DEVELOPMENT OF A COAL RESOURCE DATABASE in the IOWA NATURAL RESOURCES GEOGRAPHIC INFORMATION SYSTEM for MONROE COUNTY, IOWA

Open File Report 90-2

Iowa Department of Natural Resources

Larry J. Wilson, Director

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ABSTRACT

Remaining coal resources were evaluated in Monroe County, Iowa, using the Iowa Department of Natural Resources - Natural Resources Geographic Information System. Total resources of 972,237,477 tons of coal were determined for the Whitebreast, Laddsdale, Cliffland, and Blackoak coal beds. The project provided tests of many of the functions of the pcARC/INFO component of the Natural Resources Geographic Information System which may be used to evaluate extractable resources. The system provided tools to: 1) manage resource-related data, 2) exchange various types of data with programs outside pcARC/INFO, 3) analyze spatial data and use the results to calculate volumes, and 4) display the results as tables or maps. The methods used in the coal resource assessment were evaluated and results obtained were compared to previous coal resource estimates.

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Prepared by
Mary R. Howes

Energy and Geological Resources Division
Geological Survey Bureau

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Iowa Department of Natural Resources
Larry J. Wilson, Director

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INTRODUCTION

Statement of Purpose

Effective natural resource management systems provide tools to organize and manage data, conduct quantitative and qualitative analyses, and display the data and results of analyses as tables or maps. In the past much of this work was done by hand, a process which involves laborious recording of data, measurement, calculation, and map preparation. The development of powerful personal computers and compatible geographic information system (GIS) software provides tools to perform all these functions as well as allowing a great deal of flexibility not previously available.

Coal resource evaluations require these same tools sometimes with some specialized procedures. The types of information needed include location and extent of coal beds, stratigraphic identification, and characterization of coal quality. The resource evaluation procedure requires identification of useful data, delineation and measurement of areas of interest based on combinations of resource defining criteria, calculation of volume of coal and conversion to tonnages using a factor based on the density of the coal.

The Iowa Department of Natural Resources (IDNR) decided in 1988 to institute a computerized natural resource data system based on a GIS. PcARC/INFO was selected to manage vector (line) data and EPPL7 was selected for raster data.

The evaluation of remaining resources in four coal beds in Monroe County, reported herein, was one of the first projects undertaken. The project was selected because it was small, could be clearly defined, and would yield comparable and verifiable results. Further, it was expected to require development of some basic data files required by DNR for the Natural Resources Geographic Information System (NRGIS). Finally, much of the preliminary work of collecting, interpreting, and organizing the data had already been completed.

The coal demonstration project had two primary objectives:

1) Develop and test methods for using a geographic information system (pcARC/INFO) to manage, analyze, and display resource information. Data was drawn from disparate sources and prepared for use in the NRGIS to derive resource assessments. An evaluation of coal resources was completed in which the results were categorized by coal bed, overburden thickness, coal bed thickness, reliability of estimate, and public land survey system township. Mined-out areas were removed to produce estimates of remaining resources.

2) The second objective was evaluation of a GIS for coal resource data management and analysis. The results of the pilot study were compared qualitatively and quantitatively with previous resource evaluations for the area studied and use of the NRGIS for this purpose was also compared with methods used for past coal resource evaluations.

The four coals evaluated for the coal demonstration project were, in descending order, the Whitebreast, Laddsdale, Cliffland, and Blackoak (Fig. 1). The bulk of the coal resources were expected to be found in the Laddsdale, Cliffland, and Blackoak coals. The Whitebreast Coal, although not expected to be a significant resource, was included to provide a direct comparison with previously reported resource calculations.

This project was developed and carried out under an agreement with the Iowa Department of Natural Resources-Energy Resources Bureau (IDNR-ERB) and was paid for by the Oil Overcharge Account of the Groundwater Protection fund. The data used was drawn from the IASTRAT data set developed by the Geological Survey Bureau (GSB) under cooperative agreements with the U. S. Geological Survey-National Coal Resources Data System (NCRDS). The data is maintained and updated under a current cooperative agreement with between the Geological Survey Bureau and the U. S. Geological Survey. The data resides on a U.S. Geological Survey - Water Resources Division Prime computer in Reston, Virginia. GSB access is through a modem and personal computer with terminal emulation software.

Past Estimates Of Resources And Mining

A conservative estimate of original reserves for the state totaled 7.2 billion tons over an area of 2,056 square miles. Potential resources of 21 billion tons over 20,000 square miles were estimated by the same authors (Landis and VanEck, 1965). Earlier estimates were more generalized and much larger. Campbell and Parker (1909) estimated reserves at 29.1 billion tons over 12,560 square miles and Lees

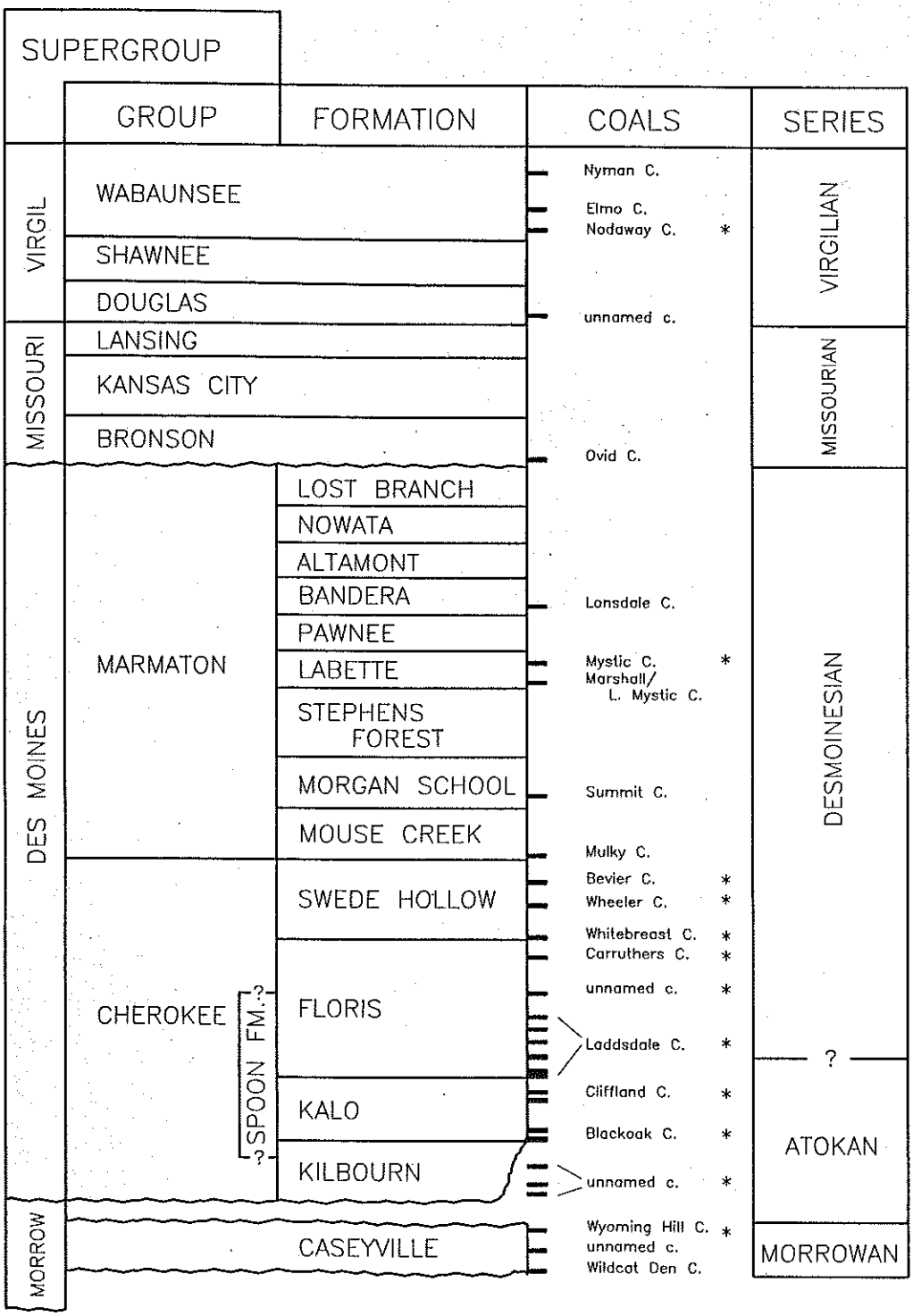

Figure 1. Stratigraphic units of the Pennsylvanian System in Iowa emphasizing important coal-bearing units. The asterisks denote coal beds known to reach economic thickness in Iowa.

(1927) estimated reserves at 29.9 billion tons over 12,750 square miles. Garvin et al. (1975 and 1976) estimated original strippable reserves for twelve counties in southeastern and south central Iowa totaling 2.04 billion tons. They defined strippable coals as those coals greater than twenty-eight inches thick with overburden of less than 150 feet.

Iowa has a long history of coal mining with the earliest production recorded in 1840 (Lees, 1908). Maximum annual production of approximately nine million tons was achieved in 1917. The largest overall coal production has come from Monroe County. As of 1982, total recorded production for the county was 68.0 million tons (Dept. of Interior, 1983). The most recent coal production in the county occurred in 1989. Statewide production in recent years has averaged approximately 500,000 tons annually.

Geologic Setting

Early writings on Iowa geology (e. g., Hall and Whitney, 1858 and White, 1870) contain discussions of coal and related sedimentary rocks observed in outcrops along the major rivers in southern and southeastern Iowa. Keyes (1894) and Hinds (1908) provided important discussions of coal geology and early mining throughout Iowa. Beyer and Young (1902) described the geology and mineral production of Monroe County.

Recent work on the geology of Pennsylvanian strata in Iowa has added to knowledge of Iowa coal resources. Ravn et al. (1984) published a revised nomenclature for the Pennsylvanian System in Iowa introducing many new coal bed names and establishing more definitive usage of some of the previously used names. Coal quality was reported by Hatch et al. (1984). Systematic studies by Ravn (1979 and 1984) and Swade (1986) on microfossils which proved useful in coal-bearing strata (palynomorphs and conodonts, respectively) have resulted in regional stratigraphic correlations and improved understanding of the depositional environments. Preliminary reports by Lambert (Howes and Lambert, 1988) on studies of microfossils (conodonts and fusulinids) recovered from Cherokee Group strata suggested further refinements of the regional stratigraphy.

Monroe County, Iowa, is situated on the eastern edge of the Forest City Basin. The bedrock in the county consists primarily of Pennsylvanian-age strata of the Des Moines Supergroup (Fig. 1). Most of the bedrock is assigned to the Cherokee Group, but small areas of Marmaton Group strata are present in the south central and southwestern parts of the county. The dominant regional geologic structure consists of a gentle southwestward dip toward the center of the Forest City Basin in northwestern Missouri. Consequently, the Pennsylvanian strata become thicker and the uppermost Pennsylvanian bedrock surface units are stratigraphically higher (younger) toward the southwest.

The Cherokee and Marmaton groups are the major coal-bearing units in the western Midcontinent. In Iowa, these two units contain seventeen palynologically distinct coal beds (Fig. 1). The majority of the coal resources in Iowa occur in the lower Cherokee Group in the Blackoak, Cliffland, and Laddsdale coals (Fig. 2). These coals crop out sporadically in the northern and eastern parts of Monroe County, but are found at increasingly greater depth toward the southwest because of the regional downwarping of the bedrock in that direction. The lower Cherokee coal beds can be quite variable laterally in thickness and quality, and each named unit may be split locally into two or more beds. Ravn et al. (1984) and Gregory (1982) suggested that these three lower Cherokee coal beds are present over most of south-central Iowa. However, outside limits of estimate the coals are either too thin to be included in the resource estimate or the data are sparse.

The thin, but laterally persistent Whitebreast Coal of the upper Cherokee Group is present in the northwestern part of the county as erosional remnants along ridges and hilltops. To the south, it forms a nearly continuous unit in the subsurface. All of these structural and erosional features affect the distribution of the coal resources and are reflected in the tonnages listed in the resource tables.

METHODS AND PROCEDURES

Sources Of Data Used In The Coal Resource Evaluation

The data used in the Monroe County study was obtained from various sources as both computer files and hand-drawn maps. Point data was derived from the Iowa data set (IASTRAT) in NCRDS. It includes descriptions of coal exploration drilling,

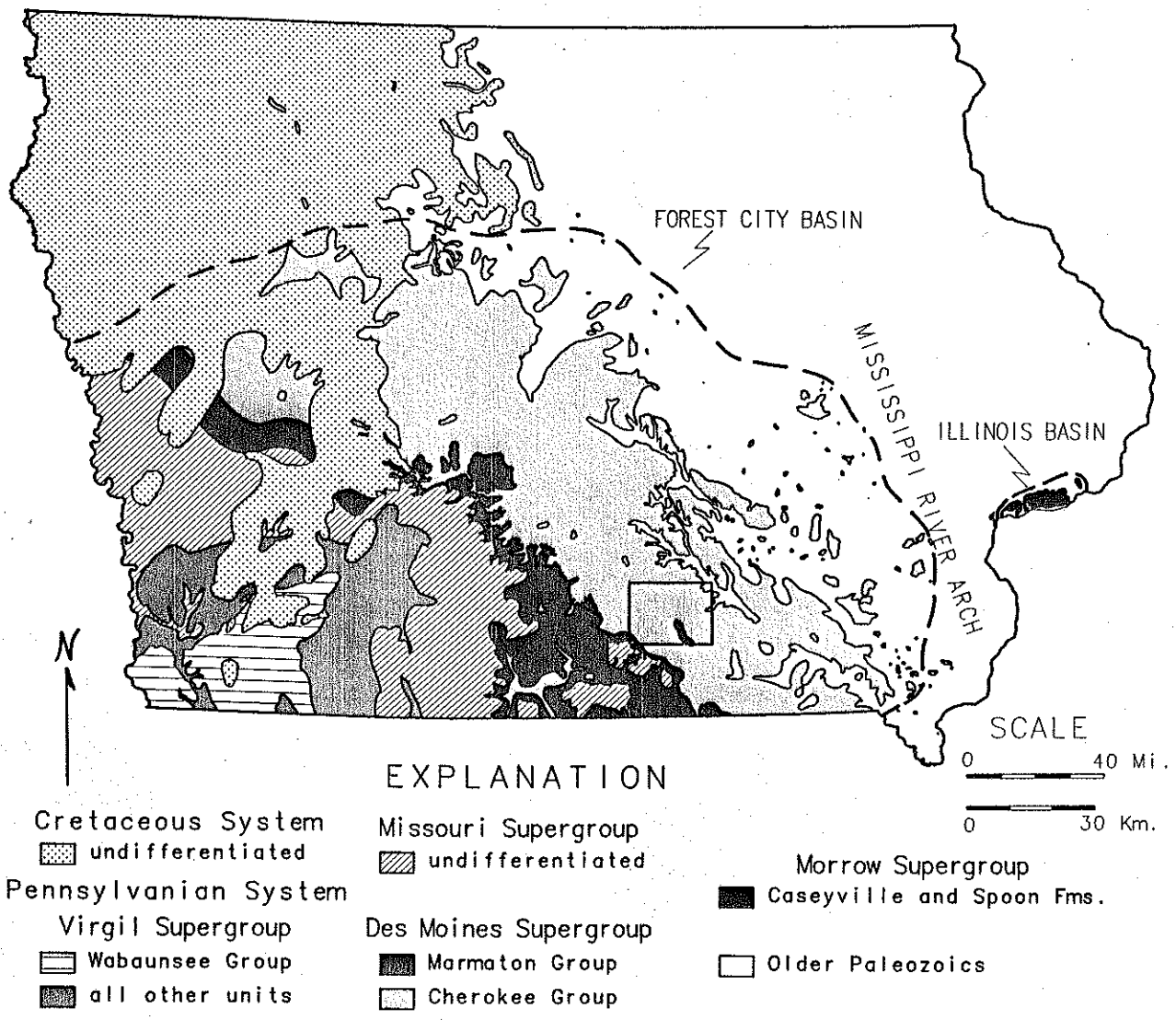

Figure 2. Geologic setting of the Monroe County study area. Coal-bearing units in the Pennsylvanian System are shown with the overlapping Cretaceous System strata. Note the "Older Paleozoics" in the northeastern part of the county and Marmaton Group strata in the south central and southwestern parts of the county.

water wells, mine shafts, etc. from IASTRAT within all of Monroe County and a one-mile buffer outside the county border. The point data was used to create pcARC/INFO data sets (coverages) for coal thickness isopachs, limits of reliability, and limits of estimate. Overburden maps for each coal bed studied were derived from mine-outcrop maps from the NCRDS files. The mined-out areas were obtained from the Iowa Mined Lands Data System.

