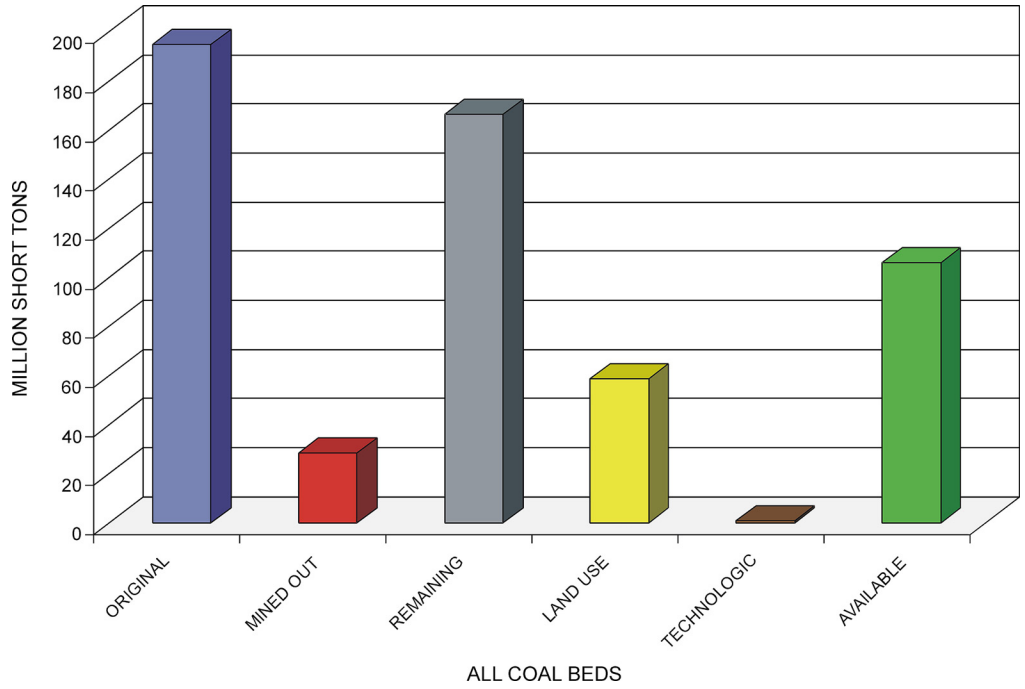
Open-File Report 06–01
2006

A STUDY OF COAL AVAILABILITY IN THE STRATTANVILLE 7.5-MINUTE QUADRANGLE, CLARION COUNTY, PENNSYLVANIA

Clifford H. Dodge



COMMONWEALTH OF PENNSYLVANIA
Edward G. Rendell, Governor
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
Michael DiBerardinis, Secretary
OFFICE OF CONSERVATION AND ENGINEERING SERVICES
Larry G. Williamson, Deputy Secretary
BUREAU OF TOPOGRAPHIC AND GEOLOGIC SURVEY
Jay B. Parrish, State Geologist

[PAGE INTENTIONALLY BLANK]

Open-File Report 06–01

A STUDY OF COAL AVAILABILITY IN THE STRATTANVILLE 7.5-MINUTE QUADRANGLE, CLARION COUNTY, PENNSYLVANIA

by Clifford H. Dodge
Pennsylvania Geological Survey

Final Report to the United States Geological Survey for
Cooperative Agreement Numbers 1434–93–A–1191 and 00HQ–AG–0130

PENNSYLVANIA GEOLOGICAL SURVEY

FOURTH SERIES

HARRISBURG

2006

Supported by the U. S. Geological Survey, Department of Interior, under assistance award Nos. 1434–93–A–1191 and 00HQ–AG–0130

ADDITIONAL COPIES
OF THIS REPORT MAY BE OBTAINED ON THE
PENNSYLVANIA GEOLOGICAL SURVEY WEB SITE
www.state.pa.us/topogeo/pub/openfile.aspx#OF06–01

CONTENTS

ILLUSTRATIONS

Page

TABLES

Page

Page

A STUDY OF COAL AVAILABILITY IN THE STRATTANVILLE 7.5-MINUTE QUADRANGLE, CLARION COUNTY, PENNSYLVANIA

by
Clifford H. Dodge

ABSTRACT

The Strattanville 7.5-minute quadrangle was one of six quadrangles investigated by the Pennsylvania Bureau of Topographic and Geologic Survey in the Main Bituminous coal field of western Pennsylvania to demonstrate the amount of coal that is available for extraction (i.e., coal that is accessible within regulatory, land-use, and technologic constraints) in several mature mining districts. Each detailed study area was selected to represent the significant variations in geology, topography, mining restrictions, and mining practices that characterize its particular setting or locality.

As of 1993, the Strattanville Coal Availability Study indicates that of the estimated 195 million short tons of bituminous coal originally present, approximately 29 million short tons has been mined out and lost in mining. An additional 60 million short tons of coal is excluded due to resource restrictions, leaving only about 106 million short tons available for mining, or about 55 percent of the total original coal resources.

Pennsylvanian-age rocks of the Pottsville and Allegheny Formations are exposed in the Strattanville quadrangle. Within the Pottsville Formation, only the Upper Mercer no. 2 coal has been mined to any extent. Minable Allegheny Formation coals include primarily the Lower Clarion, Upper Clarion, Lower Kittanning, and Middle Kittanning. The Lower Kittanning leader coal has been mined locally, and the Upper Kittanning and Lower Freeport coals are areally restricted to the southwestern part of the quadrangle, though also mined. All of the coals have been surface mined in the past, but only the Lower Kittanning bed has been mined underground on a commercial scale. Presently, coal is mined only by surface methods.

Most of the coals in Clarion County are medium to high in ash and sulfur, and require cleaning for use in steam or power generation. Overall, the coals are considered weakly coking and generally cannot be upgraded by cleaning to metallurgical quality. For the study area, the coals are mostly medium in ash and medium to high in sulfur. The same conclusions regarding coal quality are expected to apply to the Strattanville quadrangle as they do elsewhere in the county.

INTRODUCTION

This report on the Strattanville 7.5-minute quadrangle was part of a cooperative agreement between the Bureau of Topographic and Geologic Survey (Pennsylvania Geological Survey or PAGS), Pennsylvania Department of Conservation and Natural Resources, and the U.S. Geological Survey (USGS), U.S. Department of the Interior, to quantify the coal resources available for mining (i.e., coal that is accessible within regulatory, land-use, and technologic constraints). The Strattanville Coal Availability Study was one of six quadrangles investigated in the Main Bituminous coal field of western Pennsylvania to demonstrate the amount of coal that is available for extraction in several mature mining districts (Figure 1). Each detailed study area is selected to represent the significant variations in geology, topography, mining restrictions, and mining practices that characterize its particular setting or locality. The Strattanville quadrangle is representative of an unglaciated area of moderately low topographic and structural relief in the northern part of the Main Bituminous field. In this setting, most of the coals of the Allegheny Formation ("lower productive coal measures" of Rodgers, 1858) are present, occur above base level, and have been mined largely or entirely in surface operations. The information used in the Strattanville Study is current to 1993, the most recent year for which adequate aerial photography was available for examination and interpretation of surface mining throughout the entire report area. However, owing to the lack of appreciable mining since that time, the results and conclusions of this study have not materially changed to date. Selected Coal Availability (CA) studies have been undertaken elsewhere in the northern and central Appalachian basin coal regions by neighboring state geological surveys in cooperation with the USGS. (See Carter and others, 2001.)

The data collected and used for the Strattanville CA Study represent a variety of sources and include appropriate USGS digital raster graphics (DRGs); USGS digital elevation models (DEMs); identified categories of mining restrictions and associated buffer zones, based on the Commonwealth of Pennsylvania regulations; drill-hole records for coal exploration; field descriptions and measured sections of outcrops and surface-mine highwalls; coal analyses; aerial photographs of surface-mined areas; and underground-mine maps. Map information compiled on 7.5-minute topographic quadrangles (1:24,000 scale)—representing coal crop lines, mined-out areas, and buffer zones around land-use and technologic restrictions—was digitized using

