, pit drainage, runoff from refuse areas, and wastewater from processing plant. However, data from the Division of Water Pollution Control indicate no acidic conditions in Brouillett's Creek.

Peabody effectively controls the potential for acid drainage from pit waters by pumping them to storage ponds, which prohibits their release either on the surface or through underground seepage into area streams. Nine of these settling ponds have been constructed for one pit; four for the other. Refuse is hauled from the processing area to the pit and buried. An earthen dike has been constructed downslope from the processing plant to protect Gin Creek from runoff from the refuse area. Liquid waste from the washing of coal -- a slurry of coal fines, clay, and other minerals -- is pumped to settling ponds and recycled in the washing operation. Erosion and leaching of acid-forming materials is prevented by ensuring that they are adequately buried. The large amount of calcareous unconsolidated material assists in promoting good surface conditions.

While it is overly optimistic to state that the Universal Mine is a pollution-free operation, natural conditions at the mine site and, most important, careful planning and execution of reclamation practices, have gone a long way in providing for protection of the environment.

## 5 RECLAMATION

### 5.1 RECLAMATION LAWS

Strip mining of coal in Indiana began a century ago, but the first organized attempt to reclaim the state's strip mined lands began as a volunteer effort in 1926. Strip mine reclamation legislation was first enacted in 1941, making Indiana the second state to pass such a law. While far from perfect, the law was improved by a series of amendments. The original 1941 law did not require grading of spoil banks and the resulting topography consisted of a sawtooth profile of ridges and valleys. In addition, it required only the planting of some type of vegetation, much of which either died or produced crops of little or no economic value.

A 1951 amendment required top grading of spoil banks that were to be seeded as pasture and hay, and a 1963 amendment required that large-sized spoil materials, acid-forming materials, shale, and coal be covered with soil. The 1963 amendment also required coal companies to grade areas of potential cultivation; top grade along public roads; and dam water in the last cut to create bodies of water for water supply, flood control, erosion control, or pollution control. In 1967, the grading requirements were further strengthened and pre-planning of ultimate land uses and submission of reclamation designs also became necessary. The responsibilities for all aspects of reclamation lie with the coal company that posts a bond to guarantee performance. The authority for approving a license permit or reclamation design and enforcing the law lies with the Indiana Department of Natural Resources.

Surface mining and reclamation are currently regulated under the House Enrolled Acts No. 1789, Chapter 344 of the General Assembly Acts of 1967 of Indiana as amended by Acts of 1974. All reclamation at the Universal Mine has been carried out under the regulations of this 1967 law. Environmental quality is maintained by strict enforcement of this law by the Department of Natural Resources. The law requires that surface mine land be "restored to its highest land-use potential which is a function of the physical capabilities of the spoil material, the use of the surrounding land, and the local market."

Under the law, specific standards are listed for reclaiming surface mined lands to three potential uses: pasture and hay, cultivated crops, and forest or rangeland. The land must be graded to a maximum slope of 25% for pasture and hay, 8% for cultivated crops, and 33 1/3% for forestry. Additional grading is required to cover all acid forming materials, mining debris, and rocks larger than 6 in. in diameter. In addition, dams are required to form as many lakes as possible without affecting the adjoining properties.

The state also acknowledges that surface mined lands have other potential uses. Consequently, provisions are made to reclaim the disturbed lands for such "higher" uses as residential housing, recreation, wildlife preserves, and commercial and industrial development. Each must be approved by the Division of Reclamation of the Indiana Department of Natural Resources.

When an application for a surface mining permit is submitted, it is filed along with a mining and reclamation plan. In addition, a \$600-per-acre

bond must be posted and an initial permit fee of \$50 and an assessment fee of \$20 per acre are required. The permit fees are retained by the State of Indiana, whereas the bond is held in escrow until reclamation is completed.

## 5.2 RECLAMATION PLANS

The Indiana Department of Natural Resources *Form 501, Application for Permit*, contains the proposed reclamation plan for the area to be mined under the permit. Each year's mining and reclamation schedules are summarized on this form in terms of the amount of land to be disturbed, the land use objective of reclamation and the corresponding grading requirements (as discussed above), and planned revegetation. The amount and type of information that must be submitted have changed over the eight years the law has been in effect. The data format has been constantly reviewed and upgraded; thus, the comparability of reports for successive years is somewhat limited. However, by using the information contained in the forms filed by Peabody, it is possible to outline the history of reclamation at the Universal site:

- 1969. Application was made to disturb 155 acres. The land use objective for reclamation was forest or rangeland, and the planned revegetation was listed as mixed hardwoods and pines, grasses, and legumes.
- 1970. A permit was sought to disturb 280 additional acres to be reclaimed as forest or rangeland, with the same planned revegetation as in 1969.
- 1971. A permit was sought to disturb an additional 310 acres for surface mining. The final land use objective was changed, at the state's insistence, to pasture and hay, which requires the covering of all exposed rock larger than 6 in. in diameter with at least 6 in. of soil. The reclaimed area was to be revegetated in grasses and legumes.
- 1972. Application was made to disturb 388 acres that were to be reclaimed as pasture and hay.
- 1973. Planned to be disturbed in 1973 were 440 acres, with an objective of row crop land. This land use sets limits for slope lengths and requires the covering of all rock 6 in. or more in diameter with at least 18 in. of soil. The proposed revegetation was listed as grasses and legumes.
- 1974. Application was made to disturb 430 acres, with a land use objective of row crop land, and with the same planned revegetation as in 1973.
- 1975. Application was made to disturb 400 acres, with a land use objective of row crop land, and with the same planned revegetation as in 1974.