Preparation of pcARC/INFO Coverages

Iowa coal resource data is organized primarily by location on U.S. Geological Survey 7.5' quadrangle maps. These maps were used as bases for working maps showing point locations, mines, outcrop lines, and overburden thickness contours. In order to use the coal resource data effectively a statewide coverage of the 7.5' quadrangles in Universal Transverse Mercator (UTM) coordinates was created and the coordinates of the corners were extracted to register coverages for the coal resource study.

Digitized locations for the point data were converted to ARC/INFO coverages and the point data imported into the coverage database. The point locations (originally in inches) were converted

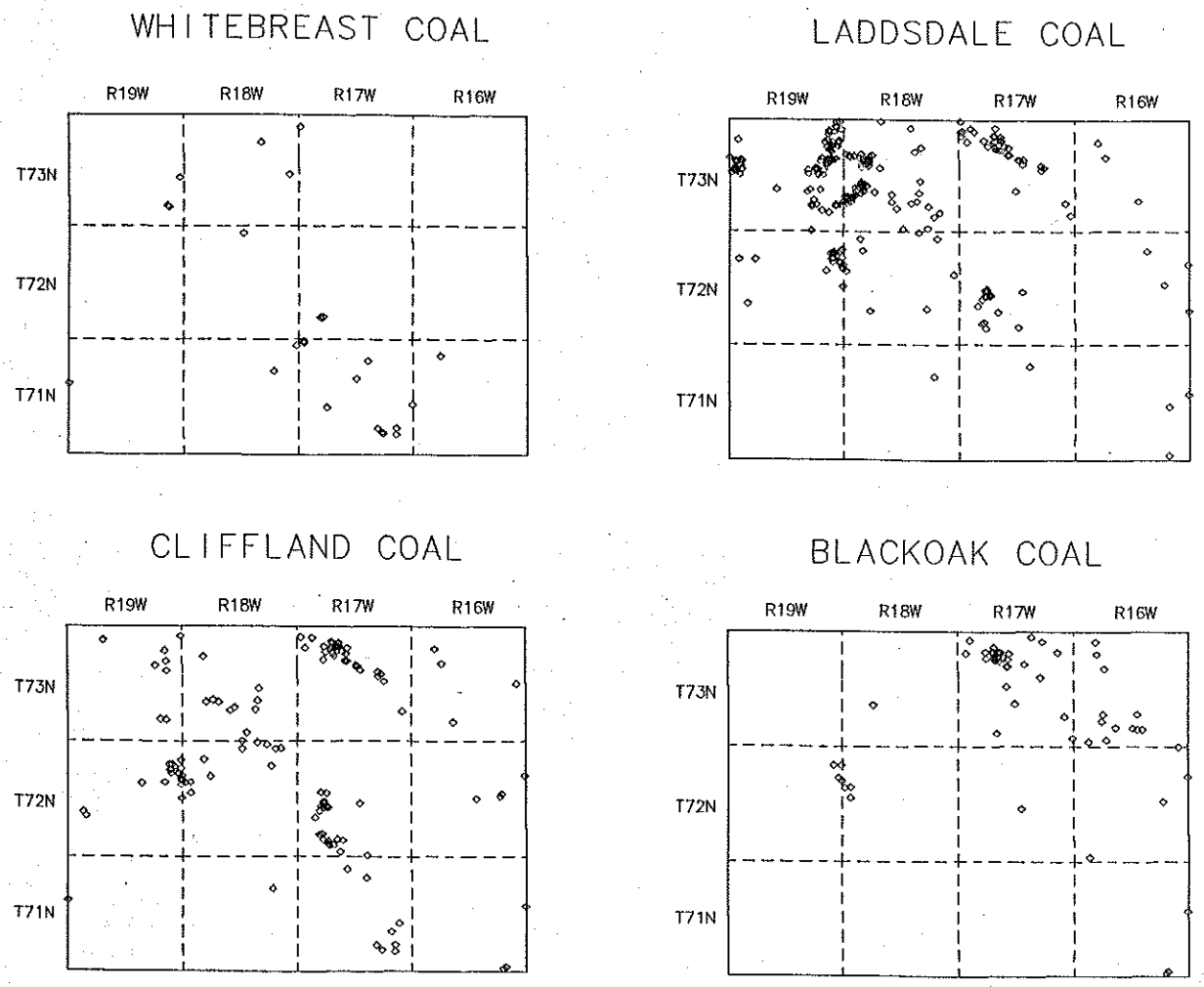

Figure 3. Distribution of data points used in the coal resource study in Monroe County. Points outside of the county within one mile of the border are included. These were used to create grids for coal-bed isopach maps and to complete edges of the coverages.

to UTM coordinates which were used thereafter for the study. Data tables associated with the points included coal bed names, thicknesses, a unique identifier, and the number of seams assigned the same bed name. Where coal beds were split into two or more beds which were assigned the same name, the thicknesses of individual beds were totaled and the split coal bed was treated as a single bed for the purpose of calculating resources. Following this step, separate point coverages were created for each coal bed. The distribution of points used for each coal is shown in figure 3.

Isopach coverages were prepared for each coal bed using the Surface II package on the IDNR-GSB Concurrent 3240 computer. The results were reformatted into a file which was generated into an pcARC/INFO coverage. The isopach coverages were prepared with one-inch contour intervals for the Whitebreast Coal and two-inch contour intervals for the Laddsdale, Cliffland, and Blackoak coals. Software limitations encountered in pcARC/INFO precluded using the one-inch contour interval for the latter coals--more lines were created than ARC could process due to the greater variability and greater overall thickness of these coals. The polygons in the coverage were labeled with the value of the highest contour which defined them and depression contours were flagged.

The point coverages were also used to create coverages for reliability categories and limits of estimate by creating buffers using radii from the

data points: Measured (0.25 mile), Indicated (0.5 mile), and Inferred (1 mile). The results of the buffers were combined to create the limit of reliability coverages. The limit of estimate coverage was simply a copy of the one mile buffer coverage.

The overburden coverages were digitized from hand-drawn maps on 7.5' quadrangle map bases (twelve in all, for Monroe County) using the computer-aided-design program, AutoCAD. The limit of estimate files were converted from pcARC/INFO to AutoCAD and used as a background for digitizing. Labels were added and the resulting lines and text were converted to pcARC/INFO. After completing edgematches on the digitized overburden maps the twelve quadrangles were appended to form a county-wide overburden map.

PcARC/INFO coverages consisting of the mined-out areas in Monroe County had been created as part of the Iowa Mined Lands Data System. Separate coverages were created for each of the coal beds studied from the Monroe County mine coverages. The mine coverages which consisted only of point locations were buffered to create polygons with an area of one acre for each point. Then all the coverages were appended to create a single coverage for each coal bed.

Coal Resource Evaluations

The overburden, reliability limit, and coal isopach coverages for each coal bed studied were combined by the intersection program in pcARC/INFO. A township coverage was obtained from the NRGIS database and intersected with the combined coverages containing the coal resource-related data. In the final stage, the mined-out areas were subtracted to complete the resource coverage preparation.

Coal resource tonnages were calculated for each polygon in the resource coverage from the area and thickness attributes assigned to each polygon and added to the database for the resource coverages. A frequency and summarizing function in pcARC/INFO was used to determine unique combinations of resource-defining criteria (overburden, coal thickness category, reliability category, and township) and to summarize tonnages and acreages for each combination. These summaries were used to prepare the tables in this report.

Classification of Coal Resources

The results of the coal resource evaluations are typically classified by criteria which define the potential value of the resource. Coal resources calculated in Monroe County were classified by stratigraphic designation, coal thickness, overburden thickness, reliability of estimate (distance from point of data), and U.S. public land survey system (i. e., township and range) location.

Stratigraphic Identification

Coal bed names used are those currently accepted by the IDNR-GSB (Fig. 1). The stratigraphic nomenclature is described by Ravn et al. (1984). Palynological correlations were available for a few of the data points used in this study, but most correlations used in this study are based on lithologic characteristics and similarities to the sections for which stratigraphic correlations had been fixed using the palynological zonation developed by Ravn (1986) for Iowa coals.

Coal Thickness

All coal seams 14 inches or more thick were included in the resource evaluation. The results were subdivided into three thickness categories, using the U.S. Geological Survey standard descriptions for bituminous coal (Averitt, 1961), as follows:

Thin	14 to 28 inches
Intermediate	28 to 42 inches
Thick	greater than 42 inches

Coals classified as "thin" are generally not considered mineable, although they are mined where the quality is exceptional or thicker coals are not available. This is true of the Whitebreast Coal in parts of southern Iowa. Its average thickness is approximately sixteen inches, but it is comparatively low in sulfur and ash content in a few localities and so it has attracted attention as a resource.

Overburden Thickness

The U.S. Geological Survey defines coal overburden categories in 1000-foot increments (Averitt, 1961). This division is not useful in Iowa, so a 100-foot increment was adopted and

overburden maps were developed accordingly. Coals with overburden 100 feet or less thick were considered potentially strippable and coals with overburden greater than 100 feet were considered potentially suitable for underground mining.

Reliability of Estimate

This is a usually defined as a radius from the point of data. Averitt (1961) described the reliability of estimate used by the U.S. Geological Survey:

Measured	0 - .25 miles
Indicated	.25 - .75 miles
Inferred	.75 - 3.0 miles

Landis and VanEck (1965) employed this system with the exception that they combined the Measured and Indicated categories into a single grouping and restricted Inferred reserves to within one mile of the point of data.

The extremely variable thickness and distribution of lower Cherokee Group coals in Iowa make smaller radii for reliability categories appropriate for resource evaluations in Monroe County. They distances used are as follows:

Measured	0 - .25 miles
Indicated	.25 - .5 miles
Inferred	.5 - 1.0 miles

Mined-out Areas

Coal mine data for the county were obtained from the Iowa Mine Lands Data System which was being developed as a set of NRGIS coverages. The coal mine coverages were developed from GSBs' collection of mine maps, State Mine Inspectors' Maps, Annual Reports, and other sources. It shares attribute data with a comprehensive database developed under a previous project. All the mines in the county are shown on Figure 4.*

Public Lands Survey System

The resources were classified by Public Land Survey System (PLSS) as a convenience for presentation of results and discussion. This coverage was taken from the PLSS coverage developed by GSB for the NRGIS.

RESULTS OF RESOURCE ESTIMATE

Remaining resources for the four coal beds studied in Monroe County were determined to total 972,237,477 tons. Strippable resources, that is, those covered with less than 100 feet of overburden, total 266,885,268 tons or 27.4% of the total. Underground mineable resources total 705,352,209 tons for the four coals. Table 1 summarizes the total resources calculated by township and Figure 5 is a graphic representation of the same data by coal bed. Resource maps prepared for each coal bed (Appendix I) differentiate areas of strippable and underground mineable coal. Coal thickness is shown as 0.5-foot increment isopach lines and mined-out areas are indicated. Detailed results are reported for each coal bed in Appendix I.

Resources calculated for the Whitebreast coal totaled 51.0 million tons. It comprises 5.2% of the total calculated resource. Strippable resources in the Whitebreast totaled 22.0 millions tons (43.1% of total for Whitebreast Coal) and underground mineable resources 29.0 million tons (Appendix I-1; Fig. 5).

The Laddsdale Coal comprised a total of 320.4 million tons (33.0% of total resources), of which 132.6 million tons (41.4% of total Laddsdale resources) were found to be strippable resources and 187.8 million tons were found to be suitable for underground mining (Appendix I-2; Fig. 5).

The Cliffland Coal accounted for the largest quantity, making up 36.7%, of the resources with a total of 357.7 million tons. Strippable resources totaled 66.8 million tons (18.6% of Cliffland resources) and resources for underground mining totaled 290.8 million tons (Appendix I-3; Fig. 5).

Resources calculated for the Blackoak Coal totaled 243.1 million tons (25.0% of the total). Strippable resources total 45.3 million tons (18.6% of the Blackoak resources) and underground mineable resources total 197.7 million tons (Appendix I-4; Fig. 5).

*This map as well as the resource maps for each coal bed (Appendix I-1b, I-2b, I-3b, I-4b) and the resource potential map (Fig. 7) are available as 1:100,000 scale maps from GSB.

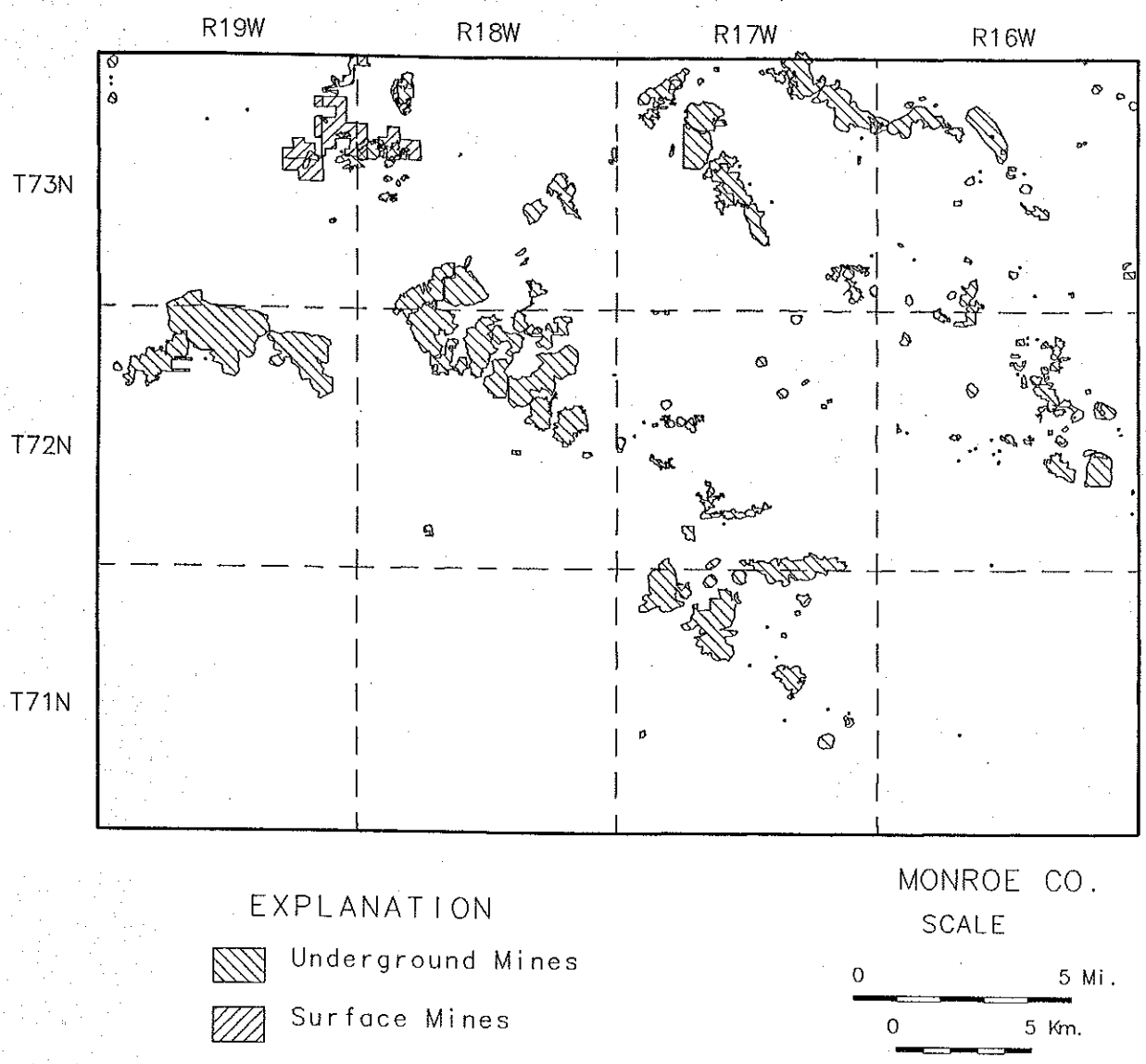

Figure 4. Coal mines in Monroe County. There are 240 mines documented in the county. Mined-out areas, totalling 18,359 acres are known for 200.