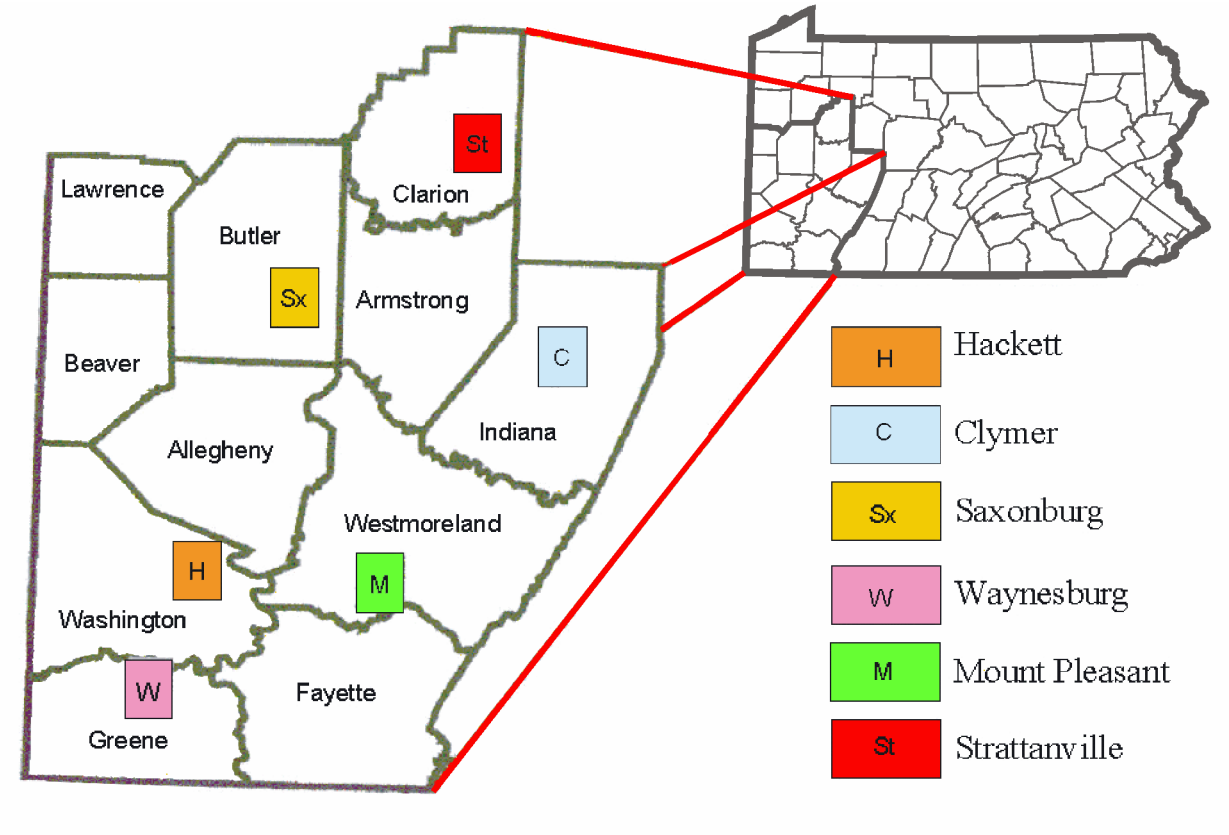


Figure 1. Location map of the Strattanville 7.5-minute quadrangle and other Coal Availability Studies in Pennsylvania.

Environmental Systems Research Institute, Inc. (ESRI) ArcInfo software to create coverages in a geographic information system (GIS). Selected stratigraphic information was entered into a customized Microsoft Access computer database that was designed for use with several of the more recent Pennsylvania CA studies, including Strattanville. As required, digital information from appropriate GIS coverages, DEMs, and stratigraphic datasets were processed through a series of ArcInfo Macro Language (AML) programs that were modified greatly from methods and procedures developed by the Montana Bureau of Mines and Geology and the Illinois Geological Survey. The AMLs were designed to emulate the geographic-analysis software called Geographical Resources Analysis Support System (GRASS), as modified by the USGS, to calculate available coal using multiple resource-reliability categories and various thickness-of-coal and overburden categories. The CA methodology is discussed elsewhere in this report.

This study included stratigraphic data for coal from the Strattanville 7.5-minute quadrangle and contiguous 3-mile-wide perimeter outside its boundary. The perimeter consists

of parts of eight quadrangles, including (clockwise from the northwestern corner of the Strattanville quadrangle) Fryburg, Lucinda, Cooksburg, Corsica, Summerville, New Bethlehem, Sligo, and Clarion. A distance of 3 miles was selected to assure proper estimation of coal resources for all reliability categories (i.e., measured, indicated, inferred, and hypothetical). (See Wood and others, 1983.) Points of measurement in the adjacent quadrangles also provided control when contouring data toward the edges of the report area. Other datasets, such as coal crop lines, mined-out areas, and mining restrictions, were relevant as well but were only required (compiled) for the Strattanville quadrangle itself.

Coal thicknesses discussed and used in this study were for "clean" coal. In general, all partings greater than 3/8-inch thick and all bony-coal benches or layers greater than 33 weight percent ash on the dry basis were excluded from the total bed thickness to determine the "clean" coal thickness (Wood and others, 1983). However, consideration was given to the actual mining practices of the area, prior to excluding certain benches that may, in fact, be mined.

The overall goals of six the Pennsylvania CA studies were as follows:

1. To select and study a series of 1:24,000-scale 7.5-minute quadrangles (each area is approximately 56 square miles) that were representative of the significant variations in geology, topography, mining restrictions, and mining practices that characterized the bituminous coal measures of western Pennsylvania and for which sufficient data existed for analysis.
2. To estimate for areas the size of a 7.5-minute quadrangle the original, mined-out and lost-in-mining, and remaining coal resources.
3. To determine the amount of remaining coal resources available for mining in the study areas by also considering the effects of regulatory, land-use, and technologic restrictions.
4. To identify and characterize the most significant availability factors within each study area so that the percent of remaining coal resources available for extraction in other regions of the Pennsylvania bituminous coal fields can be estimated.

This report summarizes the results of the Strattanville study, which provide estimates of the original, mined-out, remaining, restricted, and available coal resources.

LOCATION

The Strattanville 7.5-minute quadrangle is situated in east-central Clarion County, northwestern Pennsylvania, and lies between 41°07′30″ and 41°15′00″ north latitude and between 79°15′00″ and 79°22′30″ west longitude (Figure 1). It is located in the northern part of the Main Bituminous coal field.

The area includes the town of Strattanville and the eastern portion of the town of Clarion, both located in the northwestern part of the quadrangle (Figure 2). Several villages are also present and scattered throughout the report area, notably Mechanicsville, Limestone, Henderson, Day, Stone House, Waterson, Kingsville, and Rader. The Strattanville quadrangle contains parts of six townships, including Paint, Highland, and Millcreek to the north; Clarion toward the middle; and Monroe and Limestone in the south. Clarion and Limestone Townships are the largest two and together comprise about three quarters of the area.

Major transportation routes include both federal and state highways (Figure 2). U.S. Interstate Highway 80 (I–80) and U.S. Route 322 run roughly east-west across the center portion of the study area. State Route 66 runs north-south across the southern half of the quadrangle and merges with I–80 to the north at Interchange 64 (formerly Interchange 10). Numerous county and township roads are present throughout the area as well.

PHYSIOGRAPHY

The Strattanville quadrangle lies entirely within the Pittsburgh Low Plateau section of the Appalachian Plateaus physiographic province (Sevon, 2000). The area is underlain by sedimentary rocks—principally shale, claystone, siltstone, sandstone, limestone, and coal—and characterized by broad, open folds of low amplitude, having gently dipping flanks and shallow plunges.

The dominant topographic form consists of a smooth to irregular, undulating surface and narrow, relatively shallow valleys. Nearly all of the major streams and their principal tributaries are floored with alluvium. The upper reaches of many of the tributary streams are relatively broad and flat, and contain much colluvium along their valley sides. Based on unpublished records, estimated maximum depth to bedrock along the major streams is about 20 to 40 feet and along the principal tributaries is 20 to 50 feet.