The actual areas disturbed each year have varied somewhat from the permitted acreages, and acreages graded and seeded have lagged behind the expansion of disturbed land. Table 5.1 indicates the amounts of land disturbed, graded, and seeded each year since 1964. Totals reveal a significant time gap between disturbing and grading and a longer lag between disturbing and seeding.

Table 5.1. Acres Disturbed, Graded, and Seeded by Permit Year, 1969-75

Permit Year <sup>a</sup>	No. of Acres		
	Disturbed	Graded <sup>b</sup>	Seeded
1969-70	148	0	0
1970-71	206	175	95
1971-72	275	168	133
1972-73	446	258	333
1973-74	449	279	83
1974-75	<u>367</u>	<u>329</u>	<u>300</u>
Total	1,891	1,209	944

Source: Peabody Coal Co., *Form 502, Report of Affected Area; Form 503, Report of Grading; and Form 505, Report of Revegetation*; filed with Div. of Reclamation, Indiana Dept. of Natural Resources (1969-1974).

<sup>a</sup>The permit year for the Universal Mine runs from July 1 to June 30 of the following year.

<sup>b</sup>A small number of graded acres are not plantable because they are left as haul roads, incline roads, or water.

These discrepancies are probably due to several factors. First, there is an unavoidable lag between mining and reclamation. Tables 5.2 and 5.3 show that mined land was reclaimed up to two years after mining. For example, land mined in permit year 1971-72 was being graded in permit year 1972-73, and land mined in permit year 1970-71 was being seeded in 1972-73. Compliance with regulations is monitored by the Division of Reclamation inspectors. The grading phase must be adequately completed and approved before the revegetation phase can begin. Second, some areas remain ungraded and unseeded for long periods after they are disturbed and are carried over in the area totals from year to year. These areas include haul roads, incline roads, open pits, and water impoundments; the sum of these areas will vary from time to time and records on their status from year to year may not be consistent. Third, lack of clarity and completeness in the records, especially those of earlier years, may have resulted in mistabulation of the total areas graded and seeded.

Mine inspection reports occasionally cite the need to accelerate grading operations at the Universal Mine. From time to time, grading has been delayed by poor weather conditions and lack of equipment. Table 5.4 indicates that constant increases have been made each year in the proportion of the disturbed area graded. The cumulative percentage of land successfully graded has increased

Table 5.2. Acres Graded by Year Mined, 1969-74<sup>a</sup>

Year Mined	No. of Acres Graded						Total
	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	
1969-70	0	95	21	5	0	0	121
1970-71	--	80	75	37	0	0	192
1971-72	--	--	72	174	4	5	255
1972-73	--	--	--	42	173	125	340
1973-74	--	--	--	--	<u>102</u>	<u>199</u>	<u>301</u>
Total	0	175	168	258	279	329	1209

Source: Peabody Coal Co., *Form 503, Report of Grading*, filed with Div. of Reclamation, Indiana Dept. of Natural Resources (1969-1973).

<sup>a</sup>For any year, total acres graded will not equal total disturbed because some remain in ungradable land uses, such as incline roads.

Table 5.3. Acres Seeded by Year Mined, 1970-74<sup>a</sup>

Year Mined	No. of Acres Seeded					Total
	1970-71	1971-72	1972-73	1973-74	1974-75	
1969-70	94.9 <sup>b</sup>	18	17	0	0	129.9
1970-71	--	105	84	0	0	189
1971-72	--	10	232	0	0	242
1972-73	--	--	--	81	77	158
1973-74	--	--	--	<u>2</u>	<u>35</u>	<u>37</u>
Total	94.9	133	333	83	112	755.9

Source: Peabody Coal Co., *Form 505, Report of Revegetation*, filed with Div. of Reclamation, Indiana Dept. of Natural Resources (1970-1973).

<sup>a</sup>Normal procedure entails planting in the spring and submission of reports in the fall.

<sup>b</sup>For any year, total acres planted will not equal total disturbed or graded because some remain as unplanted land uses such as water, open pits, and incline roads.

from 49.4%, following the first year of mining, to 61.9% during 1974-75. There has also been an overall increase in the proportion seeded, from 27.4% in 1970-71 to 40.9% in 1974-75; however, the proportion has varied from year to year.

Table 5.4. Cumulative Acres Disturbed, Graded, and Seeded by Permit Year, 1969-75

Year	No. Acres Disturbed	No. Acres Graded	% Graded	No. Acres Seeded	% Seeded <sup>a</sup>
1969-70	148	0	0.0	0	0.0
1970-71	354	175	49.4	95	27.4
1971-72	629	343	54.5	228	38.5
1972-73	1,075	601	55.9	561	54.1
1973-74	1,524	880	57.7	644	44.0
1974-75	1,891	1,209	61.9	756	40.9

Source: Peabody Coal Co., *Form 502, Report of Affected Area*; *Form 503, Report of Grading*; and *Form 505, Report of Revegetation*; filed with Div. of Reclamation, Indiana Dept. of Natural Resources (1969-1974).

<sup>a</sup>Unplantable acres, such as those being used for water, open pits, and incline roads, are included in the calculation of percent seeded.