Table 1. Strippable, underground mineable, and total resources in all coal beds summarized by township.

TOWNSHIP	OVERBURDEN < 100 FT.	OVERBURDEN > 100 FT.	TOTAL
T73N, R19W	68,517,036	75,171,339	143,688,375
T73N, R18W	38,310,294	30,270,606	68,580,900
T73N, R17W	37,946,544	91,800,087	129,746,631
T73N, R16W	22,858,599	35,051,991	57,910,590
T72N, R19W	17,788,464	68,713,884	86,502,348
T72N, R18W	9,891,072	89,984,445	99,875,517
T72N, R17W	12,807,180	16,445,004	29,252,184
T72N, R16W	47,655,093	90,616,410	138,271,503
T71N, R19W	37,818	17,052,084	17,089,902
T71N, R18W	2,032,452	61,751,970	63,784,422
T71N, R17W	7,979,472	41,045,421	49,024,893
T71N, R16W	1,061,244	87,448,968	88,510,212
TOTAL	**266,885,268**	**705,352,209**	**972,237,477**

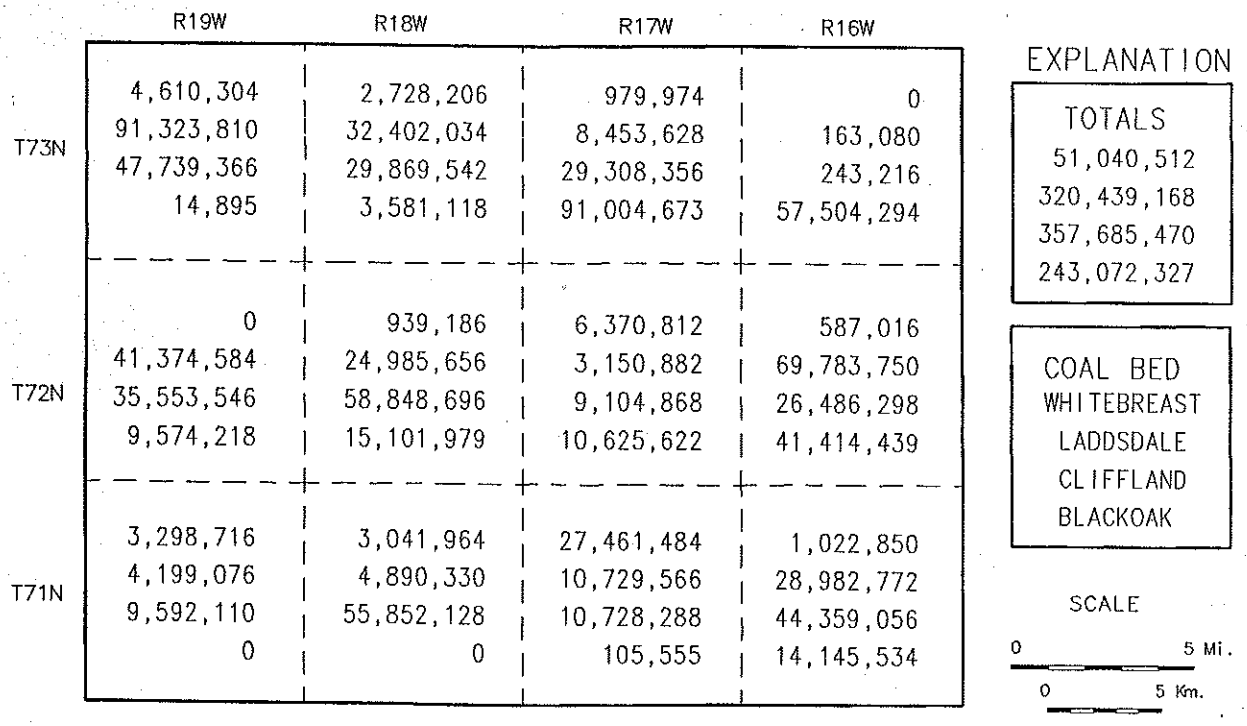

Figure 5. Summary of coal tonnages by coal bed in Monroe County. The distribution of the coal resources is influenced by the geologic setting and by the distribution of the data points used to produce the resource estimates.

Potential For Economic Development Of Coal Resources

Resource Potential Designations

The coal resources determined in this study were classified as high, moderate, or low potential for economic development based on combinations of coal thickness, overburden thickness, and reliability of estimate. The combinations of criteria assigned to each resource potential classification are listed in Table 2. Logically, thick coals with thin overburden near the point of data are judged to have a higher resource potential than thinner, more deeply buried coals. There is little analytical data available for coals in Iowa so quality was not considered as a measure of economic potential for this study. Therefore, coal quality was assumed to be uniform among all beds studied and across the extent of the study area.

The divisions between the resource potential classes used in this study are arbitrary and are expected to shift in response to changes in the economics of coal production and to changes in coal combustion technologies. For example, the advent of fluidized bed combustion technology has made clean burning of high sulfur and ash coals possible.

The results of the resource potential assessment are listed in Appendix II by township for each grouping. Strippable, underground mineable, and total resources in each class are shown for each township. Figure 6 provides a graphical representation of the quantities of coal assigned to each resource potential class.

Results of Resource Potential Assessments

Approximately 14.3% of the total (138.9 million tons) was found to have a high potential for economic development (Appendix II-1). The strippable portion comprises 88.7 million tons (63.9% of high potential resources). Figure 6 shows that most of the high resource potential coal was found in the northern and western townships of Monroe County. Thin overburden covering the coal on the east side of the county accounts for the large tonnage of high potential resources in T. 72 N., R. 16 W. Coal resources with a moderate potential for economic development comprise 295.8 million tons (30.4%) of the total resource (Appendix II-2). The strippable portion of the resources with moderate potential totals 93.6 million tons (31.6% of moderate potential resources). The distribution is similar to that of the high potential coals, although the total tonnages are larger (Fig. 6).

The largest portion of the total resources was found to have a low potential for economic development (Appendix II-3). This category comprised 537.5 million tons (55.3%) of the total. A much smaller portion (84.6 million tons; 15.7% of low potential resources) compared to the high and moderate categories was found to be strippable. In general, the largest quantity of coal with low potential is situated in the northwest and southeastern parts of the county (Fig. 6).

Resource Potential Map

Figure 7 shows the distribution of the resource potential classes. The map was prepared by assigning resource potentials to each resource coverage. Then the four resource coverages were combined with the Union program in pcARC/INFO and the highest potential selected for the resulting polygons. For example, if a given area is underlain by Blackoak Coal determined to have a "high" resource potential and by Cliffland Coal determined to have a "moderate" resource potential, that area was assigned a "high" resource potential. Finally, adjacent polygons with like values for resource potential were merged and tonnages were summarized.

DISCUSSION OF RESULTS OF RESOURCE EVALUATIONS

The coal resources were most abundant in a zone that extends from the northwestern to the southeastern parts of the county (Fig. 5). The strippable resources make up a larger portion of the total in the northwest than in the southeastern part of the county. This distribution is primarily controlled by the geologic setting and secondarily by distribution of the data points. The Pennsylvanian strata in the extreme northeastern part of Monroe County are very thin and outcrops of underlying Mississippian strata are common. The stratigraphically higher coals are eroded in northeastern Monroe County. The Whitebreast Coal and to a lesser extent with the lower Cherokee coals are typically absent in northeastern Monroe

Table 2. Classification of combinations of resource-defining criteria into resource potential classes.

RESOURCE POTENTIAL	OVERBURDEN THICKNESS (feet)	COAL THICKNESS (inches)	RELIABILITY OF ESTIMATE
HIGH	0 - 100	<42	Measured
	0 - 100	<42	Indicated
	0 - 100	28 - 42	Measured
	0 - 100	28 - 42	Indicated
	100 - 200	>42	Measured
	200 - 300	>42	Measured
	>300	>42	Measured
MODERATE	0 - 100	>42	Inferred
	0 - 100	28 - 42	Inferred
	0 - 100	14 - 28	Measured
	100 - 200	>42	Indicated
	100 - 200	>42	Inferred
	100 - 200	28 - 42	Measured
	200 - 300	28 - 42	Measured
	>300	28 - 42	Measured
LOW	0 - 100	14 - 28	Indicated
	0 - 100	14 - 28	Inferred
	100 - 200	28 - 42	Indicated
	100 - 200	28 - 42	Inferred
	100 - 200	14 - 28	Measured
	100 - 200	14 - 28	Indicated
	100 - 200	14 - 28	Inferred
	200 - 300	>42	Indicated
	200 - 300	>42	Inferred
	200 - 300	28 - 42	Indicated
	200 - 300	28 - 42	Inferred
	200 - 300	14 - 28	Measured
	200 - 300	14 - 28	Indicated
	200 - 300	14 - 28	Inferred
	>300	>42	Indicated
	>300	>42	Inferred
	>300	28 - 42	Indicated
	>300	28 - 42	Inferred
	>300	14 - 28	Measured
	>300	14 - 28	Indicated
	>300	14 - 28	Inferred

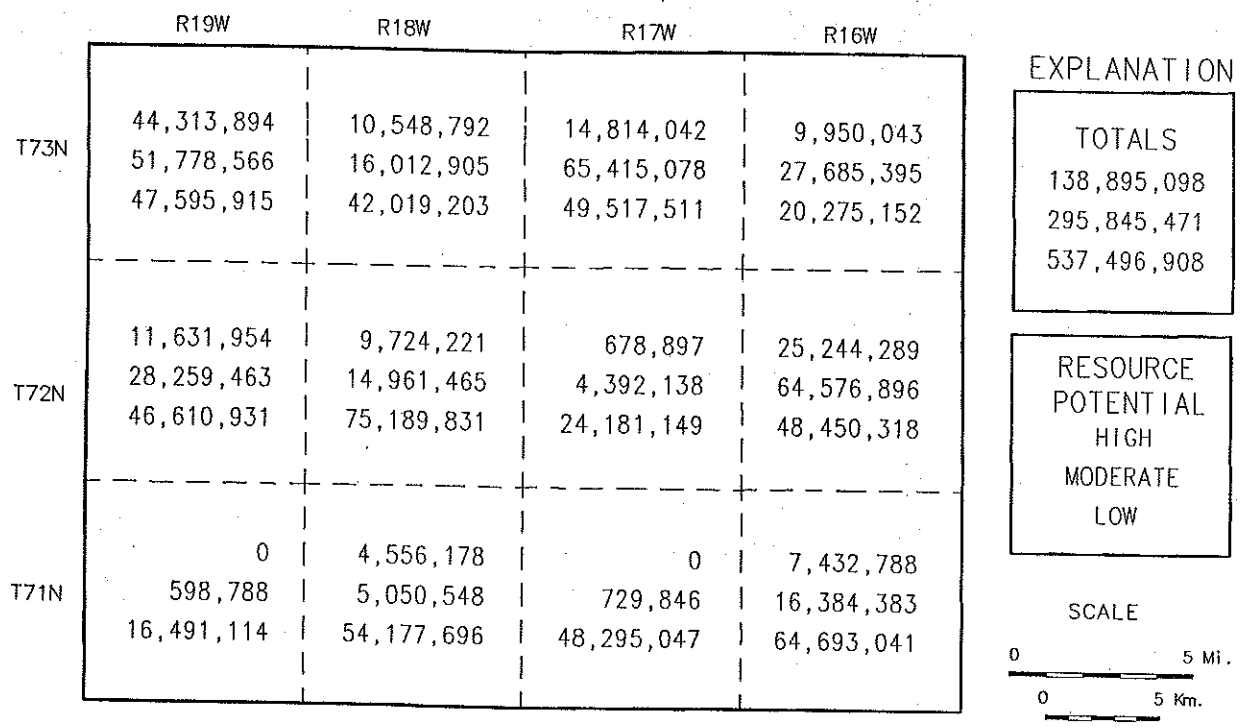

Figure 6. Summary of coal tonnages by resource potential in Monroe County. Note that much of the high potential coal is situated in the northern and eastern parts of the county where the overburden is thin.

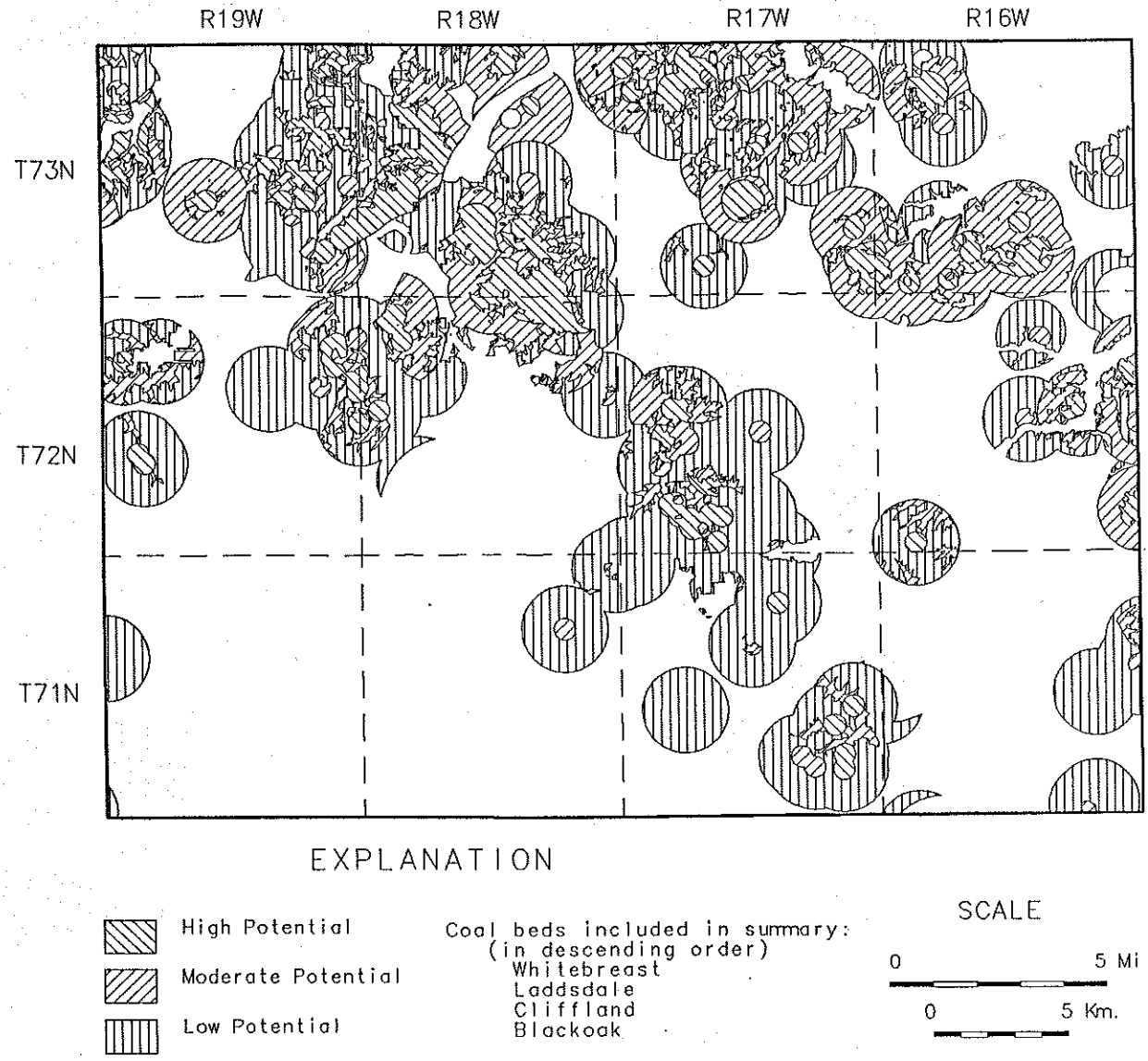

Figure 7. Potential for economic coal resources coal resources, summary of four coal beds - Monroe County.