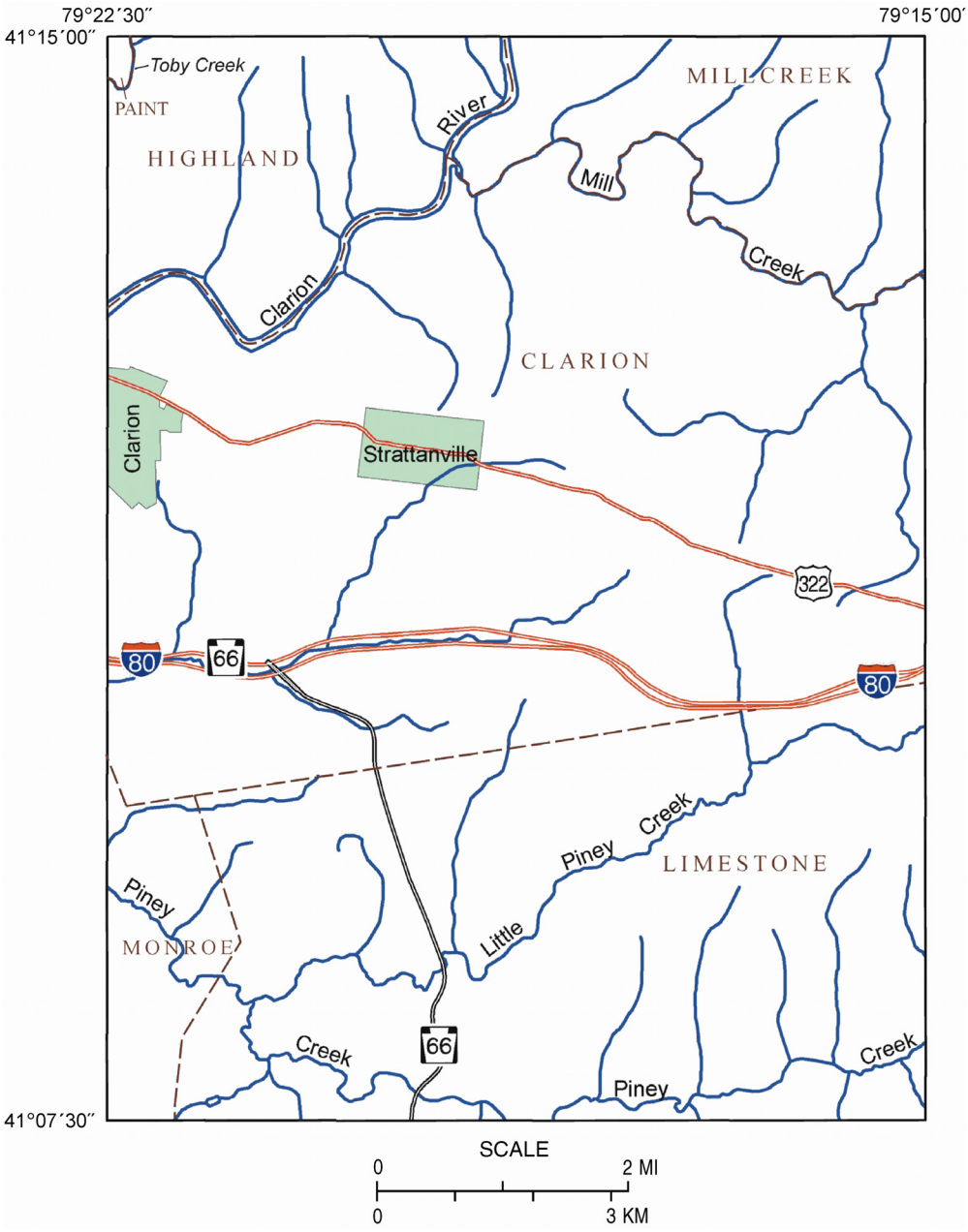


Figure 2. Locations of townships and selected roads, streams, and towns in the Strattanville quadrangle.

In general, rocks of the Allegheny and upper Pottsville Formations contain more shale than the underlying lower Pottsville and older (Mississippian-age) rocks (Figure 3). Consequently, Allegheny and upper Pottsville rocks, which form most of the bedrock of the quadrangle, are less resistant to erosion and are more highly dissected by streams. The resulting drainage pattern is dendritic. The local relief varies from about 150 to 450 feet in the Strattanville quadrangle.

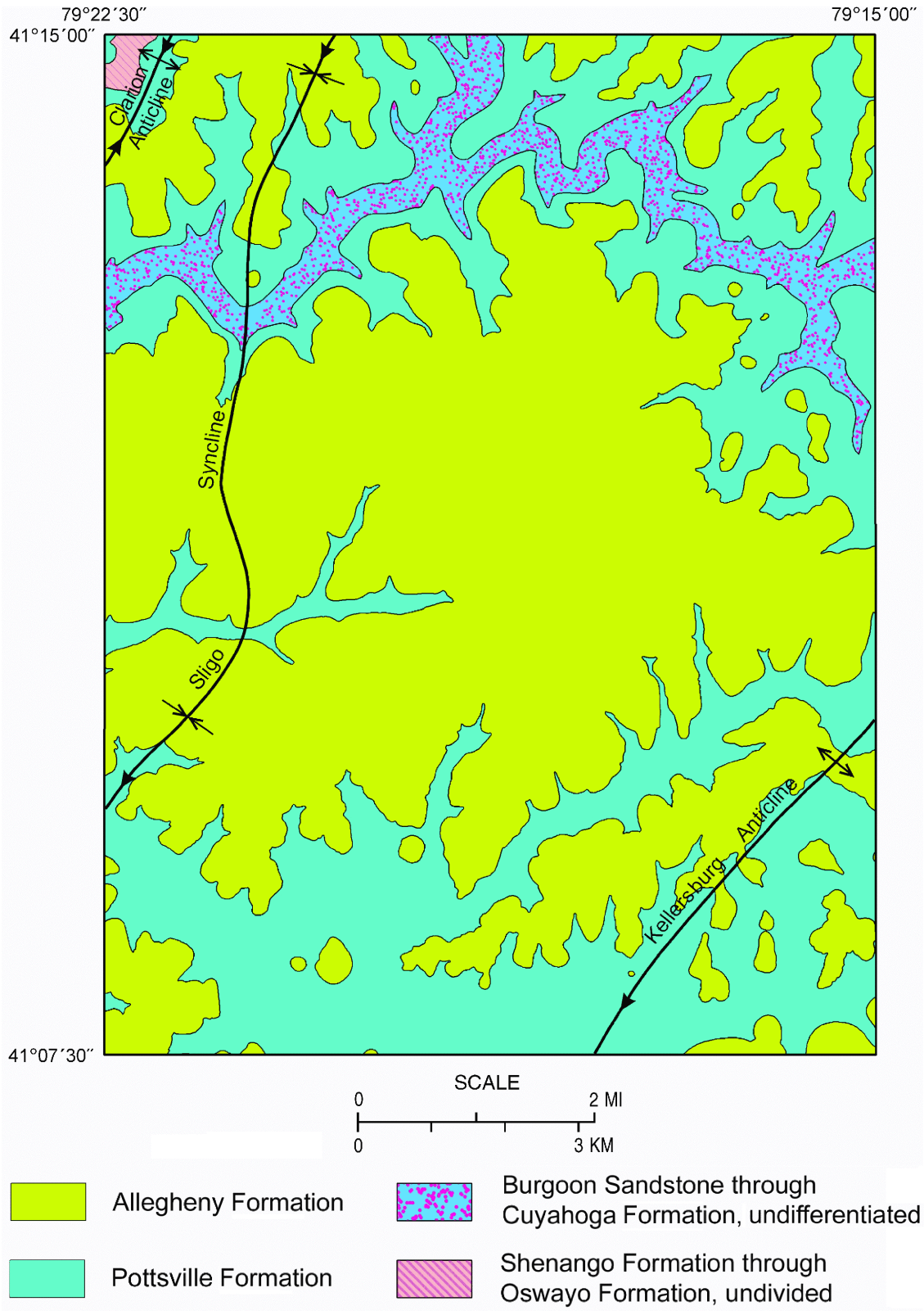


Figure 3. Generalized geologic map of the Strattanville quadrangle.

Maximum altitudes exceed 1,600 feet and are commonly found on a number of isolated knobs and small ridges throughout the report area. However, the largest areas greater than 1,600 feet are concentrated along the eastern edge of the quadrangle, adjacent to the Kellersburg anticline. The highest point is located on a knob about 0.4 mile north of Rader, along the south side of the interstate highway, and has an altitude of about 1,725 feet. The lowest point is found in the northwestern part of the quadrangle along the Clarion River, where it exits the report area at an altitude of about 1,090 feet. The total relief of the quadrangle is about 735 feet.

The drainage of the Strattanville area consists of four major watersheds, including the Clarion River, Toby Creek, Mill Creek, and Piney Creek (Figure 2). All drainage flows westward to the Ohio River and the Gulf of Mexico.

PREVIOUS WORK

Staff of the First Geological Survey of Pennsylvania (1836–1842, 1851–1858) conducted the earliest known geological reconnaissance encompassing the report area (Rogers, 1858). The area was then considered part of the "Sixth Coal-Basin," and some observations on coal and associated rocks were made around Strattanville. Several coals were identified, including the "Brookville" (Lower Clarion), "Clarion" (Upper Clarion), and "Kittanning" (Lower Kittanning).

It appears that no other fieldwork was undertaken until the Second Geological Survey of Pennsylvania (1874–1895) mapped the geology of Clarion County (Chance, 1880). In his report, H. M. Chance described the township geology of the county and discussed the occurrence of several coals, generally following the nomenclature still used today.

The U.S. Geological Survey (USGS), in cooperation with the Third Pennsylvania Geological Survey (1899–1914), briefly described the characteristics and quality of the coals in the Clarion 15-minute quadrangle, which includes the Strattanville quadrangle (Lines, 1907). Shortly thereafter, the USGS published the first detailed geologic map and account of the area (Shaw and others, 1911). Adequate topographic base maps for compilation purposes were available for the first time. The principal coals identified and mapped in the area corresponding to the Strattanville quadrangle were the "Brookville," "Clarion," "Lower Kittanning," and "Upper Freeport."

During the 1920s, the Fourth Pennsylvania Geological Survey (1919–present) published Mineral Resource Report 6, *Bituminous Coal Fields of Pennsylvania*, in four parts (Ashley,

1928; Sisler, 1926; Reese and Sisler, 1928; and U. S. Bureau of Mines, 1928). Some of the information contained therein is pertinent to Clarion County. Part I of this bulletin (Ashley, 1928) provides general information on bituminous coal. Part II (Sisler, 1926) contains information on the structure, stratigraphy, distribution, and character of the various coal beds by county. Part III of this report (Reese and Sisler, 1928) summarizes the county coal resources for the first time. The estimated coal resources were calculated by township and included three resource categories—original, recoverable, and mined out and lost. Part IV (U.S. Bureau of Mines, 1928) contains detailed information on coal analyses by county.