### 5.3 RECLAMATION PROCEDURES AT UNIVERSAL

Coal mining companies such as Peabody recognize that reclaiming spoil banks is an integral part of the strip mining process and that reclamation must be planned and carried out in a timely and orderly fashion. According to Indiana law, mining companies also have to develop an approved reclamation design before the mining process can begin. This design requires detailed information concerning the physical, chemical, hydrologic, and biotic systems at the mine site and a detailed socioeconomic characterization of the region.

By working together, the mining engineers, scientists, and reclamation specialists can develop the best potential reclamation design before mining begins. A current mining plan contains detailed procedures for handling spoil, grading, erosion control, haulage roads, and water management. The reclamation design includes a large-scale detailed land use map designating interim and future uses of the disturbed lands and an analysis of existing and projected future market forces.

Restoring spoil banks to row crop production is the most common form of interim and future land use in west central Indiana today. Since the topography is relatively level, the soil is relatively thick and fertile, the spoil is not highly acidic, and the top surface is relatively rock-free, the surface mined areas are suitable for crop land.

At the Universal Mine, topsoil is separated by the dragline during the removal of overburden and is applied to the surface during grading. Attempts to keep the topsoil at the surface are usually successful, although occasionally its distribution is discontinuous. Successful topsoiling provides a better substrate for plant growth.

Table 5.5. Percentages of Mine Area Graded, by Land Use, 1970-75<sup>a</sup>

Land Use Objective (and max. slope)	% of Mined Area
Forest & Rangeland (33 1/3%)	18.1
Hay & Pasture (25%)	29.0
Row Crop (8%)	52.9

<sup>a</sup> Calculated from Peabody Coal Co., Form 501, Permit Application, filed with Div. of Reclamation, Indiana Dept. of Natural Resources (1970-74).

The seeding of reclaimed areas at the mine is accomplished by conventional and aerial means. For the most part mixtures of grasses and legumes have been used. A typical seeding would be composed of 22 lb/acre of seed, made up of a mix of wheat, Kentucky 31 fescue, alfalfa, red clover, Korean lespedeza, timothy, sweet doner, and alsike clover. A substantial acreage was seeded to wheat and milo in 1976. These crops were tilled using conventional farming equipment. Prior to seeding, the spoil is limed if needed and fertilized.

The present topography is a result of the grading undertaken as a part of the reclamation process. Large areas of the mine have been graded to conform with the slope specifications of particular land use objectives stated in reclamation plans for the mine. Table 5.5 gives the percentages of mined land by land use objective, as stated in the reclamation plans. Specifications for each land use also regulate maximum slope lengths for various slope angles. The final contours will differ somewhat from the proposed slopes because of variations in the area mined and in mine features, such as roads, drainageways, and water impoundments. Variations in the general grading pattern will be found especially near haul roads, near cuts that remain open, and near the mine's perimeter. In any case, no slopes are permitted to exceed 33 1/3% after grading.

Division of Reclamation inspectors monitor the grading activities by measuring slopes. Their slope measurements reveal that, on occasion, slopes have been steeper than allowed for a specific land use; however, Peabody's grading generally exceeds the requirements dictated by the planned reclamation use. When necessary, Division inspectors have recommended regrading to eliminate slopes of excessive steepness or length, or special grading procedures, such as terracing. In general, grading operations at Universal are designed to achieve the lowest practicable slopes and to promote surface conditions suitable for the cultivation of row crops. In addition, grading is used to prevent erosion by producing low slopes and specialized structures such as terracing, when necessary.

Summarized in Table 5.6 are Peabody's planned land use objectives for the mine. It can be seen that over the period of operation, a transition has taken place in land use objectives from forest and rangeland, through hay and pasture, to crop land. This represents an actual transition in the quality of reclamation, because progressively more grading and management of surface spoil conditions are required with each of these succeeding land uses. The trend is in line with statewide reclamation practices under present law (LaFevers, 1974).

Revegetation reports (Peabody, 1970-1975) reveal that all the reclaimed areas of the Universal Mine had been seeded as pasture (to grasses and legumes). Despite the original land use objectives outlined in Table 5.6, neither forest

Table 5.6. Universal Mine Planned Land Use and Revegetation, 1969-1976

Permit Year	Acres to Be Disturbed	Land Use Objective(s)	Planned Revegetation
1969-70	155	Forest and Rangeland	Mixed Hardwoods and Pines, Grasses and Legumes <sup>a</sup>
1970-71	280	Forest and Rangeland	Mixed Hardwoods and Pines, Grasses and Legumes <sup>a</sup>
1971-72	310	Hay and Pasture	Grasses and Legumes
1972-73	388	Hay and Pasture <sup>b</sup>	Grasses and Legumes
1973-74	440	Row Crop	Grasses and Legumes
1974-75	430	Row Crop	Grasses and Legumes
1975-76	400	Row Crop	Grasses and Legumes

Source: Peabody Coal Co., *Form 501, Application for Permit*, and *Form 504, Plan of Revegetation*, filed with Div. of Reclamation, Indiana Dept. of Natural Resources (1969-75)

<sup>a</sup>Field observation has failed to locate any areas planted with trees.