Table 3. Comparison of estimates of coal resources for Monroe County.

SOURCE	TONNAGE	ACREAGE
Landis & VanEck (1965)[1]	884.8	129,270
Garvin et al. (1975)[2]	143.5	---
This report (1990)[3]		
Strippable reserves	266.9	---
Underground mineable	705.4	---
Total	972.2	193,254

[1]Original reserves, six coal beds.
[2]Strippable reserves (< 150' overburden, > 28" coal).
[3]Remaining reserves, four coal beds (strippable < 100' overburden; > 14" coal).

County, but in the southwestern part of the county, are covered by up to 400 feet of overburden. Data available from southwestern Monroe County and adjacent areas suggests the in addition to being deeply buried, the coals are too thin locally to include in a study of coal resources. Gregory (1982) suggests that this may be true of the Blackoak Coal in particular. The Cliffland and Laddsdale coals achieve sufficient thickness, in southwestern Monroe County to be considered in the resource evaluation, but are still thin and deeply buried so that they can be considered as marginal resources only.

The distribution of calculated resources is apparently also related to the distribution of data points (Fig. 3). The greater depth to the coal beds in the southwestern part of the county was likely to have discouraged the historic exploration drilling and mining which constitutes a large portion of the data used in this study. In addition, much exploration drilling was targeted to a particular coal seam so that deeper coal seams were ignored. This practice was particularly common in the northwestern part of the county where the Laddsdale Coal was frequently sought in exploration drilling. Consequently, many drill holes in that area do not extend to the probable depths of the Cliffland and Blackoak coals.

COMPARISON WITH PREVIOUS RESOURCE ESTIMATES

Landis and Van Eck (1965) estimated total original reserves of 884.8 million tons over an area of 129,270 acres for six coal beds in Monroe County (Table 3). That estimate included coals greater than fourteen inches thick, but did not report overburden classes. This study determined remaining reserves of 972.7 million tons over 193,254 acres for four coal beds. This represents an increase of 9.9% in coal tonnage and a 49.5% increase in acreage. The larger quantity of coal can be attributed to the larger acreage included in the resource estimate. The additional area was defined as a consequence of the addition of new data since the previous estimate.

Strippable resources were calculated for Monroe County by Garvin et al. (1975) totaling 143.5 million tons (Table 3). This study determined a strippable resource of 266.9 million tons. Part of the difference may be attributed to the inclusion of fourteen to twenty-eight inch thick coals in this study and again to an increased area included in the estimate, although the increase is partially offset by the inclusion in the former estimate of coal with 100 to 150 feet of overburden.

Bed-by-bed comparisons are not possible for the resources determined for the Laddsdale, Cliffland, and Blackoak coals as previous estimates were reported using a different system of stratigraphic nomenclature (Landis and VanEck, 1965). The Whitebreast Coal was retained by Ravn et al. (1984) for a coal associated with a distinct, easily recognized stratigraphic sequence which was determined to accord with previous usage. Thus, the results for the Whitebreast Coal can be directly compared to those of Landis and VanEck (1965). This study determined resources of 51.0 million tons in the Whitebreast Coal compared to 31.9 million tons reported by Landis and VanEck (1965). The larger tonnage calculated in the

current study is attributed to expansion of the area over which resources are calculated for each coal. The larger area is a consequence of data which has been added since 1965 to the coal data set for Iowa, particularly in northwestern Monroe County, where the coal has been mined in recent years.

EVALUATION OF THE GEOGRAPHIC INFORMATION SYSTEM FOR ASSESSING COAL RESOURCES

The Natural Resources Geographic Information System is a new resource management tool in Iowa. It proved to be an effective and flexible way to manage coal resource-related data and to prepare resource evaluations. It offers many improvements and advantages over methods of coal resource assessment previously used in the state. It is probable that similar applications can be developed for other extractable resources.

The NRGIS performed well in several areas of particular interest to GSB for resource evaluation. It proved to be a more effective system for coal resource assessments than the U.S. Geological Survey PACER/GARNET system used for the Wapello and Davis county project (Howes, 1988) and decidedly more effective than the older method of manual measurement and calculation. The NRGIS proved very useful for managing the resource data at all stages of the project. Since pcARC/INFO coverages link spatial data and attributes for the spatial entities, the database can be queried by geographic areas of interest or by attribute values. That is, it is possible to ask for data in an area of interest or by attribute values stored in the same database. This characteristic, which made it possible to create one database (coverage) for each coal bed, is its greatest asset. The results of the evaluations could then be summarized into data files used, in turn, to create reports of tonnages, acreages, etc., or the coverage could be used to prepare maps showing the distribution and location of resources.

The raw data used in the coal resource evaluations existed in many forms, both in computer files and on paper so the ability to easily move data into pcARC/INFO coverages from various sources was necessary. In addition, the capability to extract data from pcARC/INFO coverages for other applications was desirable.

Attribute data was imported from NCRDS/IASTRAT, dBase IV, and AutoCAD and exported to dBase IV and Surface II. Fixed, delimited, and DIF formats were used for transporting data depending on the destination and type of data. Most data exchanges required only careful attention to format in the target file and minimal editing of the source file. Extracting text from AutoCAD to use as attributes in pcARC/INFO coverages required the most effort, so a specialized Fortran program was written to perform this task.

Graphic data was imported from AutoCAD, Surface II, and NCRDS/IASTRAT and exported to AutoCAD, Surface II, and EPPL7. PcARC/INFO incorporates programs which provide good bi-directional conversions between pcARC/INFO coverages and AutoCAD-DXF files or EPPL7 grid files. This was particularly helpful since all hand-drawn overburden maps were digitized with AutoCAD. Exchanges between pcARC/INFO and Surface II required some additional programming for export of a point file from pcARC/INFO for gridding and contouring and to reformat the plot file from Surface II to import the completed contour map into pcARC/INFO.

PcARC/INFO provides good editing and error detection capabilities which enhance its usefulness for developing coverages and managing data. The capability to draw data from other pcARC/INFO coverages such as UTM coordinates for 7.5' quadrangle maps or the mined-out areas from Iowa Mined Land Data System was another very useful feature. Its display facilities were used to produce maps on the computer screen or on a printer or pen plotter to a specified scale. The program incorporates a CAD-type map composing program that can, with care, produce useful and attractive maps. Report generators were created in INFO to extract and summarize resource data and produce tables for this report. All of these tasks were completed within pcARC/INFO up to the point of printing tables. A word processor was used for this purpose to allow greater control over printed output.

PcARC/INFO is a large, complex system of computer programs which are closely inter-related and possess a wide range of capabilities. The complexity of the software demands time and effort to learn and successful use of the program requires detailed attention to procedures and systematic development of coverages.

As with any new and complex system, a number of problems were encountered. Some of these are related to the process of assessing coal resources and some are more general problems with the geographic information system software. The biggest drawback encountered was the lack of any facility for dealing with three-dimensional data in pcARC/INFO. The version of ARC/INFO designed for workstation and mini-computer platforms supports this function. This capability is obviously essential for coal resource studies as resource tonnages are determined from volumes. This was overcome by producing contour maps using the Surface II program on GSBs' Concurrent 3240 computer, although initially the contour plots exceeded some limitations of pcARC/INFO.

The portions of the program that rely heavily on INFO (TABLES or INFO) were particularly troublesome. INFO uses linked internal and external files and care must be taken that the association between these is not lost. INFO does not recognize path names used by pcDOS which makes it somewhat difficult to use in the DOS environment. Finally, some aspects of the software are severely limited by the pcDOS environment and attendant computer memory limitations. This is the probable reason the pcARC/INFO lacks gridding and contouring software.

The U.S. Geological Survey PACER/GARNET system was used to evaluate coal resources in Wapello and Davis counties (Howes, 1988). The technique developed for using pcARC/INFO was found to be more efficient for coal resource evaluations, particularly as PACER/GARNET was available by dial-up access to the USGS computer system only. Recent changes in communications software made communications and file transfers more difficult and ocassionally unreliable.

The biggest difference in using the two software systems was the number of calculations required to produce resource estimates. Calculating coal tonnages in the pcARC/INFO resource coverages required a single operation for each coal bed. GARNET, however, required one calculation for each combination of resource-defining criteria. For example, one calculation using Resource in the GARNET program would be required for the Laddsdale Coal in T. 73 N., R. 15 W., thickness 28 to 42 inches, overburden 100 to 200 feet thick, in the "measured" reliability category. Monroe County would have required 432 separate calculations for each coal bed if all possible combinations of resource-defining criteria were represented. The Wapello-Davis County study required 374 separate calculations for four coal seams. The resource tables generated by each calculation were concatenated to produce detailed tables similar to the appendices of this report. To prepare resource maps, the Resource program was run on sets of boundary files which included all categories for each coal and overburden thickness and the resulting maps "captured", reformatted to AutoCAD-DXF files and AutoCAD was used to produce the resource maps printed with the report. In total the program was run approximately 400 times to complete the resource evaluation for the two counties and produce the resource maps.

In GARNETs' favor, however are good gridding and contouring routines for producing coal isopach maps to use in resource calculations.

CONCLUSIONS

PcARC/INFO showed itself to be a useful tool for developing and managing coal resource data. Its ability to select and organize data based on specified criteria from a single coverage makes it very powerful for analyzing and displaying resource data. These same capabilities make it a very useful tool for providing coal resource-related information within the NRGIS or as maps and tables to users outside NRGIS.

Many of the techniques developed in the course of this project are applicable to evaluations of resources other than coal. Additionally, further refinements of the coal resource assessments, through the addition of coal quality information, or by mapping split beds, are possible. Impacts of external factors can be analyzed also, such as distance to consumers, distance to roads suitable for heavy transport, characteristics that might effect reclamation of surface mine sites, etc. Finally, the coal resource information can be used as a factor in evaluating other resources or land uses. For example, coverages of mined-out ares may prove useful in evaluating possible land use or groundwater hazards. The resource potential coverages will help assess impacts of planned construction projects on possible coal resources.

ACKNOWLEDGEMENTS

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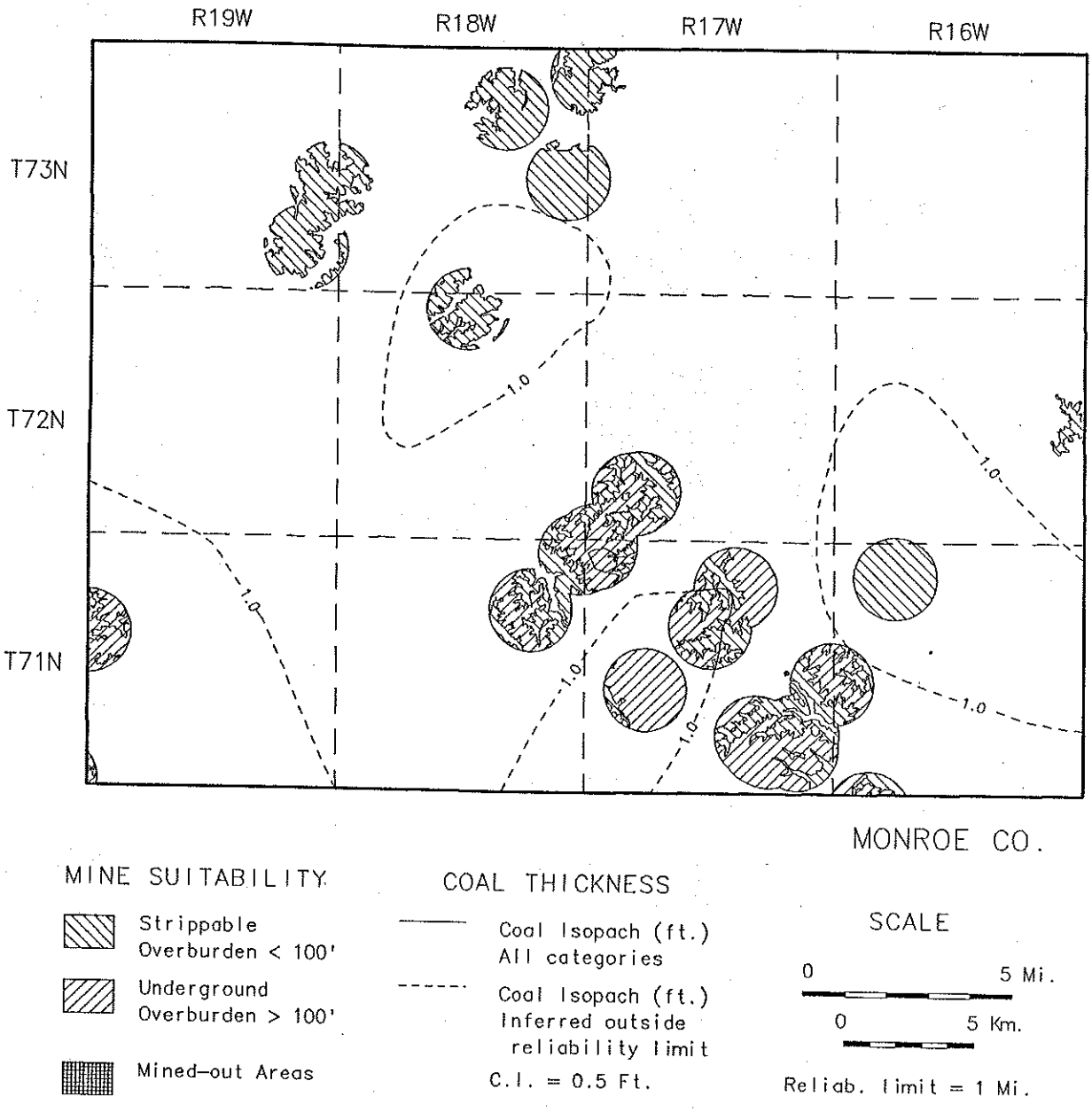
APPENDIX I.

Coal Resources by Coal Bed:
Summaries of Tonnages and Resource Maps

Appendix I-1a. Strippable, underground mineable, and total resources in the Whitebreast Coal summarized by township.