In the 1950s, the USGS, in cooperation with the PAGS, remapped the coal measures in several western Pennsylvania counties, including Beaver, Lawrence, and Butler, and calculated the coal resources of each by 7.5-minute quadrangle (Patterson, 1963; Van Lieu and Patterson, 1964; and Patterson and Van Lieu, 1971). In the reports, resources were classified according to reliability (i.e., measured, indicated, and inferred) and quantity (i.e., original, remaining, and recoverable). Although a similar study was undertaken for Clarion County, the coal-resource estimates were never completed and only the county coal-bed map was published (Patterson and Van Lieu, 1972).

The U. S. Bureau of Mines released several significant studies on coal in Clarion County. Blaylock and others (1956) estimated the total and recoverable resources by coal seam and 15-minute quadrangle, restricting the calculations to the measured and indicated categories. Birge and others (1963) discussed the carbonizing (coking) properties of coals in Clarion County and vicinity. Zeilinger and Deurbrouck (1968) reported on the preparation (washability) characteristics of Clarion County coals and included two samples from the Strattanville quadrangle.

Edmunds (1972) estimated the total, recoverable, and strippable resources for the Pennsylvania coal-producing counties. His work was based largely on the earlier studies by Reese and Sisler (1928) and Ashley (1944).

Sholes and Skema (1974) produced a set of 13 coal-resource maps (one regional map for each of the 13 important bituminous coals) that summarized known information on the distribution, thickness, and mined-out areas of the principal coals in 15 western Pennsylvania counties. Eight of the maps pertained to Clarion County and six to the Strattanville quadrangle.

Glover (1987) compiled a series of coal-resource maps for Clarion County, based largely on unpublished work by staff of the Rochester and Pittsburgh Coal Company. These maps included a set for the Strattanville quadrangle, which consisted of six separate crop-line and mined-out-area maps of the principal coals (Lower Clarion through Lower Freeport) and one composite map of all principal coal crop lines and structure contours on the base of the Lower Kittanning coal.

COAL AVAILABILITY METHODOLOGY

Fundamental to this and similar studies are accurate geologic maps showing the areal extent and mined areas for each of the coals under investigation for availability. Unlike the geologic maps for the other CA studies in Pennsylvania, the author of this report found that the published coal-resource maps for the Strattanville quadrangle (Glover, 1987) were inaccurate and incomplete, and thus were unacceptable. Furthermore, a number of surface coal mines, predating the original publication of the quadrangle in 1968, were never identified by the USGS or portrayed on the topographic base map.

Therefore, as a prerequisite to the Strattanville CA Study, it was necessary for the author to undertake a detailed stratigraphic correlation study of the area and to remap all of the coal geology of the quadrangle. Pertinent literature was thoroughly reviewed. All available published and unpublished stratigraphic information was examined, including copies of the field notes of Patterson and Van Lieu (1972). Many new drill-hole records were obtained from the Knox District Office, Bureau of District Mining Operations, Pennsylvania Department of Environmental Protection. All known underground-mine maps were georeferenced and compiled. Moreover, information was sufficient to estimate the limits of two other abandoned underground mines. Seven sets of aerial photographs, taken over a period of 35 years, were used to identify and compile all known surface mines. Compiled surface-mined areas are current to 1993, the last year for which complete aerial photographic coverage was available. The revised geologic mapping of the Strattanville quadrangle did not involve any new fieldwork.

In accordance with federal, state, and local regulations, restrictions to mining were determined and based on land-use, environmental, regulatory, societal, and technologic constraints. These factors are commonly listed under the categories of land use and technology. In general, land-use restrictions involve surface and underground features affecting strip mining,

whereas technologic constraints include those features affecting deep mining. Specific restrictions for the Strattanville quadrangle are summarized in Table 1. Land-use restrictions

Table 1. *Identified Mining Restrictions and Associated Buffer Zones Used in the Strattanville Coal Availability Study*

Land-Use Restrictions	Buffer Zone[1]
Cemeteries	Boundary + 100 feet
Lakes[2]	Shoreline + 100 feet
Oil and gas wells[3]	100-foot radius
Pipelines[4]	Right-of-way + 100 feet
Power lines[4]	Right-of-way + 100 feet
Private buildings[5]	Structure + 300 feet
Public buildings[6]	Structure + 300 feet
Public lands	Boundary + 300 feet
Railroads[4]	Right-of-way + 100 feet
Roads	Right-of-way + 100 feet
Streams[7]	Bank + 100 feet
Towns	Corporate boundary
Wetlands	Boundary + 100 feet
Technologic Restrictions	**Buffer Zone[1]**
Oil and gas wells[3]	100-foot radius
Public buildings[6,8]	Structure + 300 feet
Thickness of coal beds[9]	Greater than 14 inches to 28 inches[9]

[1] Compiled from Title 25, Pennsylvania Code, Chapter 86, "Surface and Underground Coal Mining: General," and other sources.
[2] Include lakes, ponds, and other enclosed bodies of water greater than 20 acre-feet in volume.
[3] Active and abandoned, unplugged wells only; do not include abandoned, plugged wells, which can be mined through. Surface-mine regulations require 125-foot radial barrier unless variance granted by property owner. However, variance must conform with requirement by Pennsylvania Department of Environmental Protection that barrier is equal to or greater than highwall height that would be in proximity to well. Therefore, from a practical standpoint, 100-foot radius chosen for Pennsylvania Coal Availability studies.
[4] Pennsylvania Bituminous Mine Subsidence and Land Conservation Act, 1994 amendments (Act 54) recommended protection but did not define buffer zone. For this study, buffer zone established by analogy with similar categories of restrictions that are defined.
[5] Include commercial structures, houses, industrial buildings, and manufacturing facilities.
[6] Include churches, community buildings, institutional facilities, government buildings, and schools.
[7] Include streams and rivers (perennial and intermittent).
[8] Pennsylvania Bituminous Mine Subsidence and Land Conservation Act, 1994 amendments (Act 54) removed private buildings from designated mandatory surface restrictions to underground mining.
[9] From Wood and others (1983). Technically, thickness category is not a buffer zone.

include rivers and streams, lakes and ponds, wetlands (as defined by the National Wetlands Inventory of the U. S. Department of the Interior), highways and improved roads, active railroads, pipelines (6 inches or more in diameter), power lines, active oil and gas wells, public lands (such as State Game Lands), public buildings (including churches, schools, and government buildings), private buildings (including houses, commercial structures, and manufacturing facilities), cemeteries, and incorporated towns. Technologic restrictions include active oil and gas wells and public buildings (both are found in the land-use category as well), and thickness of coal beds. Reference to these and other land-use and technologic restrictions are made in several figures under the heading, "Coal Resources," and in several tables in Appendices A and B. The restrictions not pertinent to the Strattanville Study and not included in Table 1 are for completeness only but nevertheless do signify other criteria that need to be considered for any Pennsylvania CA study.

Topographic base maps showing coal crop lines, surface mines, and underground mines compiled by the author were scanned and georeferenced using ArcMap. The coal crop lines, mined-out areas, and mining restrictions were subsequently digitized on screen ("heads up"), attributed, and made into layers as part of a geographic information system (GIS), using ArcInfo software. ArcInfo was also used to create buffers for all of the identified restrictions to mining (Table 1). In some situations, restriction categories overlap, such as important roads within the incorporated boundary of a town. Where this overlap occurs, the resultant resource estimate is only counted once, and the value is apportioned equally among the identified categories. The resultant digital GIS coverages constitute a database for determining the original areal extent, mined areas, and areas restricted from mining for each coal bed studied for availability. Detailed procedures using AMLs to subsequently process the coal data and calculate the coal-resource estimates are presented in Appendix C.

GEOLOGY

STRUCTURE

The structural geology of the Strattanville quadrangle is characterized by broad, open, asymmetrical folds of low amplitude, having gently dipping flanks and shallow plunges. Three folds are present in the report area, generally trending northeast-southwest and plunging to the

southwest. In succession, from the southeast corner of the quadrangle, the folds are the Kellersburg anticline, Sligo syncline, and Clarion anticline (Figure 3).

The Kellersburg anticline has an axial bearing of about N40°E and plunges to the southwest at about 20 to 40 feet per mile. It is asymmetrical in profile, and the southeastern flank dips more steeply than the northwestern one. On the southeastern flank, dips range from about 80 to 120 feet per mile. Along the northwestern flank, dips vary from about 40 to 80 feet per mile. To the east of the Strattanville quadrangle, the bearing of the fold axis turns northward, and the flanks of the anticline dip to the east and west. Therefore, for much of the area between the Sligo syncline and Kellersburg anticline, the beds strike roughly north-south and dip to the west.

The Sligo syncline is the dominant fold and covers the western half to two thirds of the quadrangle. The axis of the syncline undulates, with a bearing of N10°W to N40°E. The fold plunges to the south or southwest at about 10 to 40 feet per mile.