<sup>b</sup>The 1972-73 reclamation plan was amended after submission from hay and pasture to row crop.

nor continual cropping has been established on any portion of the mined land. Lack of any tree plantings is, however, not surprising in light of present reclamation trends. Perlar (1976) and visual inspection of the site reveal that Peabody is attempting to utilize reclaimed land for row crops such as corn, soybeans, wheat, and milo. At present, 500-600 acres have been planted in wheat and milo, and wheat was harvested in the 1976 growing season. Conventional farm machinery was used in planting, cultivating and harvesting. Cropping has been attempted on a more-or-less experimental basis to test the growth of various species on the reclaimed spoil (Perlar, 1976). On the whole, the basic objectives of the mine staff consist of extracting the mineral, reclaiming the land, and maintaining adequate environmental control, rather than the economic production of farm products. Although almost 700 acres were earmarked for use as hay and pasture, no livestock grazing has been initiated as yet because the bond has not been released by the state. Peabody Coal Co. does raise livestock at its Dugger and Hawthorne mines in Clay County, Indiana, and livestock operations might be planned at the Universal Mine.

Responsibility for longer range plans for "higher uses," such as recreation or housing, rest in the hands of the Peabody management. The local mine superintendent is responsible only for planning and managing basic reclamation activities on the site with supervision from company planning personnel. Thus, development plans for the Universal Mine are determined more by internal decisions made within the mining company than by the fulfillment of regulations as specified in the land use objective of the permit application. In the long run this flexibility should be beneficial, since it will allow the land use on reclaimed land to adjust to local market conditions and to be continually upgraded by appropriate management practices. In short, the protection of the environment is coequal with restoring the land to productivity as dual goals

of reclamation. It requires proper grading and revegetation to accomplish both.

The actual objectives of the reclamation operation -- grading the spoil, providing water impoundments and access roads, and reestablishing a vegetative cover -- are similar in most modern mining operations in the Midwest. The methods of achieving these ends, and the results, will vary from area to area with the nature of the site, the methods of mining, and reclamation laws in effect in the various states.

Reclamation at the Universal Mine will have more similarities to that carried out by other large-scale operators engaged in area stripping relatively level terrain in the glaciated regions of the Midwest than to that conducted at other types of mines in other areas. For example, sites in the more rugged, unglaciated areas of Ohio or Kentucky are often contour mined. In contrast to the Universal Mine, these spoils have less unconsolidated material and more rock debris, with steeper slopes. The spoil in these areas often contains more of the minerals that can cause acid conditions that adversely affect vegetation and water quality. Steep, stony spoil slopes contribute to erosion and limit mechanized agriculture.

#### 5.4 RECLAMATION COSTS

Detailed data on exact reclamation costs are not available for the Universal Mine. It may be of value, however, to examine some representative costs for similar operations in other areas. Tables 5.7 and 5.8 show reclamation costs for two area-strip coal mines that have many similarities to the Universal Mine.

Major differences are in the thickness of the overburden and coal seams. Since the overburden and coal seam are both thicker at the Universal site than at either of the sample sites in Tables 5.7 and 5.8, the highwall will be higher and backfilling costs will probably be greater at the Universal Mine. However, reclamation costs per ton will be less at the Universal Mine since more coal is produced per acre.

A recent study of reclamation costs (Skelly and Loy, 1975) indicates that reclamation costs at an area stripping operation in Ohio might go as high as \$2.00/ton, a figure that is comparable to those in Tables 5.7 and 5.8, which indicate a cost range of \$1.23 to \$2.34/ton. Another recent study of surface coal mining in North Dakota (LaFevers et al., 1976), indicates reclamation costs will average up to \$6600/acre, which again is comparable to the figures cited in the other reports. It is reasonable to assume that reclamation costs for the Universal Mine will be reasonably similar to those cited for similar operations, within a range prescribed by differences in physical conditions and mining and reclamation methods. According to Peabody personnel, the average reclamation-related costs for the Universal mine were \$2628.94/acre, or \$0.403/ton in 1975 and \$2566.76/acre or \$0.276/ton in 1976 (Healy, 1977).

Table 5.7. U.S. Bureau of Mines Estimations of Reclamation Premining Planning, Backfilling, and Revegetation Costs for Sample Mine Using Area Mining

Cost Components		Total Cost					
		\$/acre	\$/yd <sup>3</sup>	\$/ton			
<u>Premining Planning Costs</u>		Planning:	181	--	0.04		
Engineering Design	Pollution Control	Bonds, Permits, Fees					
\$7,200 (\$40/acre)	\$9,450 (\$53/acre)	\$15,840 (\$88/acre)					
<u>Backfilling Equipment (Operating and Ownership) Costs</u>		Backfilling:	4,915	0.15	1.11		
Equipment, Reclamation Hrs/Day	<u>Operating (\$/hr)</u>		<u>Ownership (\$/hr)</u>		<u>Total<sup>a</sup></u>		
	Fuel	Labor	Maint.	Overhead	Deprec.	\$/hr	\$/day
1 med. Dragline, 4.8 hrs	28.41	11.20	39.34	69.80	34.90	183.65	881.52
2 385 hp Dozers, 7.2 hrs	4.39	6.20	28.19	4.78	15.88	118.88	855.94
1 35 yd <sup>3</sup> Scraper, 14.4 hrs	5.70	6.20	41.29	5.42	15.34	73.95	1,064.88
<u>Revegetation Costs</u>		Revegetation:	346	--	0.08		
Equipment (operating and ownership) Cost <sup>b</sup>	<u>Soil Preparation</u>						
	Fertilizer	Lime	Mulch	Seeding			
\$20/hr (\$60/acre)	\$52/acre	\$148/acre	\$100/acre	\$86/acre			
		Total Reclamation:	5,442	0.15	1.23		

Source: Evans, R.J., and J.R. Bitler, *Reclamation Costs: Appalachian and Midwestern Coal Supply Districts*, U.S. Bureau of Mines Information Circular 8695, Washington, D.C. (1975).