TOWNSHIP	OVERBURDEN < 100 FT.	OVERBURDEN > 100 FT.	TOTAL
T73N, R19W	4,610,304	0	4,610,304
T73N, R18W	2,728,206	0	2,728,206
T73N, R17W	979,974	0	979,974
T73N, R16W	0	0	0
T72N, R19W	0	0	0
T72N, R18W	345,258	593,928	939,186
T72N, R17W	2,953,062	3,417,750	6,370,812
T72N, R16W	587,016	0	587,016
T71N, R19W	0	3,298,716	3,298,716
T71N, R18W	2,025,756	1,016,208	3,041,964
T71N, R17W	7,298,946	20,162,538	27,461,484
T71N, R16W	501,480	521,370	1,022,850
TOTAL	**22,030,002**	**29,010,510**	**51,040,512**

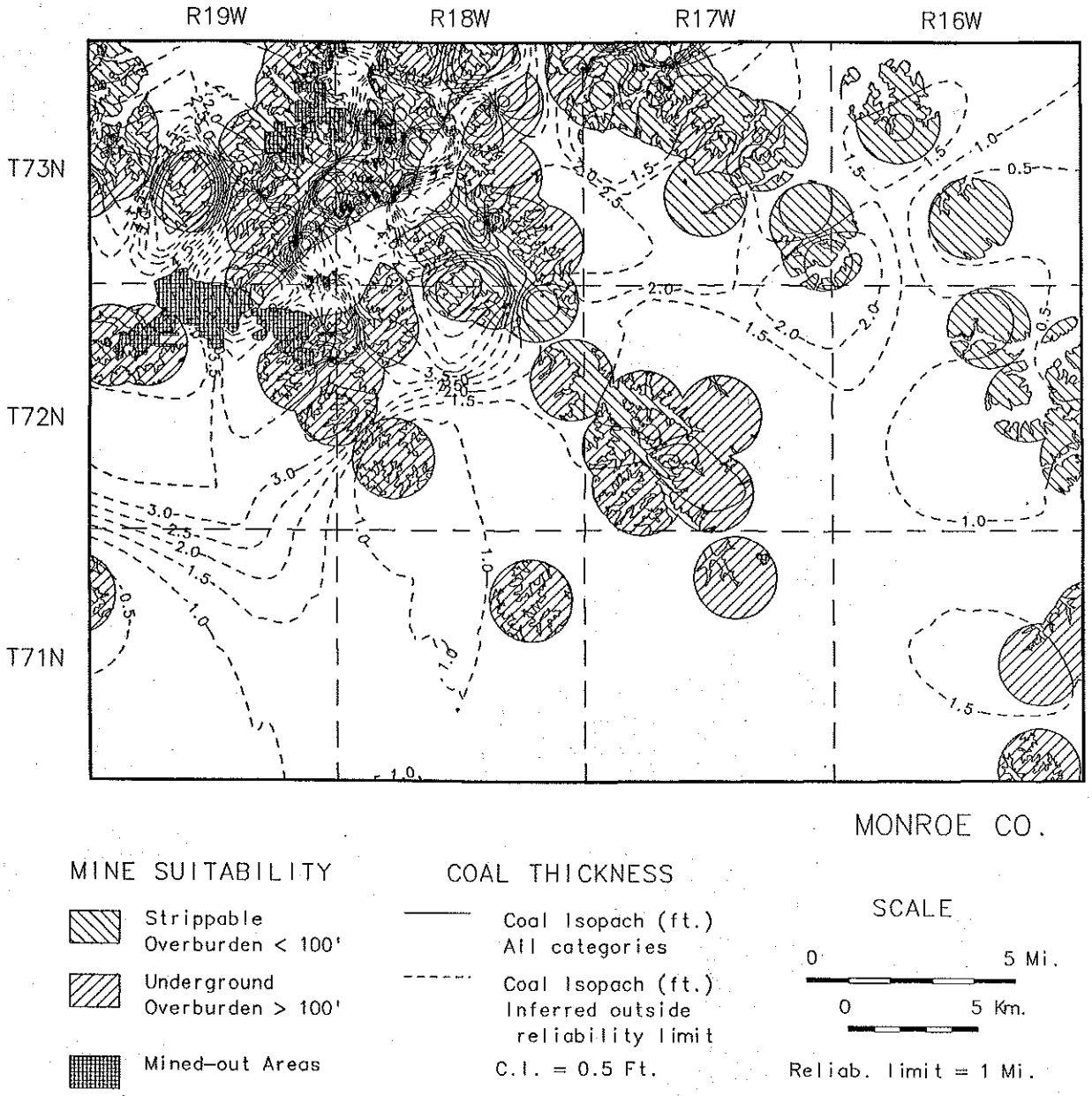
Appendix I-1b. Coal resource map for the Whitebreast Coal Member in Monroe County showing the distribution, suitability for mining, and coal thickness. Abandoned coal mines in the Whitebreast Coal are also shown.



Appendix I-2a. Strippable, underground mineable, and total resources in the Laddsdale Coal summarized by township.

TOWNSHIP	OVERBURDEN < 100 FT.	OVERBURDEN > 100 FT.	TOTAL
T73N, R19W	46,610,208	44,713,602	91,323,810
T73N, R18W	24,831,396	7,570,638	32,402,034
T73N, R17W	8,453,628	0	8,453,628
T73N, R16W	55,458	107,622	163,080
T72N, R19W	13,911,984	27,462,600	41,374,584
T72N, R18W	7,382,268	17,603,388	24,985,656
T72N, R17W	3,150,882	0	3,150,882
T72N, R16W	27,312,372	42,471,378	69,783,750
T71N, R19W	37,818	4,161,258	4,199,076
T71N, R18W	6,696	4,883,634	4,890,330
T71N, R17W	680,526	10,049,040	10,729,566
T71N, R16W	204,210	28,778,562	28,982,772
TOTAL	**132,637,446**	**187,801,722**	**320,439,168**

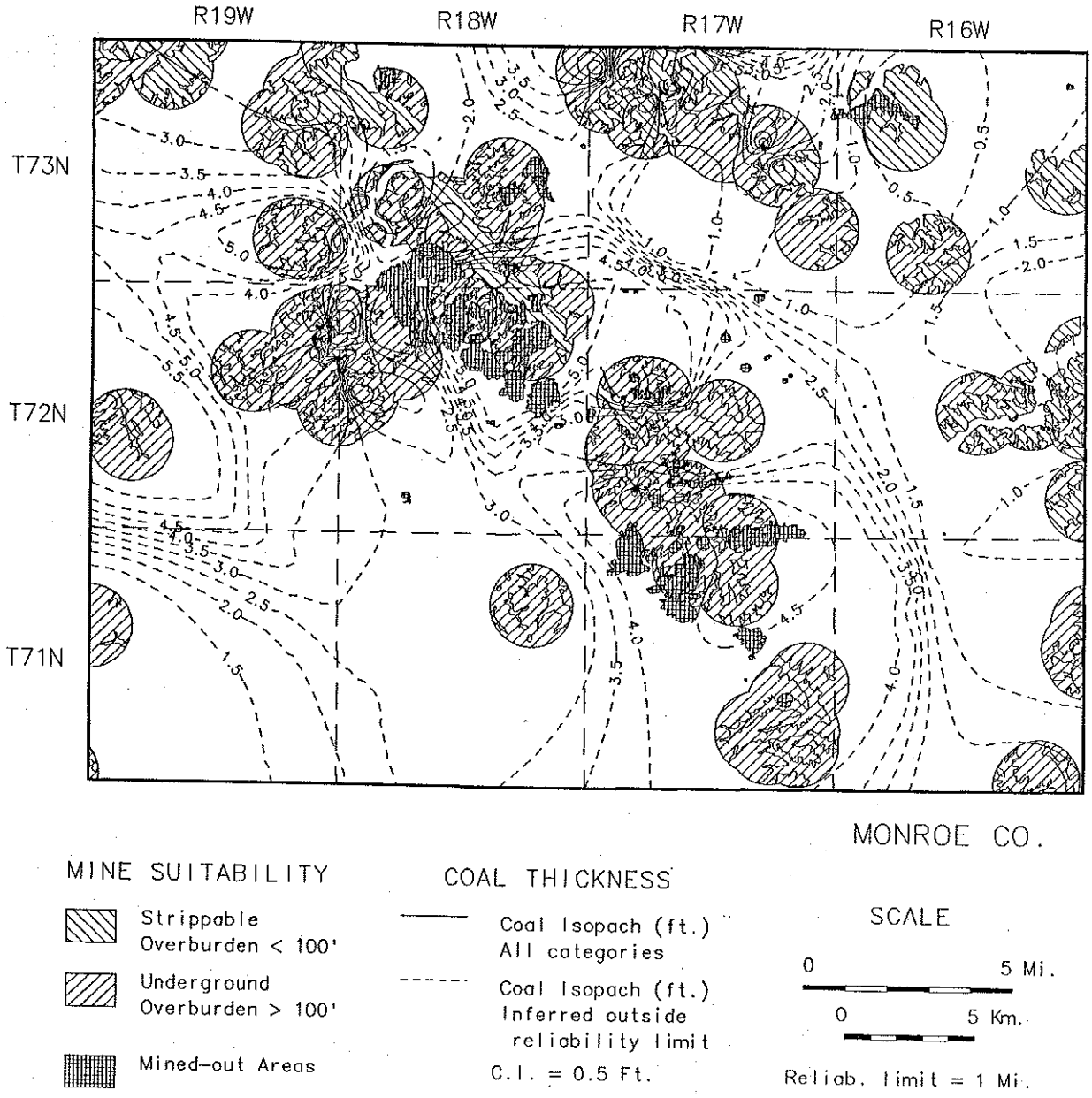
Appendix I-2b. Coal resource map for the Laddsdale Coal Member in Monroe County showing distribution, suitability for mining, and coal thickness. Abandoned coal mines in the Laddsdale Coal are also shown.



Appendix I-3a. Strippable, underground mineable, and total resources in the Cliffland Coal summarized by township.

TOWNSHIP	OVERBURDEN < 100 FT.	OVERBURDEN > 100 FT.	TOTAL
T73N, R19W	17,296,524	30,442,842	47,739,366
T73N, R18W	10,729,836	19,139,706	29,869,542
T73N, R17W	19,427,382	9,880,974	29,308,356
T73N, R16W	76,266	166,950	243,216
T72N, R19W	3,876,480	31,677,066	35,553,546
T72N, R18W	2,163,546	56,685,150	58,848,696
T72N, R17W	6,372,666	2,732,202	9,104,868
T72N, R16W	6,586,416	19,899,882	26,486,298
T71N, R19W	0	9,592,110	9,592,110
T71N, R18W	0	55,852,128	55,852,128
T71N, R17W	0	10,728,288	10,728,288
T71N, R16W	355,554	44,003,502	44,359,056
TOTAL	**66,884,670**	**290,800,800**	**357,685,470**

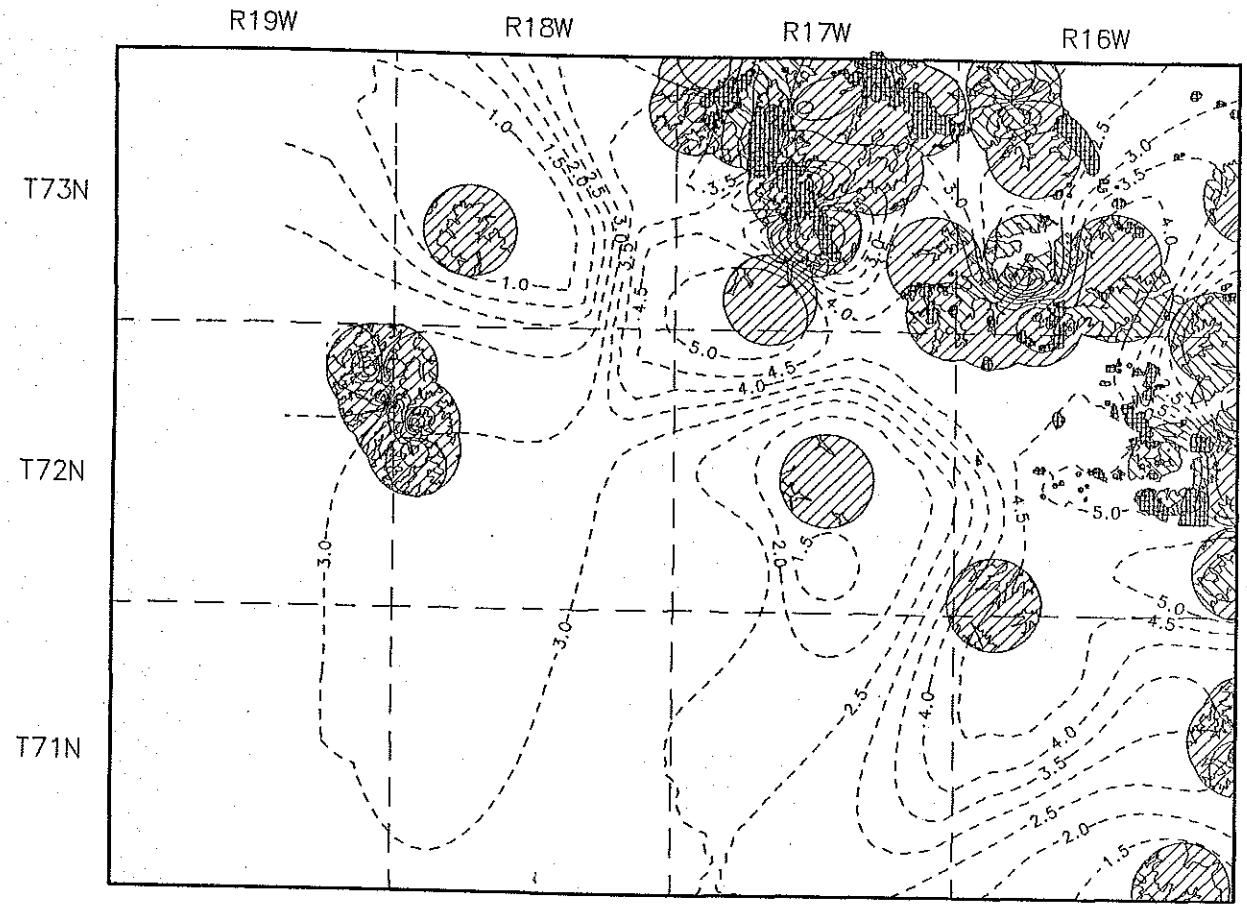
Appendix I-3b. Coal resource map for the Cliffland Coal Member in Monroe County showing the distribution, suitability for mining, and coal thickness. Abandoned coal mines in the Cliffland Coal are also shown.



Appendix I-4a. Strippable, underground mineable, and total resources in the Blackoak Coal summarized by township.

TOWNSHIP	OVERBURDEN < 100 FT.	OVERBURDEN > 100 FT.	TOTAL
T73N, R19W	0	14,895	14,895
T73N, R18W	20,856	3,560,262	3,581,118
T73N, R17W	9,085,560	81,919,113	91,004,673
T73N, R16W	22,726,875	34,777,419	57,504,294
T72N, R19W	0	9,574,218	9,574,218
T72N, R18W	0	15,101,979	15,101,979
T72N, R17W	330,570	10,295,052	10,625,622
T72N, R16W	13,169,289	28,245,150	41,414,439
T71N, R19W	0	0	0
T71N, R18W	0	0	0
T71N, R17W	0	105,555	105,555
T71N, R16W	0	14,145,534	14,145,534
TOTAL	**45,333,150**	**197,739,177**	**243,072,327**

Appendix I-4b. Coal resource map for the Blackoak Coal Member in Monroe County showing the distribution, suitability for mining, and coal thickness. Abandoned coal mines in the Blackoak Coal are also shown.