The Clarion anticline is confined to the northwest corner of the report area. Here it is doubly plunging, forming a small saddle with an axial bearing of about N30°E. Just to the west of the quadrangle, a small dome is present along the fold axis. In general, elsewhere along its length, the fold gently plunges to the southwest at about 10 to 20 feet per mile. Dips along the southeastern side of the fold range from about 20 to 60 feet per mile. On the northwestern flank, dips vary from about 30 to 70 feet per mile.

The structural relief (fold height), measured from the top of the Kellersburg anticline to the bottom of the Sligo syncline, is approximately 220 feet. The wavelength of the Sligo syncline is about 8 miles, measured between the axes of the flanking anticlines. However, the half wavelength between the Sligo syncline and Kellersburg anticline is about 4.5 to 6.5 miles, whereas it varies from about 1.5 to 3.5 miles between the Sligo syncline and the Clarion anticline.

There is little evidence of faulting in the Strattanville quadrangle. Chance (1880, p. 144) reported a fault in the Lower Kittanning coal near the town of Strattanville with an offset of up to 3 feet or so. From his description, the fault was a thrust fault. It is unclear, however, if the fault was the result of sedimentary slumping or tectonic activity. At any rate, except for Chance's observation, there are no other known occurrences of faulting that affected mining operations in the quadrangle.

The structural geology influences the overall drainage pattern in the report area. The major streams generally flow to the west in response to the prevailing westward dips of the rocks. Although there are exceptions, the principal tributary streams tend to flow from the north, reflecting the dominant south-to-southwest plunges of the folds (and similar directions of regional dip) both within Clarion County and throughout the Main Bituminous coal field.

STRATIGRAPHY

The coal measures in the report area include sedimentary rocks of the Middle Pennsylvanian Pottsville and Allegheny Formations (Figure 3). The lower Pottsville is mostly sandstone, whereas the upper Pottsville consists of interbedded shale, claystone, siltstone, sandstone, and several subordinate, lenticular coals. Only one coal, the Upper Mercer no. 2, has been mined to any extent (Figure 4). The Allegheny Formation comprises a cyclic sequence of shale, claystone, siltstone, sandstone, subordinate limestone, and several persistent coals. Up to seven Allegheny coals, the Lower Clarion through Lower Freeport, have been mined in the quadrangle (Figure 4).

DEPOSITIONAL SETTING

On a regional scale, Edmunds and others (1999), Edmunds and others (1979), and Williams (1960) have discussed the depositional environments and depositional controls of the rocks comprising the Pottsville and Allegheny Formations in Pennsylvania. In Clarion County, the lower Pottsville (Connoquenessing Sandstone) sediments were deposited as fluvial sands and finer grained clastics on an alluvial plain. Thereafter, marine conditions shifted eastward from the mid-continent into western Pennsylvania, resulting in a series of shallow-marine transgressions that largely controlled deposition of the upper Pottsville and lower Allegheny units (including the Mercer through Middle Kittanning coals). Depositional environments included delta-plain, marginal-marine, and shallow-marine clastics; coastal peat marshes and swamps; lagoons; and subordinate, shallow-marine carbonate banks. Several of the peat swamps were relatively persistent, including those representing the Lower Clarion, Upper Clarion, Lower Kittanning, and Middle Kittanning coals. Subsequently, marine conditions retreated into Ohio, and the upper Allegheny rocks were deposited as sediments on an alluvial plain that contained numerous fluvial channel systems; extensive, isolated peat swamps; and freshwater (carbonate) lakes.

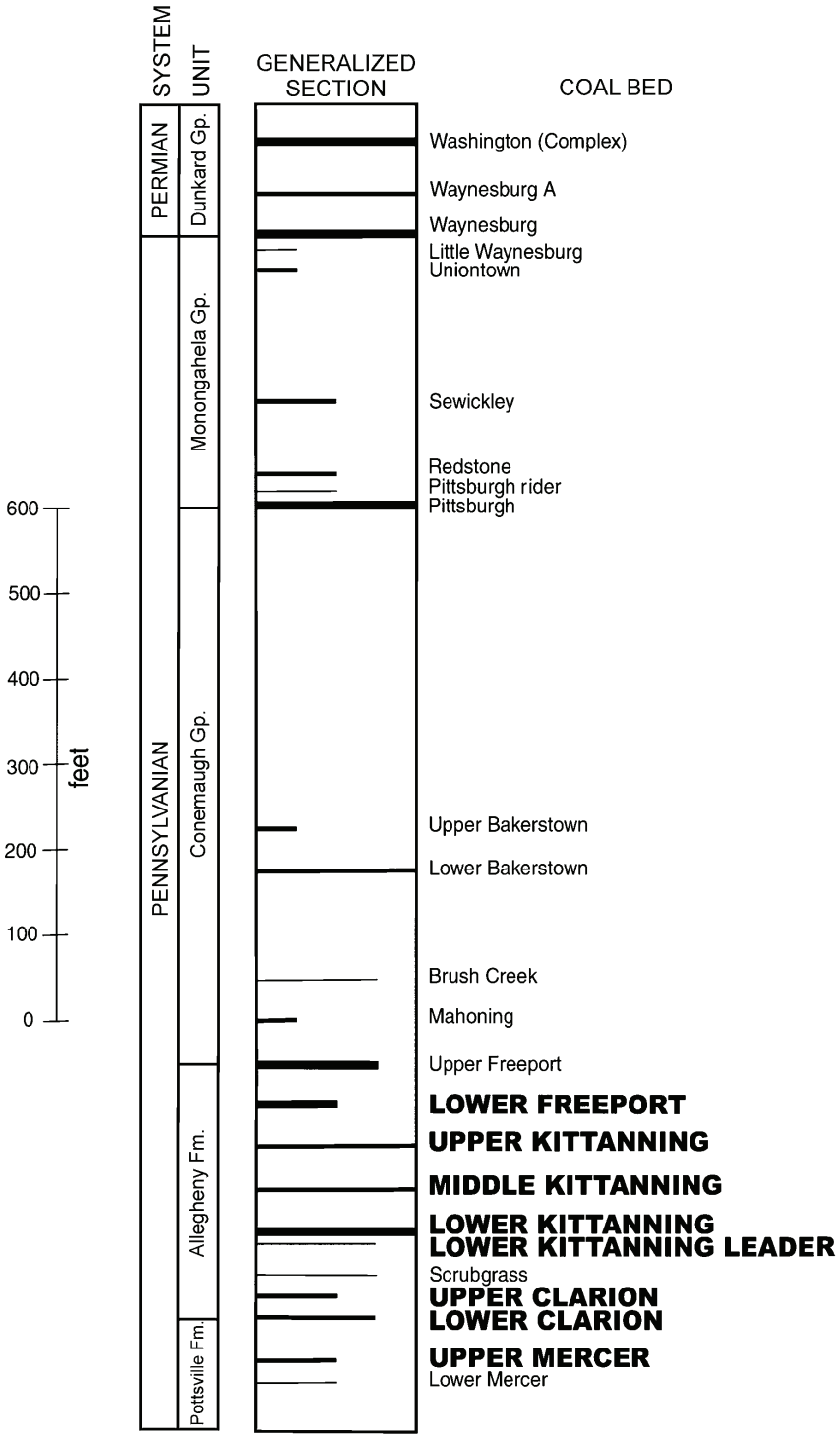


Figure 4. Generalized columnar section of coals of the Main Bituminous coal field of western Pennsylvania, highlighting investigated coals (bold, uppercase) of the Strattanville quadrangle. The coal measures of the report area are Pennsylvanian in age and subdivided into the Pottsville and Allegheny Formations.

During the Middle Pennsylvanian, the climate in Pennsylvania was tropical and transitional between ever-wet (earlier) and semiarid wet-dry seasonal (later) conditions (Cecil and others, 1985). Although both allocyclic and autocyclic controls operated during this time, it appears likely that the changes in lithologic character (composition and distribution) between the rocks of the upper Pottsville and lower Allegheny and those of the upper Allegheny were primarily in response to base-level drop (i.e., tectonic, epeirogenic, or eustatic effects) and climate change (i.e., increased seasonality of precipitation) (Dodge, 1992).

COAL DESCRIPTIONS

Dodge (this study) has identified eight coals in the Strattanville quadrangle that have been mined historically and were greater than 14 inches thick over appreciable areas within their outcrop belts prior to mining. In ascending stratigraphic order (oldest to youngest), the coals studied for availability are the Upper Mercer no. 2, Lower Clarion, Upper Clarion, Lower Kittanning leader, Lower Kittanning, Middle Kittanning, Upper Kittanning, and Lower Freeport (Figure 4). Only the Upper Mercer no. 2 coal is from the Pottsville Formation; the remainder are found in the Allegheny Formation. Thickness information on the eight coals is summarized in Tables 2 and 3.

Table 2. *Coal-Thickness Means, Ranges, and Standard Deviations by Coal Bed for Measurements Made in the Strattanville Quadrangle*[1]

[Measurements are in inches.]