<sup>a</sup>These columns are not totaled because different pieces of equipment operate a different number of days each year.

<sup>b</sup>Equipment: farm tractor, disk, grain drill, and lime spreader.

Table 5.8. U.S. Bureau of Mines Estimations of Reclamation Premining Planning, Backfilling, and Revegetation Costs for Sample Mine Using Area and Block Cut Mining

Cost Components								Total Cost			
								\$/acre	\$/yd <sup>3</sup>	\$/ton	
<u>Premining Planning Costs</u>								Planning:	277	--	0.08
Engineering Design	Pollution Control	Bonds, Permits, Fees									
\$43,200 (\$180/acre)	\$11,280 (\$47/acre)	\$12,000 (\$50/acre)									
<u>Backfilling Equipment (Operating and Ownership) Costs</u>								Backfilling:	7,031	0.22	2.15
	<u>Operating (\$/hr)</u>			<u>Ownership (\$/hr)</u>		<u>Total</u>					
Equipment, Reclamation Hrs/Day	Fuel	Labor	Maint.	Overhead	Deprec.	\$/hr	\$/day				
1 small Dragline, 4 hrs	8.74	10.47	132.83	11.86	36.60	200.50	802.00				
4 385 hp Dozers, 6 hrs	4.39	5.47	28.19	4.78	15.88	234.84	1,409.04				
2 31 yd <sup>3</sup> Scrapers, 18 hrs	4.73	5.47	34.08	4.47	12.66	122.82	2,210.76				
1 180 hp Grader, 6 hrs	2.03	5.47	13.22	1.13	3.84	25.69	154.14				
1 10 yd <sup>3</sup> Front-end Loader, 6 hrs	7.06	5.47	58.82	5.92	19.43	96.70	580.20				
						680.55	5,156.14				
<u>Revegetation Costs</u>								Revegetation:	370	--	0.11
	<u>Soil Preparation</u>										
Equipment (operating and ownership) Cost <sup>a</sup>	Fertilizer	Lime	Mulch	Seeding							
\$20/hr (\$90/acre)	\$60/acre	\$40/acre	\$100/acre	\$80/acre							
								Total Reclamation:	7,678	0.22	2.34

Source: Evans, R.J., and J.R. Bitler, *Reclamation Costs: Appalachian and Midwestern Coal Supply Districts*, U.S. Bureau of Mines Information Circular 8695, Washington, D.C. (1975).

<sup>a</sup>Equipment: farm tractor, disk, rock picker, lime truck, grain drill.

## 6 RECLAMATION PLANNING

### 6.1 MINING AND RECLAMATION PLANNING

Mapping the land is the first step in developing a surface coal mine. After a base map is prepared, geological information about the coal seam, overburden and topographic features are plotted. These maps are used along with plat maps to acquire the mine property, usually by buying the land and minerals outright and by leasing the minerals. The next step is to develop an environmental assessment report based on data from a cursory literature review and a short field reconnaissance. The new property is given an environmental rating and the report is sent on to the mining company's exploration, marketing, land, and engineering planning departments for evaluation.

Core drillings and blasting tests are then taken to obtain additional information on the location, thickness, and depth of the coal and the type and composition of the overburden. Core drillings data also will show where special mining and reclamation problems exist. The mapping and core sampling form the basis for determining the mine feasibility plan.

If the area appears feasible to mine, properties that have environmental questions or problems are examined in more detail in environmental baseline studies. The detailed data contained in these studies are normally used by federal and state agencies to determine the site-specific conditions that are to be stipulated in the mine permit. The data also are used to: (1) detect and predict unsatisfactory environmental conditions before public complaints are filed, (2) legally protect the coal company against unjustifiable legal action for environmental deterioration, (3) demonstrate that the coal company is showing social responsibility, and (4) develop optimum reclamation plans for mined lands.

If federal or state agencies decide that a proposed mine may create a significant environmental impact, the coal company may be required to file an environmental impact statement before it receives a final operating permit. The data needed to prepare this statement should already be available to the company in the baseline studies.

The next step is to design a mine sequence plan that includes information about the coal geology, coal handling and preparation, mine waste disposal facilities, blasting, haulage units, overburden removal units, loading units, and reclamation equipment. Included in the mine plan is the grading and revegetation schedule, stating the time of grading and dates for planting the appropriate cover crops. A map is normally included that depicts the estimated tonnages and affected acres on an annual basis for the projected lifetime of the mine.

The final step is to design a reclamation plan, which must comply with the Indiana guidelines. These guidelines include, but are not necessarily limited to, the following objectives:

- To provide improved land use practices in these areas;
- To prevent or minimize injurious effects to the people and the natural resources of the state, including the need to protect the lakes and streams from pollution;

- To decrease soil erosion;
- To decrease the hazards of fire;
- To improve the aesthetic value of the landscape;
- To enhance the development of wildlife resources; and
- To increase the economic contributions of the affected area.