APPENDIX II.

Coal Resources by Potential for Development

Appendix II-1. Strippable, underground mineable, and total resources with high resource potential summarized by township.

TOWNSHIP	OVERBURDEN < 100 FT.	OVERBURDEN > 100 FT.	TOTAL
T73N, R19W	37,964,934	6,348,960	44,313,894
T73N, R18W	8,553,888	1,994,904	10,548,792
T73N, R17W	8,624,742	6,189,300	14,814,042
T73N, R16W	6,683,955	3,266,088	9,950,043
T72N, R19W	7,489,530	4,142,424	11,631,954
T72N, R18W	1,496,862	8,227,359	9,724,221
T72N, R17W	678,897	0	678,897
T72N, R16W	17,137,518	8,106,771	25,244,289
T71N, R19W	0	0	0
T71N, R18W	0	4,556,178	4,556,178
T71N, R17W	0	0	0
T71N, R16W	109,962	7,322,826	7,432,788
TOTAL	**88,740,288**	**50,154,810**	**138,895,098**

Appendix II-2. Strippable, underground mineable, and total resources with moderate resource potential summarized by township.

TOWNSHIP	OVERBURDEN < 100 FT.	OVERBURDEN > 100 FT.	TOTAL
T73N, R19W	19,917,504	31,861,062	51,778,566
T73N, R18W	10,916,004	5,096,901	16,012,905
T73N, R17W	17,814,561	47,600,517	65,415,078
T73N, R16W	10,381,461	17,303,934	27,685,395
T72N, R19W	5,965,146	22,294,317	28,259,463
T72N, R18W	2,298,888	12,662,577	14,961,465
T72N, R17W	2,483,847	1,908,291	4,392,138
T72N, R16W	22,784,811	41,792,085	64,576,896
T71N, R19W	0	598,788	598,788
T71N, R18W	46,350	5,004,198	5,050,548
T71N, R17W	528,390	201,456	729,846
T71N, R16W	449,802	15,934,581	16,384,383
TOTAL	**93,586,764**	**202,258,707**	**295,845,471**

Appendix II-3. Strippable, underground mineable, and total resources with low resource potential summarized by township.

TOWNSHIP	OVERBURDEN < 100 FT.	OVERBURDEN > 100 FT.	TOTAL
T73N, R19W	10,634,598	36,961,317	47,595,915
T73N, R18W	18,840,402	23,178,801	42,019,203
T73N, R17W	11,507,241	38,010,270	49,517,511
T73N, R16W	5,793,183	14,481,969	20,275,152
T72N, R19W	4,333,788	42,277,143	46,610,931
T72N, R18W	6,095,322	69,094,509	75,189,831
T72N, R17W	9,644,436	14,536,713	24,181,149
T72N, R16W	7,732,764	40,717,554	48,450,318
T71N, R19W	37,818	16,453,296	16,491,114
T71N, R18W	1,986,102	52,191,594	54,177,696
T71N, R17W	7,451,082	40,843,965	48,295,047
T71N, R16W	501,480	64,191,561	64,693,041
TOTAL	**84,558,216**	**452,938,692**	**537,496,908**

APPENDIX III.

Detailed Coal Resources Estimates for Monroe County

Appendix III-1. Whitebreast Coal resources.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T73N, R19W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	134.94	185.30	1.37	333,540.00
Indicated	1800	316.14	435.55	1.38	783,990.00
Inferred	1800	903.20	1,202.15	1.33	2,163,870.00
T73N, R18W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	800	32.77	43.69	1.33	78,642.00
Indicated	1800	156.49	208.65	1.33	375,570.00
Inferred	1800	597.67	769.90	1.29	1,385,820.00
T73N, R17W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	84.29	112.39	1.33	202,302.00
Indicated	1800	152.61	203.49	1.33	366,282.00
Inferred	1800	172.55	228.55	1.32	411,390.00
T72N, R18W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	4.15	5.88	1.42	10,584.00
Inferred	1800	131.24	185.93	1.42	334,674.00
T72N, R18W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	41.97	59.46	1.42	107,028.00
Inferred	1800	190.94	270.50	1.42	486,900.00
T72N, R17W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	27.76	39.33	1.42	70,794.00
Indicated	1800	225.46	316.42	1.40	569,556.00
Inferred	1800	916.91	1,284.84	1.40	2,312,712.00
T72N, R17W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	170.18	235.15	1.38	423,270.00
Indicated	1800	326.15	450.46	1.38	810,828.00
Inferred	1800	856.97	1,192.64	1.39	2,146,752.00
T72N, R17W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	13.35	17.73	1.33	31,914.00
Indicated	1800	2.08	2.77	1.33	4,986.00
Inferred	1800	0.00	0.00	0.00	0.00

Appendix III-1. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T71N, R19W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	14.01	22.18	1.58	39,924.00
Indicated	1800	121.15	191.83	1.58	345,294.00
Inferred	1800	641.93	1,049.30	1.63	1,888,740.00
T71N, R19W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	58.73	92.99	1.58	167,382.00
Indicated	1800	76.28	120.77	1.58	217,386.00
Inferred	1800	220.92	355.55	1.61	639,990.00
T71N, R18W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	18.39	25.75	1.40	46,350.00
Indicated	1800	94.29	133.57	1.42	240,426.00
Inferred	1800	511.18	691.51	1.35	1,244,718.00
T71N, R18W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	81.28	114.76	1.41	206,568.00
Indicated	1800	96.17	136.26	1.42	245,268.00
Inferred	1800	94.95	132.22	1.39	237,996.00
T71N, R17W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	193.80	290.73	1.50	523,314.00
Indicated	1800	597.18	878.13	1.47	1,580,634.00
Inferred	1800	1,792.99	2,637.29	1.47	4,747,122.00
T71N, R17W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	633.60	1,005.13	1.59	1,809,234.00
Indicated	1800	1,460.78	2,347.94	1.61	4,226,292.00
Inferred	1800	4,707.49	7,526.40	1.60	13547520.00
T71N, R17W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	26.25	39.03	1.49	70,254.00
Indicated	1800	4.20	5.85	1.39	10,530.00
Inferred	1800	0.00	0.00	0.00	0.00
T71N, R16W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	94.88	123.86	1.31	222,948.00

Appendix III-1. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T71N, R16W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	64.45	84.37	1.31	151,866.00

Appendix III-2. Laddsdale Coal resources

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T73N, R19W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	176.62	306.02	1.73	550,836.00
Indicated	1800	381.36	721.73	1.89	1,299,114.00
Inferred	1800	432.24	812.11	1.88	1,461,798.00
T73N, R19W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	519.96	1,558.80	3.00	2,805,840.00
Indicated	1800	853.93	2,533.39	2.97	4,560,102.00
Inferred	1800	978.10	2,719.41	2.78	4,894,938.00
T73N, R19W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	1,203.46	6,248.78	5.19	11,247,804.00
Indicated	1800	1,085.78	5,438.77	5.01	9,789,786.00
Inferred	1800	1,229.29	5,555.55	4.52	9,999,990.00
T73N, R19W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	247.06	491.53	1.99	884,754.00
Indicated	1800	474.72	927.42	1.95	1,669,356.00
Inferred	1800	658.47	1,279.40	1.94	2,302,920.00
T73N, R19W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	389.12	1,164.12	2.99	2,095,416.00
Indicated	1800	870.69	2,527.41	2.90	4,549,338.00
Inferred	1800	2,450.38	6,958.23	2.84	12,524,814.00
T73N, R19W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	517.31	2,556.79	4.94	4,602,222.00
Indicated	1800	888.76	4,236.12	4.77	7,625,016.00
Inferred	1800	1,058.31	4,699.87	4.44	8,459,766.00
T73N, R18W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	566.97	934.95	1.65	1,682,910.00
Indicated	1800	1,103.56	1,780.70	1.61	3,205,260.00
Inferred	1800	2,518.90	3,852.67	1.53	6,934,806.00
T73N, R18W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	450.72	1,223.12	2.71	2,201,616.00
Indicated	1800	661.60	1,765.21	2.67	3,177,378.00
Inferred	1800	1,316.61	3,440.26	2.61	6,192,468.00

Appendix III-2. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T73N, R18W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	32.76	137.89	4.21	248,202.00
Indicated	1800	126.76	519.00	4.09	934,200.00
Inferred	1800	37.45	141.42	3.78	254,556.00
T73N, R18W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	623.49	1,048.37	1.68	1,887,066.00
Indicated	1800	485.73	828.93	1.71	1,492,074.00
Inferred	1800	615.53	1,120.86	1.82	2,017,548.00
T73N, R18W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	128.27	325.41	2.54	585,738.00
Indicated	1800	84.72	210.53	2.49	378,954.00
Inferred	1800	167.33	406.85	2.43	732,330.00
T73N, R18W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	49.72	204.76	4.12	368,568.00
Indicated	1800	0.67	2.77	4.13	4,986.00
Inferred	1800	12.75	47.55	3.73	85,590.00
T73N, R18W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	4.94	9.88	2.00	17,784.00
T73N, R17W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	132.62	255.39	1.93	459,702.00
Indicated	1800	536.39	930.67	1.74	1,675,206.00
Inferred	1800	1,650.57	2,808.70	1.70	5,055,660.00
T73N, R17W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	2.60	7.74	2.98	13,932.00
Indicated	1800	59.92	160.15	2.67	288,270.00
Inferred	1800	206.90	533.81	2.58	960,858.00
T73N, R16W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	1.41	2.21	1.57	3,978.00
Indicated	1800	1.62	2.80	1.73	5,040.00
Inferred	1800	2.45	3.47	1.42	6,246.00

Appendix III-2. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T73N, R16W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	0.98	3.14	3.20	5,652.00
Indicated	1800	0.31	0.72	2.32	1,296.00
Inferred	1800	1.59	4.49	2.82	8,082.00
T73N, R16W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	1.05	4.05	3.86	7,290.00
Indicated	1800	1.37	6.13	4.47	11,034.00
Inferred	1800	0.92	3.80	4.13	6,840.00
T73N, R16W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	8.50	12.38	1.46	22,284.00
Indicated	1800	14.91	19.19	1.29	34,542.00
Inferred	1800	12.04	15.09	1.25	27,162.00
T73N, R16W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.08	0.19	2.38	342.00
Inferred	1800	0.10	0.23	2.30	414.00
T73N, R16W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	0.14	0.54	3.86	972.00
T73N, R16W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	0.04	0.05	1.25	90.00
Indicated	1800	3.28	4.37	1.33	7,866.00
Inferred	180	5.81	7.75	1.33	13,950.00
T72N, R19W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	196.20	298.36	1.52	537,048.00
Indicated	1800	428.65	726.85	1.70	1,308,330.00
Inferred	1800	846.31	1,617.84	1.91	2,912,112.00
T72N, R19W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	32.02	86.26	2.69	155,268.00
Indicated	1800	83.60	236.92	2.83	426,456.00
Inferred	1800	141.99	390.51	2.75	702,918.00

Appendix III-2. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T72N, R19W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	142.77	721.66	5.05	1,298,988.00
Indicated	1800	372.39	1,781.13	4.78	3,206,034.00
Inferred	1800	377.57	1,869.35	4.95	3,364,830.00
T72N, R19W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	79.60	160.61	2.02	289,098.00
Indicated	1800	262.21	509.16	1.94	916,488.00
Inferred	1800	830.20	1,607.36	1.94	2,893,248.00
T72N, R19W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	127.38	341.16	2.68	614,088.00
Indicated	1800	210.64	597.64	2.84	1,075,752.00
Inferred	1800	331.57	1,000.56	3.02	1,801,008.00
T72N, R19W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	244.43	1,082.39	4.43	1,948,302.00
Indicated	1800	509.60	2,247.77	4.41	4,045,986.00
Inferred	1800	884.72	4,084.11	4.62	7,351,398.00
T72N, R19W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	1.42	1.82	1.28	3,276.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	180.52	250.85	1.39	451,530.00
T72N, R19W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	10.31	29.63	2.87	53,334.00
Indicated	1800	76.14	202.79	2.66	365,022.00
Inferred	1800	485.62	1,454.48	3.00	2,618,064.00
T72N, R19W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	32.90	125.90	3.83	226,620.00
Indicated	1800	87.89	339.66	3.86	611,388.00
Inferred	1800	309.07	1,221.11	3.95	2,197,998.00
T72N, R18W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	56.61	147.29	2.60	265,122.00
Indicated	1800	82.88	201.82	2.44	363,276.00
Inferred	1800	48.35	122.22	2.53	219,996.00

Appendix III-2. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T72N, R18W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	538.33	719.95	1.34	1,295,910.00
Indicated	1800	1,458.94	2,055.64	1.41	3,700,152.00
Inferred	1800	3,957.34	5,628.78	1.42	10,131,804.00
T72N, R18W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	68.24	178.24	2.61	320,832.00
Indicated	1800	135.60	331.56	2.45	596,808.00
Inferred	1800	44.68	105.08	2.35	189,144.00
T72N, R18W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	120.33	140.38	1.17	252,684.00
Indicated	1800	138.25	161.45	1.17	290,610.00
Inferred	1800	380.73	458.58	1.20	825,444.00
T72N, R17W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	142.79	166.59	1.17	299,862.00
Indicated	1800	402.29	469.34	1.17	844,812.00
Inferred	1800	936.35	1,092.42	1.17	1,966,356.00
T72N, R17W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	8.31	22.14	2.66	39,852.00
T72N, R16W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	292.50	588.24	2.01	1,058,832.00
Indicated	1800	490.60	950.16	1.94	1,710,288.00
Inferred	1800	489.28	959.15	1.96	1,726,470.00
T72N, R16W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	881.27	2,438.58	2.77	4,389,444.00
Indicated	1800	567.55	1,625.05	2.86	2,925,090.00
Inferred	1800	609.88	1,791.74	2.94	3,225,132.00
T72N, R16W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	344.97	1,601.52	4.64	2,882,736.00
Indicated	1800	256.51	1,251.66	4.88	2,252,988.00
Inferred	1800	665.54	3,967.44	5.96	7,141,392.00

Appendix III-2. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T72N, R16W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	212.04	388.01	1.83	698,418.00
Indicated	1800	325.19	634.89	1.95	1,142,802.00
Inferred	1800	572.68	1,158.27	2.02	2,084,886.00
T72N, R16W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	259.26	724.74	2.80	1,304,532.00
Indicated	1800	539.21	1,505.36	2.79	2,709,648.00
Inferred	1800	1,232.02	3,500.65	2.84	6,301,170.00
T72N, R16W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	570.41	3,080.35	5.40	5,544,630.00
Indicated	1800	918.76	5,042.85	5.49	9,077,130.00
Inferred	1800	968.45	5,307.14	5.48	9,552,852.00
T72N, R16W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	119.21	202.27	1.70	364,086.00
Indicated	1800	149.20	265.46	1.78	477,828.00
Inferred	1800	381.46	610.24	1.60	1,098,432.00
T72N, R16W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	83.78	216.08	2.58	388,944.00
Indicated	1800	122.07	338.73	2.77	609,714.00
Inferred	1800	55.62	151.39	2.72	272,502.00
T72N, R16W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	23.45	102.05	4.35	183,690.00
Indicated	1800	78.57	339.16	4.32	610,488.00
Inferred	1800	6.76	27.57	4.08	49,626.00
T71N, R19W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	18.01	21.01	1.17	37,818.00
T71N, R18W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	2.48	3.72	1.50	6,696.00