Coal name	Mean	Minimum	Maximum	Standard deviation	Number of measurements
Lower Freeport	N.A.	33.0	33.0	N.A.	1
Upper Kittanning	16.8	9.0	24.0	7.4	4
Middle Kittanning	24.5	17.0	54.0	8.4	21
Lower Kittanning	28.4	14.0	48.0	8.4	45
Lower Kittanning leader	20.6	0	60.0	21.6	18
Upper Clarion	22.8	0	60.0	15.3	41
Lower Clarion	25.2	4.0	60.0	13.9	36
Upper Mercer no. 2	12.9	0	70.5	19.0	14

[1]Data used in statistical analysis from Lord and others (1913b), Skema and others (1975), Sponseller (1973), and unpublished records on file at the Pennsylvania Bureau of Topographic and Geologic Survey. N.A., not applicable.

Table 3. *Coal-Thickness Means, Ranges, and Standard Deviations by Coal Bed for all Measurements Used in the Strattanville Coal Availability Study to Determine Coal-Resource Estimates Based on Reliability Categories*[1,2]

[Measurements are in inches.]

Coal name	Mean	Minimum	Maximum	Standard deviation	Number of measurements
Lower Freeport	16.6	0	41.0	14.1	11
Upper Kittanning	18.3	0	94.8	20.2	25
Middle Kittanning	20.5	0	54.0	11.4	74
Lower Kittanning	27.1	8.0	48.0	8.0	134
Lower Kittanning leader	13.7	0	109.0	21.9	76
Upper Clarion	15.2	0	60.0	14.4	136
Lower Clarion	27.6	0	78.0	14.2	136
Upper Mercer no. 2	12.6	0	70.5	16.3	62

[1]Data used in statistical analysis from Lord and others (1913b), Skema and others (1975), Sponseller (1973), and unpublished records on file at the Pennsylvania Bureau of Topographic and Geologic Survey.
[2]Include point data up to 3 miles outside the Strattanville 7.5-minute quadrangle.

Other coals are present within the report area but do not meet the criteria for coal availability as previously described. Up to four Mercer coals representing two coal complexes occur within the Strattanville quadrangle. In ascending stratigraphic order, these are the Lower Mercer no. 1 and no. 2 and the Upper Mercer no. 1 and no. 2. Locally, one or more of these coals may split as well. Except for the Upper Mercer no. 2, the other Mercer coals are highly lenticular, thin, and commonly absent. The Lower Mercer no. 2 and Upper Mercer no. 1 are known to have each been mined in at least one location for domestic consumption. From drilling, one or two highly lenticular, thin, very local unnamed coals are known to occur below the Mercer coal complexes in the lower Pottsville.

Upper Mercer No. 2 Coal

In the report area, the Upper Mercer no. 2 coal has erroneously been called the Brookville coal by previous workers (e.g., Patterson and Van Lieu, 1972; Shaw and others, 1911). The Upper Mercer no. 2 is situated about 25 to 40 feet (averaging about 30 feet) below the Lower Clarion coal or about 115 to 130 feet (averaging about 120 feet) below the Lower Kittanning bed. It is absent throughout much of the middle section and south-central part of the quadrangle (Figure 5). It is unclear if the no-coal area was the result of nondeposition or subsequent erosion.

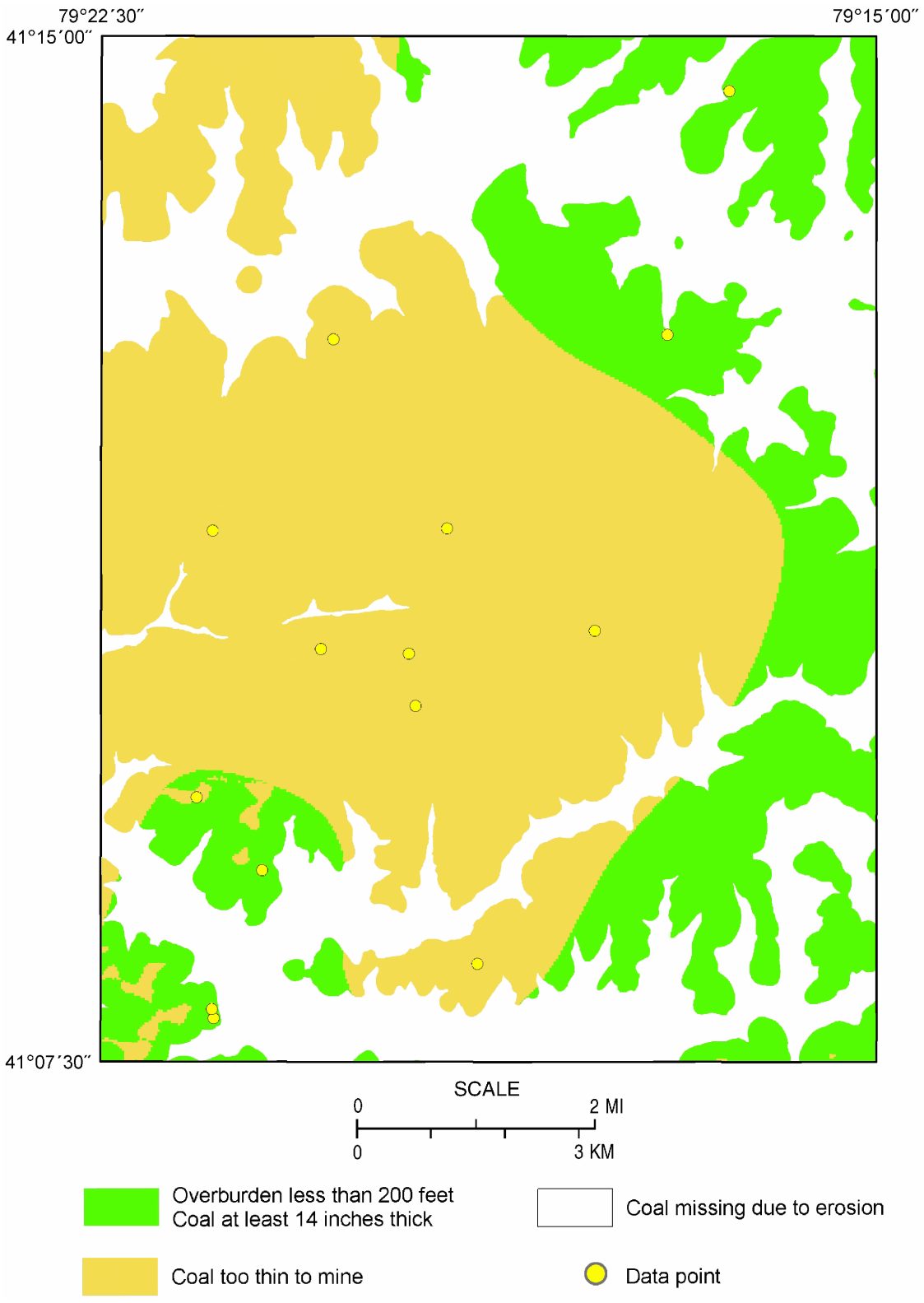


Figure 5. Outcrop extent, amount of overburden, coal thickness, and data-point locations for the Upper Mercer no. 2 coal.

Where present, the Upper Mercer no. 2 crops out throughout the quadrangle. The mean (average) thickness of the Upper Mercer no. 2 is 12.9±19.0 inches (mean±1 standard deviation) for measurements obtained in the quadrangle (Table 2) and 12.6±16.3 inches for all measurements used in the coal availability study (Table 3). Although the mean coal thickness is less than the 14-inch minimum normally required for resource consideration, the Upper Mercer no. 2 is locally up to 70.5 inches thick in the northeastern corner of the quadrangle (Table 2). Moreover, where present (non-zero thickness) in the quadrangle, the coal is commonly greater than 14 inches thick. The coal is locally bony in part but does not appear to have any relatively persistent partings, though some may occur in places. The Upper Mercer no. 2 coal has been underground mined to a limited extent (i.e., several country banks) in the past in the northeastern part of the quadrangle and has been surface mined on a small scale in both the northeastern and southeastern corners of the report area (Figure 6). There are no known maps showing the extent of underground mining, but such operations were undoubtedly small in output and area. Depth of cover ranges from 0 feet along its outcrop to over 300 feet along several ridges in the southwestern part of the quadrangle, just to the east of the Sligo synclinal axis. The maximum depth of cover is about 350 feet at a knob approximately a half mile due west of Mechanicsville.

In his investigation of the coal geology of Clarion County, Glover (1987) did not recognize this coal or map it in the Strattanville 7.5 quadrangle or elsewhere.