The extensive data collected in the above studies form the foundations for the reclamation plan. A well designed reclamation plan should include both an interim and a long-range plan. The interim plan, which can be implemented immediately upon the cessation of mining activity on any part of the site, provides for short-term productive use of the site. The economic base developed by the interim land use plan can be used to implement the more sophisticated long-range plan that can provide a greater return to investors.

The reclamation phase of the surface coal mining operation should occur concurrently with the coal mining process. By linking the interim and long-range reclamation plans in an orderly manner, the disturbed land will be out of production for the minimum period of time, before being brought to its highest possible long-term use.

## 6.2 LAND USE CHANGES AND FUTURE DEVELOPMENT PLANS

A comparison of premining land uses in Vigo and Vermillion counties (Table 6.1) with the planned land use objectives of reclamation at the Universal Mine indicates the role of surface mining in land use change. Assuming short-range (six years since the beginning of mining) stability in land uses in the surrounding area, the Universal site will be characterized by a distribution of land uses differing in many respects from the unmined countryside. Pasture land will have increased from its former minor role (8% of the area) to more than 50% of the reclaimed area. Concurrently, the proportion of cropland will decrease from more than 60% to about 40%.

The second most prevalent premining regional land use, woodland, will no longer exist on the reclaimed land after mining, because no areas have been seeded to trees. Certain minor land uses at the Universal site prior to mining, such as farmsteads and nonfarm residences, will also be eliminated. As of 1975, the area of disturbance had eliminated approximately 22 farmsteads and 9 nonfarm residences. Additional properties have been vacated on land that is controlled by Peabody but not yet disturbed; similar premining land use effects can be seen to operate on crop lands and pasture. Although precise figures are not available, the process of mining will eliminate natural drainages, lakes and farm ponds, but will increase the total area covered by water.

Coal companies have recently given more emphasis to reclaiming surface mined land for recreational and housing developments. Where population pressures warrant it, the topography is suitable, and acid-forming material is not abundant enough to make the water toxic, reclaimed strip mines are excellent sites for housing and recreational developments. However, these have been isolated endeavors, primarily because their marketability has not been thoroughly investigated.

Table 6.1. Regional Land Use Acreages

County	No. of Acres				
	Cropland	Forests	Pasture	Hay	Grazing
Vigo	97,200	45,000	19,620	13,000	6,004
Vermillion	78,675	30,346	13,162	5,400	1,126
Total	175,875	75,346	32,782	18,400	7,130
Land Use Percentages					
Total	56.8	24.3	10.6	6.0	2.3

Source: USDA, Soil Conservation Service, *Indiana Soil and Water Conservation Needs Inventory* (1967).

Five semiprivate recreational areas and one larger public recreational area are located on strip mined lands in the southeastern part of Vigo County, along with five housing developments. The largest development included 91 residences and another one, 46, in 1976. Significantly, 37 of the 91 and 45 of the 46 houses were built during the last 10 years, reflecting a current trend in land use of reclaimed strip mines.

LaFevers' work on Vigo County (1974) demonstrates that certain surface mined land uses, such as recreation and housing, have typically developed on unreclaimed land, or land reclaimed for other purposes at a date subsequent to reclamation, often decades later. Establishment of these more "intensive" types of land use appears to depend more on the local population's perception of mined land as a resource than upon planned development efforts by public agencies or private entrepreneurs.

A survey of recent sales in the Universal Mine area indicates the range of potential types of future land use developments for strip mined lands. These real estate sales may be grouped into three types:

- Farms and tillable land of 80 acres or more that include a house, out buildings, and one or more lakes created by surface mining currently sell at from \$800-\$1000 per acre. Generally the closer the land is to Terre Haute, the higher the value, especially if it is suitable for residential subdividing. From multiple listing sales data, it is not possible to determine which purchases are speculative in terms of eventual sale to coal companies and which are for long-term farm production and/or recreational type living. Since small farms are not always economical to operate and purchases are normally limited to small tracts, it appears that most purchases made in rural areas are either for mining or residential purposes.
- Homes adjacent to surface mine lakes constitute another major type of real estate sales. These purchases indicate a high value placed on residences located on water and, based on a

comparison of sales data in multiple listed sales, increases in the land value of \$300-\$400 per acre.

- Speculative land sales represent the third type of sales. The reasons for selling include normal personal reasons of health, changing family compositions, different household needs, transfers, retirement, death, and divorce. Multiple listed sales data do not indicate negative impacts due to surface mining; they show a steady increase in value for every type of real estate listed.

### 6.3 SOCIAL COSTS, PERCEPTIONS, AND BENEFITS

Perhaps some of the major costs of surface coal mining are environmental and social. These costs include those associated with disturbing such "human interest" sites as unusual natural resource and historical areas, archaeological sites, and rare fossil and rock deposits. The aesthetic impact of surface mining should also be considered as a possible cost; if mined lands are not properly reclaimed, they will intrude upon the aesthetic quality of the landscape. Because it is not always possible to avoid mining sites having an existing high aesthetic value, reclamation costs are often increased by minimizing the visual impacts through the use of buffer zones, scenic vistas, and vegetation screens.

Social costs that involve resettling former residents of the mined areas may be attributed to both the mining and reclamation processes. Social costs also include those due to disrupting roads, changing employment patterns, vibrations from blasting, new traffic generated in the mined areas, and the readjustment of community lifestyles. However, if the social costs of surface mining to individuals and mining communities are to be assessed, so that the anticipated social impacts can be more fully integrated into premining reclamation designs within the constraints of the site's environmental characteristics, more socioeconomic studies will be needed.