Appendix III-2. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T71N, R18W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	19.48	25.97	1.33	46,746.00
Indicated	1800	29.49	39.32	1.33	70,776.00
Inferred	1800	146.48	197.56	1.35	355,608.00
T71N, R18W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	105.37	140.49	1.33	252,882.00
Indicated	1800	345.07	460.09 1.33		828,162.00
Inferred	1800	1,375.35	1,849.70	1.34	3,329,460.00
T71N, R17W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	12.01	19.11	1.59	34,398.00
Inferred	1800	261.06	358.96	1.38	646,128.00
T71N, R17W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	286.22	453.07	1.58	815,526.00
Indicated	1800	758.25	1,207.90	1.59	2,174,220.00
Inferred	1800	1,879.05	3,005.53	1.60	5,409,954.00
T71N, R17W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	33.75	45.00	1.33	81,000.00
Indicated	1800	108.10	144.13	1.33	259,434.00
Inferred	1800	545.24	727.17	1.33	1,308,906.00
T71N, R16W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	28.79	52.36	1.82	94,248.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	0.00	0.00	0.00	0.00
T71N, R16W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	19.16	50.46	2.63	90,828.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	0.00	0.00	0.00	0.00
T71N, R16W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	2.74	10.63	3.88	19,134.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	0.00	0.00	0.00	0.00

Appendix III-2. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T71N, R16W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	108.75	188.61	1.73	339,498.00
Indicated	1800	18.91	34.47	1.82	62,046.00
Inferred	1800	0.00	0.00	0.00	0.00
T71N, R16W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	266.25	758.04	2.85	1,364,472.00
Indicated	1800	265.97	788.82	2.97	1,419,876.00
Inferred	1800	407.67	1,211.63	2.97	2,180,934.00
T71N, R16W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	93.63	387.53	4.14	697,554.00
Indicated	1800	291.41	1,227.73	4.21	2,209,914.00
Inferred	1800	670.54	2,805.28	4.18	5,049,504.00
T71N, R16W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	36.58	70.38	1.92	126,684.00
Indicated	1800	0.19	0.41	2.16	738.00
Inferred	1800	0.00	0.00	0.00	0.00
T71N, R16W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	86.26	232.26	2.69	418,068.00
Indicated	1800	127.18	356.30	2.80	641,340.00
Inferred	1800	320.10	884.72	2.76	1,592,496.00
T71N, R16W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	120.27	480.89	4.00	865,602.00
Indicated	1800	359.40	1,467.38	4.08	2,641,284.00
Inferred	1800	1,217.18	5,093.64	4.18	9,168,552.00

Appendix III-3. Cliffland Coal resources

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T73N, R19W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	110.56	210.84	22.88	379,512.00
Indicated	1800	379.48	698.34	22.08	1,257,012.00
Inferred	1800	808.86	1,436.56	21.31	2,585,808.00
T73N, R19W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	81.97	220.88	32.34	397,584.00
Indicated	1800	166.84	498.09	35.83	896,562.00
Inferred	1800	208.48	589.03	33.90	1,060,254.00
T73N, R19W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	299.68	1,626.34	65.12	2,927,412.00
Indicated	1800	614.93	2,966.58	57.89	5,339,844.00
Inferred	1800	308.50	1,362.52	53.00	2,452,536.00
T73N, R19W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	65.72	125.17	22.86	225,306.00
Indicated	1800	176.83	312.43	21.20	562,374.00
Inferred	1800	996.37	1,739.63	20.95	3,131,334.00
T73N, R19W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	182.43	507.52	33.38	913,536.00
Indicated	1800	404.62	1,107.81	32.85	1,994,058.00
Inferred	1800	950.02	2,646.14	33.42	4,763,052.00
T73N, R19W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	192.02	970.41	60.64	1,746,738.00
Indicated	1800	455.56	2,193.84	57.79	3,948,912.00
Inferred	1800	1,071.96	4,637.51	51.91	8,347,518.00
T73N, R19W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	6.08	13.17	25.99	23,706.00
Indicated	1800	7.54	11.28	17.95	20,304.00
Inferred	1800	79.19	142.34	21.57	256,212.00
T73N, R19W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	111.31	261.61	28.20	470,898.00
Indicated	1800	198.87	474.10	28.61	853,380.00
Inferred	1800	631.53	1,643.47	31.23	2,958,246.00

Appendix III-3. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T73N, R19W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	28.13	126.26	53.86	227,268.00
T73N, R18W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	394.56	676.58	20.58	1,217,844.00
Indicated	1800	661.38	1,136.02	20.61	2,044,836.00
Inferred	1800	1,302.71	2,232.85	20.57	4,019,130.00
T73N, R18W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	252.02	668.18	31.82	1,202,724.00
Indicated	1800	178.30	428.61	28.85	771,498.00
Inferred	1800	305.83	737.90	28.95	1,328,220.00
T73N, R18W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	2.90	10.15	42.00	18,270.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	17.23	70.73	49.26	127,314.00
T73N, R18W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	775.59	1,234.91	19.11	2,222,838.00
Indicated	1800	1,036.09	1,659.93	19.23	2,987,874.00
Inferred	1800	1,547.04	2,553.08	19.80	4,595,544.00
T73N, R18W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	255.23	667.84	31.40	1,202,112.00
Indicated	1800	374.10	1,020.49	32.73	1,836,882.00
Inferred	1800	496.93	1,371.38	33.12	2,468,484.00
T73N, R18W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	184.95	903.52	58.62	1,626,336.00
Indicated	1800	183.33	780.00	51.06	1,404,000.00
Inferred	1800	102.13	442.02	51.94	795,636.00
T73N, R17W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	124.75	145.54	14.00	261,972.00
Indicated	1800	356.34	432.15	14.55	777,870.00
Inferred	1800	1,324.04	1,739.01	15.76	3,130,218.00

Appendix III-3. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T73N, R17W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	66.57	197.65	35.63	355,770.00
Inferred	1800	325.45	954.03	35.18	1,717,254.00
T73N, R17W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	63.25	296.92	56.33	534,456.00
Indicated	1800	312.41	1,591.63	61.14	2,864,934.00
Inferred	1800	1,021.54	5,436.06	63.86	9,784,908.00
T73N, R17W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	5.57	6.50	14.00	11,700.00
Inferred	1800	180.12	226.79	15.11	408,222.00
T73N, R17W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	101.29	607.74	72.00	1,093,932.00
Indicated	1800	187.22	1,123.32	72.00	2,021,976.00
Inferred	1800	612.10	3,525.08	69.11	6,345,144.00
T73N, R16W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	0.34	0.74	26.12	1,332.00
Indicated	1800	3.92	4.61	14.11	8,298.00
Inferred	1800	12.82	17.26	16.16	31,068.00
T73N, R16W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	2.63	7.11	32.44	12,798.00
Indicated	1800	1.57	4.10	31.34	7,380.00
Inferred	1800	1.63	4.02	29.60	7,236.00
T73N, R16W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	1.08	4.53	50.33	8,154.00
T73N, R16W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	3.04	5.87	23.17	10,566.00
Indicated	1800	4.39	7.72	21.10	13,896.00
Inferred	1800	5.79	9.23	19.13	16,614.00

Appendix III-3. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T73N, R16W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	3.42	8.25	28.95	14,850.00
Indicated	1800	1.00	2.53	30.36	4,554.00
Inferred	1800	1.06	2.90	32.83	5,220.00
T73N, R16W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	1.08	5.20	57.78	9,360.00
T73N, R16W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	6.04	8.93	17.74	16,074.00
Indicated	1800	7.36	12.93	21.08	23,274.00
Inferred	1800	11.55	20.39	21.18	36,702.00
T73N, R16W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	0.52	1.24	28.62	2,232.00
Indicated	1800	0.31	0.74	28.65	1,332.00
Inferred	1800	0.92	2.88	37.57	5,184.00
T73N, R16W - Overburden 300' - 400' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	1.82	3.94	25.98	7,092.00
T72N, R19W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	26.96	48.03	21.38	86,454.00
Indicated	1800	31.66	62.17	23.56	111,906.00
Inferred	1800	0.37	0.80	25.95	1,440.00
T72N, R19W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	101.70	274.50	32.39	494,100.00
Indicated	1800	94.23	274.12	34.91	493,416.00
Inferred	1800	46.64	138.86	35.73	249,948.00
T72N, R19W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	68.11	318.46	56.11	573,228.00
Indicated	1800	118.91	467.80	47.21	842,040.00
Inferred	1800	138.02	568.86	49.46	1,023,948.00

Appendix III-3. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T72N, R19W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	112.72	178.53	19.01	321,354.00
Indicated	1800	239.31	371.28	18.62	668,304.00
Inferred	1800	414.89	770.80	22.29	1,387,440.00
T72N, R19W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	42.41	122.40	34.63	220,320.00
Indicated	1800	79.59	238.18	35.91	428,724.00
Inferred	1800	243.05	650.74	32.13	1,171,332.00
T72N, R19W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	73.04	382.44	62.83	688,392.00
Indicated	1800	234.01	1,243.77	63.78	2,238,786.00
Inferred	1800	694.49	3,455.61	59.71	6,220,098.00
T72N, R19W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	279.02	481.38	20.70	866,484.00
Indicated	1800	503.72	884.67	21.08	1,592,406.00
Inferred	1800	765.79	1,370.45	21.48	2,466,810.00
T72N, R19W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	176.85	558.98	37.93	1,006,164.00
Indicated	1800	403.35	1,189.09	35.38	2,140,362.00
Inferred	1800	514.03	1,414.52	33.02	2,546,136.00
T72N, R19W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	108.22	498.45	55.27	897,210.00
Indicated	1800	133.08	617.01	55.64	1,110,618.00
Inferred	1800	426.83	2,101.06	59.07	3,781,908.00
T72N, R19W - Overburden 300' - 400' - Coal thickness 14" - 28"					
Measured	1800	32.65	64.93	23.86	116,874.00
Indicated	1800	98.50	175.85	21.42	316,530.00
Inferred	1800	217.87	398.90	21.97	718,020.00
T72N, R19W - Overburden 300' - 400' - Coal thickness 28" - 42"					
Measured	1800	0.92	3.00	39.13	5,400.00
Indicated	1800	9.30	23.67	30.54	42,606.00
Inferred	1800	42.09	133.69	38.12	240,642.00

Appendix III-3. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T72N, R19W - Overburden 300' - 400' - Coal thickness > 42"					
Measured	1800	10.04	40.65	48.59	73,170.00
Indicated	1800	1.21	4.34	43.04	7,812.00
Inferred	1800	62.40	223.98	43.07	403,164.00
T72N, R18W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	102.29	279.01	32.73	502,218.00
Indicated	1800	51.91	145.16	33.56	261,288.00
Inferred	1800	55.84	163.20	35.07	293,760.00
T72N, R18W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	13.73	58.31	50.96	104,958.00
Inferred	1800	134.18	556.29	49.75	1,001,322.00
T72N, R18W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	51.86	108.88	25.19	195,984.00
T72N, R18W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	310.09	915.06	35.41	1,647,108.00
Indicated	1800	616.05	1,736.39	33.82	3,125,502.00
Inferred	1800	1,439.66	3,995.34	33.30	7,191,612.00
T72N, R18W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	333.28	1,441.60	51.91	2,594,880.00
Indicated	1800	429.81	1,902.04	53.10	3,423,672.00
Inferred	1800	670.89	2,945.12	52.68	5,301,216.00
T72N, R18W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	246.70	695.08	33.81	1,251,144.00
Indicated	1800	263.79	712.00	32.39	1,281,600.00
Inferred	1800	878.74	2,437.83	33.29	4,388,094.00
T72N, R18W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	498.26	2,064.19	49.71	3,715,542.00
Indicated	1800	690.54	2,889.37	50.21	5,200,866.00
Inferred	1800	1,463.98	6,439.14	52.78	11,590,452.00

Appendix III-3. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T72N, R18W - Overburden 300' - 400' - Coal thickness > 42"					
Measured	1800	42.69	178.91	50.29	322,038.00
Indicated	1800	201.48	888.97	52.95	1,600,146.00
Inferred	1800	493.02	2,141.83	52.13	3,855,294.00
T72N, R17W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	161.24	225.78	16.80	406,404.00
Indicated	1800	387.92	544.02	16.83	979,236.00
Inferred	1800	1,126.42	1,650.98	17.59	2,971,764.00
T72N, R17W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	72.39	204.65	33.92	368,370.00
Indicated	1800	62.99	169.32	32.26	304,776.00
Inferred	1800	297.22	733.84	29.63	1,320,912.00
T72N, R17W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	2.02	11.78	69.98	21,204.00
T72N, R17W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	18.93	26.19	16.60	47,142.00
Indicated	1800	88.99	129.17	17.42	232,506.00
Inferred	1800	899.18	1,309.41	17.47	2,356,938.00
T72N, R17W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	4.38	12.64	34.63	22,752.00
Indicated	1800	0.22	0.62	33.82	1,116.00
Inferred	1800	0.01	0.02	24.00	36.00
T72N, R17W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	6.83	39.84	70.00	71,712.00
T72N, R16W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	208.92	375.85	21.59	676,530.00
Indicated	1800	331.45	554.44	20.07	997,992.00
Inferred	1800	591.85	920.03	18.65	1,656,054.00

Appendix III-3. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T72N, R16W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	44.75	135.11	36.23	243,198.00
Indicated	1800	140.55	380.63	32.50	685,134.00
Inferred	1800	254.45	659.92	31.12	1,187,856.00
T72N, R16W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	19.13	67.74	42.49	121,932.00
Indicated	1800	16.51	70.21	51.03	126,378.00
Inferred	1800	127.65	495.19	46.55	891,342.00
T72N, R16W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	24.28	38.92	19.24	70,056.00
Indicated	1800	261.38	389.18	17.87	700,524.00
Inferred	1800	1,441.99	2,133.92	17.76	3,841,056.00
T72N, R16W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	21.44	62.62	35.05	112,716.00
Indicated	1800	236.95	709.19	35.92	1,276,542.00
Inferred	1800	1,094.60	3,026.44	33.18	5,447,592.00
T72N, R16W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	124.60	516.95	49.79	930,510.00
Indicated	1800	180.51	754.67	50.17	1,358,406.00
Inferred	1800	230.54	871.01	45.34	1,567,818.00
T72N, R16W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	35.67	54.34	18.28	97,812.00
Indicated	1800	175.98	276.45	18.85	497,610.00
Inferred	1800	429.43	821.53	22.96	1,478,754.00
T72N, R16W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	31.92	87.08	32.74	156,744.00
Indicated	1800	101.86	282.24	33.25	508,032.00
Inferred	1800	280.83	786.88	33.62	1,416,384.00
T72N, R16W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	37.20	170.87	55.12	307,566.00
Indicated	1800	14.67	53.79	44.00	96,822.00
Inferred	1800	5.46	19.41	42.66	34,938.00

Appendix III-3. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T71N, R19W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	0.09	0.24	32.00	432.00
Indicated	1800	65.81	175.49	32.00	315,882.00
Inferred	1800	404.31	1,078.16	32.00	1,940,688.00
T71N, R19W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	118.46	315.89	32.00	568,602.00
Indicated	1800	282.83	754.21	32.00	1,357,578.00
Inferred	1800	1,034.48	2,758.61	32.00	4,965,498.00
T71N, R19W - Overburden 300' - 400' - Coal thickness 28" - 42"					
Measured	1800	6.20	16.53	31.99	29,754.00
Indicated	1800	25.64	68.38	32.00	123,084.00
Inferred	1800	60.54	161.44	32.00	290,592.00
T71N, R18W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	7.29	22.30	36.71	40,140.00
Indicated	1800	60.40	193.48	38.44	348,264.00
Inferred	1800	33.80	110.53	39.24	198,954.00
T71N, R18W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	125.04	571.39	54.84	1,028,502.00
Indicated	1800	266.22	1,173.37	52.89	2,112,066.00
Inferred	1800	205.60	894.67	52.22	1,610,406.00
T71N, R18W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	163.72	497.86	36.49	896,148.00
Indicated	1800	140.20	448.06	38.35	806,508.00
Inferred	1800	311.36	1,028.98	39.66	1,852,164.00
T71N, R18W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	294.48	1,361.64	55.49	2,450,952.00
Indicated	1800	1,131.56	4,968.37	52.69	8,943,066.00
Inferred	1800	2,287.02	9,669.22	50.73	17,404,596.00
T71N, R18W - Overburden 300' - 400' - Coal thickness 28" - 42"					
Measured	1800	62.60	191.91	36.79	345,438.00
Indicated	1800	128.85	410.54	38.23	738,972.00
Inferred	1800	243.82	804.15	39.58	1,447,470.00