Lower Clarion Coal

The Lower Clarion coal in Clarion County is correlative with the Brookville coal of Rogers (1858), in accordance with the intended use of the name Brookville—that is, the coal marking the base of the "lower productive coal measures" (i.e., the Allegheny Formation) and occurring about 40 to 50 feet below the top of the "ferriferous" (Vanport) marine limestone. The Lower Clarion occurs about 5 to 30 feet (averaging about 20 feet) below the Upper Clarion bed, or approximately 90 to 100 feet below the Lower Kittanning coal. In terms of thickness, persistence, and minability, it is one of the most important coals in the quadrangle (Figure 7). However, it is too thin to mine in several scattered areas in the southern half of the quadrangle. The Lower Clarion crops out throughout the report area. The mean thickness of the coal is 25.2±13.9 inches for the quadrangle and 27.6±14.2 inches for the coal availability database. The mean for the quadrangle is the second highest value for any of the available coals (i.e., only

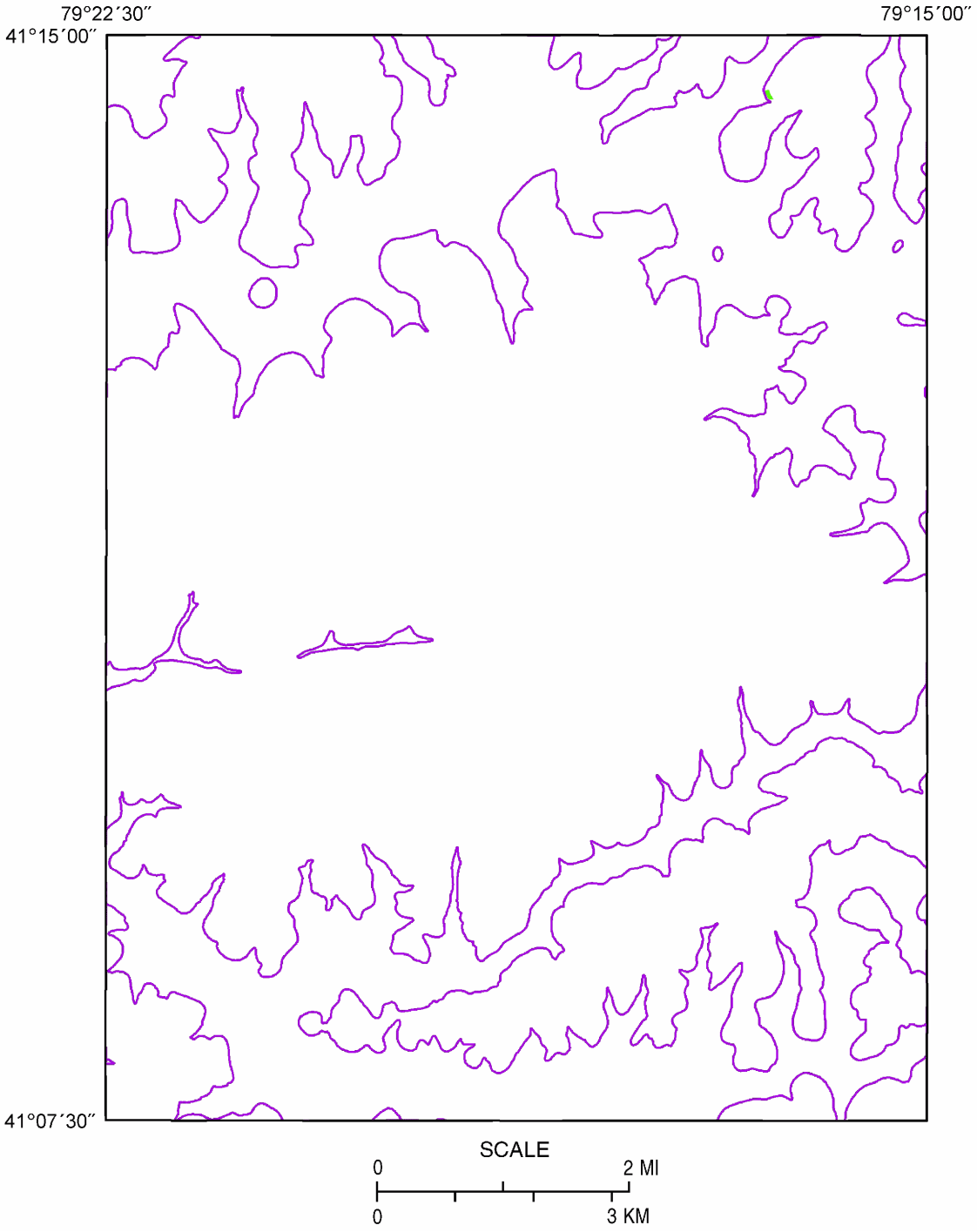


Figure 6. Upper Mercer no. 2 coal crop lines (purple) with surface-mined-out areas (green).

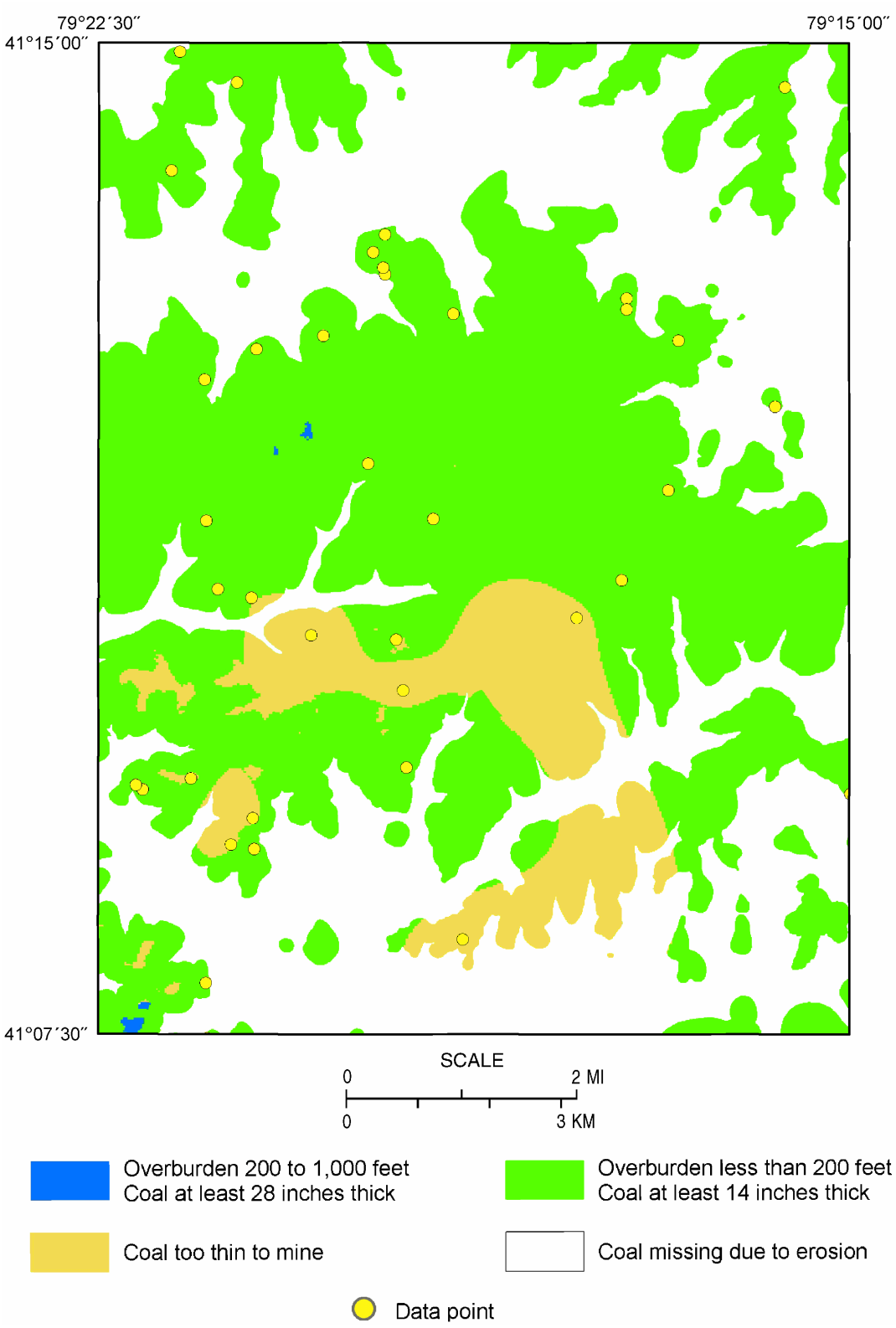


Figure 7. Outcrop extent, amount of overburden, coal thickness, and data-point locations for the Lower Clarion coal.

exceeded by the Lower Kittanning coal) and for the database is the highest. The coal varies in thickness from 4.0 to 60.0 inches in the quadrangle. The Lower Clarion locally contains up to two or three bony coal benches and partings. Historically, the coal has been both deep mined in a few small adits and surface mined extensively in the northern part of the quadrangle (Figure 8). Scattered surface mining has occurred in the southern part as well. No maps are available of the underground mine workings, but the contribution of underground operations to overall mining is considered insignificant. Depth of overburden ranges from 0 feet to as much as 300 feet or so in several isolated areas in the southwestern part of the quadrangle.