An alternative method of assessing the socioeconomic costs of surface mining is to study public perception of mining and reclamation. A general model of perception considers that an individual's or a group's perceptions, or images, of the environment are based upon sensory inputs of information subjected to a process of altering or selection by such factors as language, personal values, social class, and culture. These perceptions, then, and not objective information, form the basis of attitudes and behavior (Saarinen, 1974).

Tiller (work in progress) has conducted a public perception study of surface coal mine reclamation in the Universal Mine area, in which questionnaires were administered to a random sample of households in Universal and three other small communities near the mine. This questionnaire was designed to assess the inhabitants' perceptions of the types of landscape that result from the reclamation of surface coal mines. Data were also collected on perception of the effect of surface coal mining upon the land use, economy, environment, and population.

Area residents perceived land use changes resulting from surface mining as the most significant impact. Over 75% of the 61 respondents viewed the effect of surface mining on land use as serious; an additional 13% perceived it as somewhat serious. The mean scaled response for the land use question was 2.59, in a range of 0.0 to 3.0, with 3.0 indicating the highest level of impact. Two perceptions of the impact of mining upon land use were that surface mining results in poor land use and less productive land and decreases the amount of land available for agricultural production. The perception of surface mining upon agricultural land use was generally negative.

In comparison to the perception of land use change, the mean scaled response for the economic effect of surface mining was 1.56. Perceptions of both a positive and negative nature focused upon identical aspects -- the job market and economic conditions. While 23% of the respondents perceived that "strip mining makes only a few jobs," 31% perceived a significant increase in employment due to surface mining. An additional 18% viewed surface mining as a help to the area's economy.

The mean scaled response for environmental impact was 2.16. The negative environmental impact more often perceived than all others combined was the noise caused by blasting and machinery. Over 49% of the respondents mentioned this problem. An additional 21% cited blasting, shaking, and vibration as an impact, and 25% saw air pollution as an environmental impact.

Effects upon the local population rated a mean of 1.57 in scaled responses. More than 50% of the respondents perceived the effect of surface mining on the population as not serious while 28% rated the effects as serious.

Thus, the survey revealed that land use change is perceived as the most significant local impact of the Universal Mine. Environmental pollution, particularly noise and air pollution, is also perceived as a significant impact. Area inhabitants feel that the Universal Mine has altered the quality of their environment in a way that affects their daily lives. Mining impacts on the economy and population are viewed as much less serious. About a third of the respondents perceive a positive effect upon the economy of the local area in terms of income and jobs.

Not only was public perception of surface mine impacts used to assess the costs of mining, it was also used to measure the benefits of reclamation. The cost of reclamation, in terms of a per acre investment, increased directly with the amount of grading done and with the addition of such improvements as water impoundments, recreation facilities, and housing.

Table 6.2 lists the mean ratings and frequencies of response to particular landscape details. The highest rating belongs to the high-quality residential type; the lowest to the ridged mixed forest. The mean ratings varied directly with the hierarchy of reclamation cost, indicating that the benefit of positive public perception of surface mine reclamation was related to the level of investment applied in the reclamation process or subsequent development of reclaimed land. Landscapes recently reclaimed as crop land and pasture scored higher than landscapes reclaimed earlier. Thus, in terms of the perceptions of Universal area residents, reclamation is becoming more beneficial.

Table 6.2. Mean Rating and Response Frequencies of Selected Reclaimed Landscapes

Landscape Type	Mean Rating	Mean (f) of Positive Responses	Mean (f) of Negative Responses
High Quality Residential	3.8	1.7	0.0
Recreation-Residential	3.3	1.3	0.1
Cropland	3.0	1.0	0.1
Rolling Grassland	3.0	1.5	0.1
Ridged Grassland	1.5	0.5	0.7
Ridged Mixed Forest	0.7	0.3	0.9

Source: M. E. Tiller, *Public Perception of Surface Coal Mine Reclamation: A Case Study of the Universal Mine, Universal, Indiana*, work in progress.

The implications of these results are important in terms of the reclamation program at the Universal Mine. First, people perceive positively the reclamation landscapes produced by crop land and rolling grassland (pasture), which represent the future land uses of the Universal Mine. Secondly, people perceive most highly landscapes produced by recreational and residential (especially high-quality, low density) land uses. Future development of such land uses at the Universal site would be well accepted, and, if a larger population shares the perceptions of the Universal area residents, could meet a demand for recreation and housing.

When the people of Vigo County were interviewed about the benefits of reclamation by LaFevers in 1974, three major conclusions were reached: (1) most of the acreage of strip mined land was reclaimed for similar land use (forestry), (2) costs do not vary consistently with variations in use, and (3) only a few of the possible uses were present. LaFevers determined that the costs and benefits varied with time because of changes mandated by amendments in surface mining laws. As a consequence, he used an alternate method of measuring benefits, namely, the "relative attractiveness index." Since external forces strongly affect the economic benefits of reclamation, it became more relevant to use noneconomic data to measure reclamation benefits. Therefore, the relative attractiveness of surface mined land as compared to that of unmined land was used to determine benefits of reclamation.