Appendix III-3. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T71N, R18W - Overburden 300' - 400' - Coal thickness > 42"					
Measured	1800	143.27	598.18	50.10	1,076,724.00
Indicated	1800	455.02	2,033.17	53.62	3,659,706.00
Inferred	1800	1,358.74	6,051.14	53.44	10,892,052.00
T71N, R17W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	48.03	90.56	22.63	163,008.00
Indicated	1800	239.83	363.40	18.18	654,120.00
Inferred	1800	935.02	1,421.45	18.24	2,558,610.00
T71N, R17W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	15.72	36.68	28.00	66,024.00
Indicated	1800	7.17	16.73	28.00	30,114.00
Inferred	1800	0.00	0.00	0.00	0.00
T71N, R17W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	99.04	205.61	24.91	370,098.00
Indicated	1800	306.38	594.53	23.29	1,070,154.00
Inferred	1800	788.85	1,556.01	23.67	2,800,818.00
T71N, R17W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	28.89	67.41	28.00	121,338.00
Indicated	1800	1.22	2.85	28.03	5,130.00
Inferred	1800	0.00	0.00	0.00	0.00
T71N, R17W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	292.46	1,262.99	51.82	2,273,382.00
T71N, R17W - Overburden 300' - 400' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	140.57	303.63	25.92	546,534.00
T71N, R17W - Overburden 300' - 400' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	9.14	38.31	50.30	68,958.00

Appendix III-3. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T71N, R16W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	50.58	197.53	46.86	355,554.00
T71N, R16W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	65.46	104.18	19.10	187,524.00
Indicated	1800	57.10	93.87	19.73	168,966.00
Inferred	1800	126.30	231.91	22.03	417,438.00
T71N, R16W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	63.43	182.97	34.62	329,346.00
Indicated	1800	20.51	56.91	33.30	102,438.00
Inferred	1800	170.23	480.33	33.86	864,594.00
T71N, R16W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	199.91	917.41	55.07	1,651,338.00
Indicated	1800	116.89	524.86	53.88	944,748.00
Inferred	1800	423.59	1,673.46	47.41	3,012,228.00
T71N, R16W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	150.31	240.99	19.24	433,782.00
Indicated	1800	441.89	706.07	19.17	1,270,926.00
Inferred	1800	1,110.20	1,926.38	20.82	3,467,484.00
T71N, R16W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	57.62	167.59	34.90	301,662.00
Indicated	1800	80.79	227.88	33.85	410,184.00
Inferred	1800	224.20	629.37	33.69	1,132,866.00
T71N, R16W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	462.69	2,092.39	54.27	3,766,302.00
Indicated	1800	801.40	3,652.09	54.69	6,573,762.00
Inferred	1800	1,574.72	7,563.83	57.64	13614894.00
T71N, R16W - Overburden 300' - 400' - Coal thickness 14" - 28"					
Measured	1800	34.47	57.45	20.00	103,410.00
Indicated	1800	94.43	155.31	19.74	279,558.00
Inferred	1800	161.60	265.37	19.71	477,666.00

Appendix III-3. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T71N, R16W - Overburden 300' - 400' - Coal thickness > 42"					
Measured	1800	42.97	183.81	51.33	330,858.00
Indicated	1800	79.33	350.40	53.00	630,720.00
Inferred	1800	443.11	1,961.56	53.12	3,530,808.00

Appendix III-4. Blackoak Coal resources.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T73N, R19W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	1.07	2.32	2.17	4,173.00
T73N, R19W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	2.65	5.95	2.25	10,722.00
T73N, R18W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	3.02	11.59	3.84	20,856.00
T73N, R18W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	210.37	642.22	3.05	1,156,023.00
T73N, R18W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	1.44	5.42	3.76	9,756.00
Inferred	1800	145.69	560.60	3.85	1,009,083.00
T73N, R18W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	0.23	0.54	2.35	966.00
T73N, R18W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	25.74	89.99	3.50	161,982.00
T73N, R18W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	18.50	72.79	3.93	131,019.00
Inferred	1800	160.38	606.35	3.78	1,091,433.00

Appendix III-4. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T73N, R17W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	0.59	0.79	1.34	1,416.00
Indicated	1800	17.14	25.89	1.51	46,587.00
Inferred	1800	12.00	24.46	2.04	44,028.00
T73N, R17W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	159.01	486.62	3.06	875,901.00
Indicated	1800	183.96	593.37	3.23	1,068,033.00
Inferred	1800	316.66	1,046.67	3.31	1,883,931.00
T73N, R17W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	114.85	470.61	4.10	847,077.00
Indicated	1800	223.34	986.90	4.42	1,776,369.00
Inferred	1800	325.65	1,412.37	4.34	2,542,218.00
T73N, R17W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	219.20	451.46	2.06	812,640.00
Indicated	1800	746.55	1,400.58	1.88	2,521,080.00
Inferred	1800	602.87	1,221.20	2.03	2,198,145.00
T73N, R17W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	268.61	831.41	3.10	1,496,547.00
Indicated	1800	491.64	1,454.56	2.96	2,618,316.00
Inferred	1800	977.57	2,926.09	2.99	5,266,941.00
T73N, R17W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	350.56	1,497.10	4.27	2,694,741.00
Indicated	1800	1,142.19	5,264.13	4.61	9,475,365.00
Inferred	1800	3,417.92	15,420.28	4.51	27,756,468.00
T73N, R17W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	9.88	14.01	1.42	25,206.00
Indicated	1800	57.54	97.53	1.69	175,575.00
Inferred	1800	111.51	233.41	2.09	420,132.00
T73N, R17W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	92.14	280.57	3.05	505,017.00
Indicated	1800	69.79	226.35	3.24	407,418.00
Inferred	1800	508.50	1,554.00	3.06	2,797,167.00

Appendix III-4. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T73N, R17W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	256.48	1,333.68	5.20	2,400,627.00
Indicated	1800	679.92	3,489.56	5.13	6,281,196.00
Inferred	1800	1,585.79	7,814.76	4.93	14,066,532.00
T73N, R16W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	119.13	227.25	1.91	409,056.00
Indicated	1800	401.06	691.92	1.73	1,245,459.00
Inferred	1800	1,287.86	2,498.35	1.94	4,497,072.00
T73N, R16W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	6.84	21.98	3.21	39,558.00
Indicated	1800	194.92	593.33	3.04	1,067,970.00
Inferred	1800	732.52	2,239.59	3.06	4,031,193.00
T73N, R16W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	335.44	1,368.18	4.08	2,462,703.00
Indicated	1800	416.20	1,704.59	4.10	3,068,274.00
Inferred	1800	841.67	3,280.89	3.90	5,905,590.00
T73N, R16W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	113.89	228.34	2.00	410,997.00
Indicated	1800	547.46	1,116.41	2.04	2,009,523.00
Inferred	1800	1,127.81	2,421.51	2.15	4,358,754.00
T73N, R16W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	118.19	370.10	3.13	666,171.00
Indicated	1800	435.72	1,355.80	3.11	2,440,428.00
Inferred	1800	951.44	2,786.16	2.93	5,015,109.00
T73N, R16W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	406.84	1,814.51	4.46	3,266,088.00
Indicated	1800	1,049.43	4,511.80	4.30	8,121,249.00
Inferred	1800	1,159.94	4,716.16	4.07	8,489,100.00
T72N, R19W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	10.75	22.22	2.07	39,999.00
Indicated	1800	21.80	41.76	1.92	75,141.00
Inferred	1800	200.62	389.80	1.94	701,655.00

Appendix III-4. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T72N, R19W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	43.36	135.96	3.14	244,707.00
Indicated	1800	58.25	179.09	3.07	322,368.00
Inferred	1800	65.40	205.06	3.14	369,108.00
T72N, R19W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	28.74	111.89	3.89	201,402.00
Indicated	1800	1.61	5.90	3.66	10,626.00
Inferred	1800	0.00	0.00	0.00	0.00
T72N, R19W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	90.91	156.39	1.72	281,532.00
Indicated	1800	221.03	398.49	1.80	717,264.00
Inferred	1800	438.74	910.97	2.08	1,639,737.00
T72N, R19W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	53.21	157.44	2.96	283,410.00
Indicated	1800	117.65	359.31	3.05	646,800.00
Inferred	1800	315.49	942.92	2.99	1,697,232.00
T72N, R19W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	15.06	59.63	3.96	107,328.00
Indicated	1800	4.87	17.94	3.68	32,277.00
Inferred	1800	15.58	57.14	3.67	102,855.00
T72N, R19W - Overburden 300' - 400' - Coal thickness 14" - 28"					
Measured	1800	18.09	26.72	1.48	48,102.00
Indicated	1800	96.38	167.68	1.74	301,839.00
Inferred	1800	144.17	299.03	2.07	538,275.00
T72N, R19W - Overburden 300' - 400' - Coal thickness 28" - 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	2.49	8.66	3.48	15,582.00
Inferred	1800	161.59	520.84	3.22	937,488.00
T72N, R19W - Overburden 300' - 400' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	3.51	12.93	3.68	23,265.00
Inferred	1800	35.77	131.23	3.67	236,226.00

Appendix III-4. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T72N, R18W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	0.72	1.68	2.33	3,024.00
T72N, R18W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	49.81	162.29	3.26	292,128.00
Indicated	1800	111.60	330.29	2.96	594,540.00
Inferred	1800	282.30	761.28	2.70	1,370,286.00
T72N, R18W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	35.75	146.85	4.11	264,321.00
Indicated	1800	10.02	37.50	3.74	67,488.00
Inferred	1800	0.00	0.00	0.00	0.00
T72N, R18W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	58.07	106.89	1.84	192,399.00
Indicated	1800	22.36	50.69	2.27	91,245.00
Inferred	1800	0.72	1.68	2.33	3,024.00
T72N, R18W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	63.43	194.66	3.07	350,406.00
Indicated	1800	178.49	539.52	3.02	971,178.00
Inferred	1800	382.06	1,089.56	2.85	1,961,205.00
T72N, R18W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	175.39	729.66	4.16	1,313,379.00
Indicated	1800	188.77	752.11	3.98	1,353,798.00
Inferred	1800	215.97	807.58	3.74	1,453,635.00
T72N, R18W - Overburden 300' - 400' - Coal thickness 14" - 28"					
Measured	1800	20.03	41.51	2.07	74,730.00
Indicated	1800	10.53	24.25	2.30	43,686.00
Inferred	1800	0.00	0.00	0.00	0.00
T72N, R18W - Overburden 300' - 400' - Coal thickness 28" - 42"					
Measured	1800	1.88	4.77	2.54	8,583.00
Indicated	1800	116.14	327.90	2.82	590,211.00
Inferred	1800	449.05	1,391.22	3.10	2,504,184.00

Appendix III-4. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T72N, R18W - Overburden 300' - 400' - Coal thickness > 42"					
Measured	1800	2.35	9.55	4.06	17,199.00
Indicated	1800	45.39	177.64	3.91	319,758.00
Inferred	1800	188.89	700.88	3.71	1,261,572.00
T72N, R17W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.71	3.20	4.51	5,751.00
Inferred	1800	40.26	180.47	4.48	324,819.00
T72N, R17W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	134.95	230.97	1.71	415,764.00
T72N, R17W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	12.69	57.10	4.50	102,789.00
Inferred	1800	211.30	950.58	4.50	1,711,038.00
T72N, R17W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	124.82	208.03	1.67	374,460.00
Indicated	1800	374.47	624.12	1.67	1,123,410.00
Inferred	1800	1,365.25	2,287.26	1.68	4,117,074.00
T72N, R17W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	264.44	1,361.40	5.15	2,450,517.00
T72N, R16W - Overburden 0 - 100' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	33.42	47.08	1.41	84,744.00
Inferred	1800	369.32	594.73	1.61	1,070,532.00
T72N, R16W - Overburden 0 - 100' - Coal thickness 28" - 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	6.31	22.09	3.50	39,753.00
Inferred	1800	88.92	250.54	2.82	450,912.00

Appendix III-4. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T72N, R16W - Overburden 0 - 100' - Coal thickness > 42"					
Measured	1800	100.62	560.69	5.57	1,009,257.00
Indicated	1800	250.49	1,367.56	5.46	2,461,608.00
Inferred	1800	916.27	4,473.65	4.88	8,052,483.00
T72N, R16W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	11.53	15.76	1.37	28,362.00
Inferred	1800	168.77	264.27	1.57	475,647.00
T72N, R16W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	55.70	185.67	3.33	334,200.00
Indicated	1800	163.93	553.11	3.37	995,616.00
Inferred	1800	107.54	339.72	3.16	11,484.00
T72N, R16W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	30.53	150.39	4.93	270,723.00
Indicated	1800	275.78	1,342.84	4.87	2,417,088.00
Inferred	1800	1,817.26	8,623.19	4.75	15,521,655.00
T72N, R16W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	103.53	483.14	4.67	869,652.00
Indicated	1800	228.06	1,064.28	4.67	1,915,704.00
Inferred	1800	573.23	2,669.46	4.66	4,805,019.00
T71N, R17W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	1.74	7.83	4.50	14,094.00
T71N, R16W - Overburden 100' - 200' - Coal thickness 14" - 28"					
Measured	1800	6.31	12.43	1.97	22,377.00
Indicated	1800	28.24	65.64	2.32	118,167.00
Inferred	1800	113.57	160.54	1.41	288,966.00
T71N, R16W - Overburden 100' - 200' - Coal thickness 28" - 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	29.57	90.67	3.07	163,194.00
Inferred	1800	241.51	718.42	2.97	1,293,168.00

Appendix III-4. cont.

Reliability Category	Tons/ Acre-ft.	Acreage	Acre-ft.	Ave. Thk.	Tonnage
T71N, R16W - Overburden 100' - 200' - Coal thickness > 42"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	11.58	43.65	3.77	78,552.00
Inferred	1800	258.06	1,091.43	4.23	1,964,586.00
T71N, R16W - Overburden 200' - 300' - Coal thickness 14" - 28"					
Measured	1800	24.66	52.02	2.11	93,651.00
Indicated	1800	37.15	83.20	2.24	149,754.00
Inferred	1800	360.47	488.33	1.35	878,991.00
T71N, R16W - Overburden 200' - 300' - Coal thickness 28" - 42"					
Measured	1800	53.20	145.29	2.73	261,501.00
Indicated	1800	100.89	288.08	2.86	518,565.00
Inferred	1800	442.19	1,242.59	2.81	2,236,644.00
T71N, R16W - Overburden 200' - 300' - Coal thickness > 42"					
Measured	1800	1.33	6.21	4.67	11,172.00
Indicated	1800	147.59	656.18	4.45	1,181,118.00
Inferred	1800	514.56	2,346.92	4.56	4,224,444.00
T71N, R16W - Overburden 300' - 400' - Coal thickness 14" - 28"					
Measured	1800	0.00	0.00	0.00	0.00
Indicated	1800	0.00	0.00	0.00	0.00
Inferred	1800	264.74	367.05	1.39	660,684.00