The relative attractiveness index permits quantification by the end use of the land rather than by fiscal data. It is essentially a comparison of expected and actual land use frequencies. The bottom line figure obtained is the attractiveness of strip mined land relative to undisturbed land for a given land use. Between 1963 and 1973, 4330 new homes were built in those townships of Vigo County where strip mining occurred. The attractiveness of strip mined land for housing in the seven townships relative to unstripped land ranged from 0.59-9.96. The high figure means that strip mined land is almost 10 times as attractive for housing as undisturbed land. For Vigo County as a whole, the

study indicated that reclamation created an environment for housing that is 250% as attractive as unmined land (LaFevers, 1974).

After this study was completed, a multilist printout of all the properties for sale in Vigo County was obtained. By analyzing the Vigo County real estate market, another measurement of the benefits of reclamation became evident. The analysis revealed that reclamation has a positive impact on real estate values and provides more market opportunities for selling homes, and that the buying populace was favorably inclined to buy housing sites on reclaimed strip mined lands. On the other hand, it should be pointed out that most active surface mines in Indiana are not located in as close proximity to a large urban area as the Universal Mine is to Terre Haute.

The housing responses from realtors who commented on the listings in mined areas include the following:

- In general, the property values of the land and improvements adjacent to strip mining operations are not affected. No negative externalities were
- The general west central Indiana region has had surface coal mining operations for several decades without apparent detrimental effects on the real estate market.
- Persons living adjacent to the Universal Mine are mostly farmers or long-term residents of the town of Universal. They choose to stay in their homes since they have lived there for many years.
- The people of Universal have become accustomed to living near mining activities since the town was originally established as an underground coal mining center.
- The present high demand for housing makes it impossible to measure any negative externalities in property values near the Universal Mine.

While the conclusions for benefits of the Universal Mine are generally positive, certain contingent conditions need to be acknowledged. It must be kept in mind that, because of the 15-20 years required to complete the mining and reclamation process, the benefits for residential developments are long range in time span.

It should be further assumed that housing developments will be professionally designed to meet the intrinsic suitability of the reclaimed lands and that the lots would be platted to achieve harmonious land uses. Because the major attraction of reclaimed areas for homesites is a location on or adjacent to a strip mine lake, developed water areas should be of adequate quality to permit swimming and fishing. Finally, an exceptionally well conceived and conducted marketing strategy is needed for the full potential benefits of housing developments to be realized.

One of the major benefits and opportunities in reclaiming surface mined lands is to provide environmental diversity. In west central Indiana, a net effect of surface mining operations is to create a new, more varied landscape, which should contribute positively to the quality of life.

An example of the environmental diversity is the unusual recreational facilities that are provided by rearranging the landscape and creating attractive water areas. About 10-15% of mined areas is normally left as lakes. The sloping terrain and lakes can produce an attractive recreational area. Most land owners have access to a source of water for recreational purposes on the reclaimed land they own. At the Universal site, however, only about five percent of the mined area is left in useable water bodies because of the requirement to grade to eight percent slopes (Healy, 1977).

Local officials and civic leaders should take a more dynamic role in encouraging strip mine developments and coordination of regional recreational plans with adjoining counties and communities. A tourist committee should be organized to inventory all potential resources, develop promotional brochures, and cooperate with surrounding county promotion groups in developing recreation in strip mined areas. The following benefits could be expected from these actions: better use of funds, avoidance of duplication of functions, more equitable distribution of recreational opportunities throughout the two-county area, and the possibility of creating large regional parks to serve the cities and counties.

## 7 OBSERVATIONS FOR PLANNERS

In the absence of public planning or zoning that encompasses the mine area, it is possible for the operating company to undertake both interim and long-term reclamation and land use planning as integral parts of its overall operations. Many of the larger mining companies operate environmental control and land use planning departments to ensure that all legal requirements are met and that the development potential of land owned by the company will be realized. Integrated mining and reclamation planning has become common practice at many mines because of the cost savings realized by having parts of the reclamation work done during the extraction process, often by using what is generally considered mining equipment.

Effective planning for the reuse of mined land should include consideration of the local and regional land use needs. The marketability of the reclaimed land depends, in large part, on the demand for specific end land uses. Similarly, the benefit to the public sector will depend upon the degree to which the company is successful in reclaiming mined areas to satisfy these needs. Public planning agencies can be of benefit by providing the mining companies with land use needs inventories and market strategies. This case study demonstrates, however, that such help has not generally been forthcoming. Rather, the progressive companies have had to generate such inventories and strategies without much input from public sector planners.

Coal company planners can help provide for the necessary interaction with public sector planners by supplying them with critical information about the mine site. For housing developments, for example, the reclamation personnel and developers must be aware of the bearing-strength requirements of the spoil that will be necessary to support buildings. They must also consider drainage patterns and other hydrologic factors that might affect sewage disposal. If the company provides enough data to the planning agencies, reasonable and effective building codes can be established and guidelines can be issued to assist the developer in making decisions.

Surficial maps can provide information on drainage patterns and potential stability of surface mined materials. Sufficient data can be provided to planning departments to enable them to designate areas over which an unusually large amount of slumping might be expected. *Local planners also often have information that can help guide the course of developments and devise local controls and regulations to help cope with the problems of a new environment.\** It is apparent from this case study that the potential exists for creative land development in area coal mining regions. Although the mining companies and the planning agencies are generally capable of doing their job well, *the public benefit potential will not be realized until a concerted effort is made to work conjunctively.\**

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\*Emphasis added at the request of Peabody Coal Co. planning and environmental control personnel.

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