Upper Clarion Coal

The Upper Clarion coal is about 40 to 50 feet below the Lower Kittanning leader coal or about 60 to 90 feet (averaging 70 feet) below the Lower Kittanning coal. It is also one of the most important coals of the report area (Figure 9). However, it is too thin to mine over much of the southern third of the quadrangle. The Upper Clarion crops out throughout the quadrangle. The mean thickness of the Upper Clarion is 22.8±15.3 inches for the Strattanville quadrangle and 15.2±14.4 inches for the database used in the coal availability study. The coal thickness in the report area ranges from 0 to 60.0 inches. The Upper Clarion contains some bony coal benches and thin partings in places. The coal was rarely mined underground in the past. Such mining was limited to a few small country-bank operations. Although no known underground-mine maps exist, the contribution of deep mines to overall mining is negligible. The Upper Clarion coal has generally been mined with the Lower Clarion in surface operations because of their proximity and association (Figure 10). Depth of cover ranges from 0 feet to about 280 feet in a few places in the southwestern corner of the report area.

Glover (1987) greatly underestimated the occurrence and distribution of the Upper Clarion coal in the Strattanville quadrangle and mapped the coal in only a few places.

Lower Kittanning Leader Coal

The Lower Kittanning leader coal (stratigraphically equivalent to the Lower Kittanning no. 1 coal of Clearfield County (Edmunds, 1968)) is situated about 15 to 35 feet (averages about 30 feet) below the Lower Kittanning coal. The leader coal is absent in the northern third of the quadrangle and much of the southern third as well (Figure 11). It is present over most of the middle third, though it is too thin to mine in places. The coal also occurs in much of the

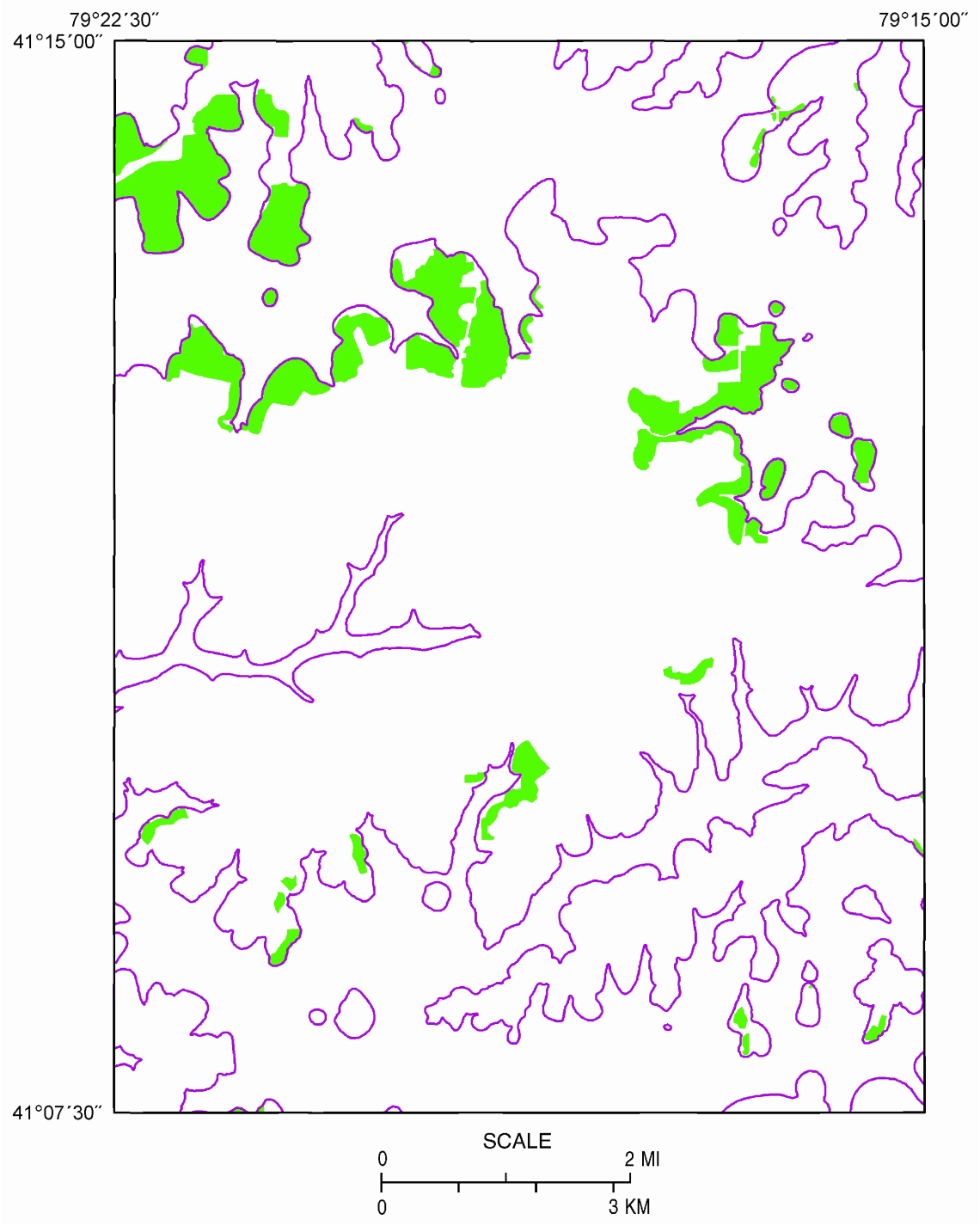


Figure 8. Lower Clarion coal crop lines (purple) with surface-mined-out areas (green).

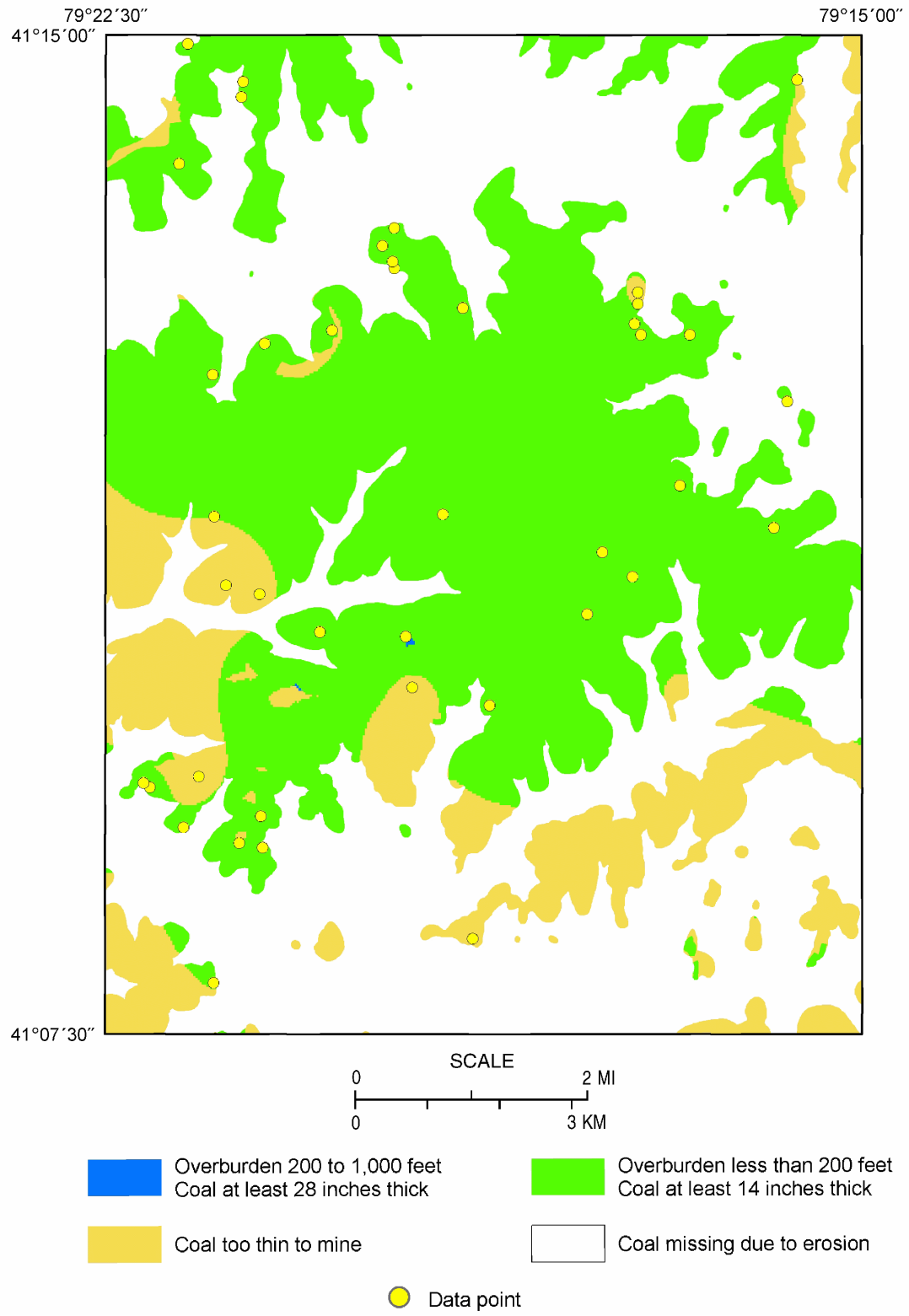


Figure 9. Outcrop extent, amount of overburden, coal thickness, and data-point locations for the Upper Clarion coal.

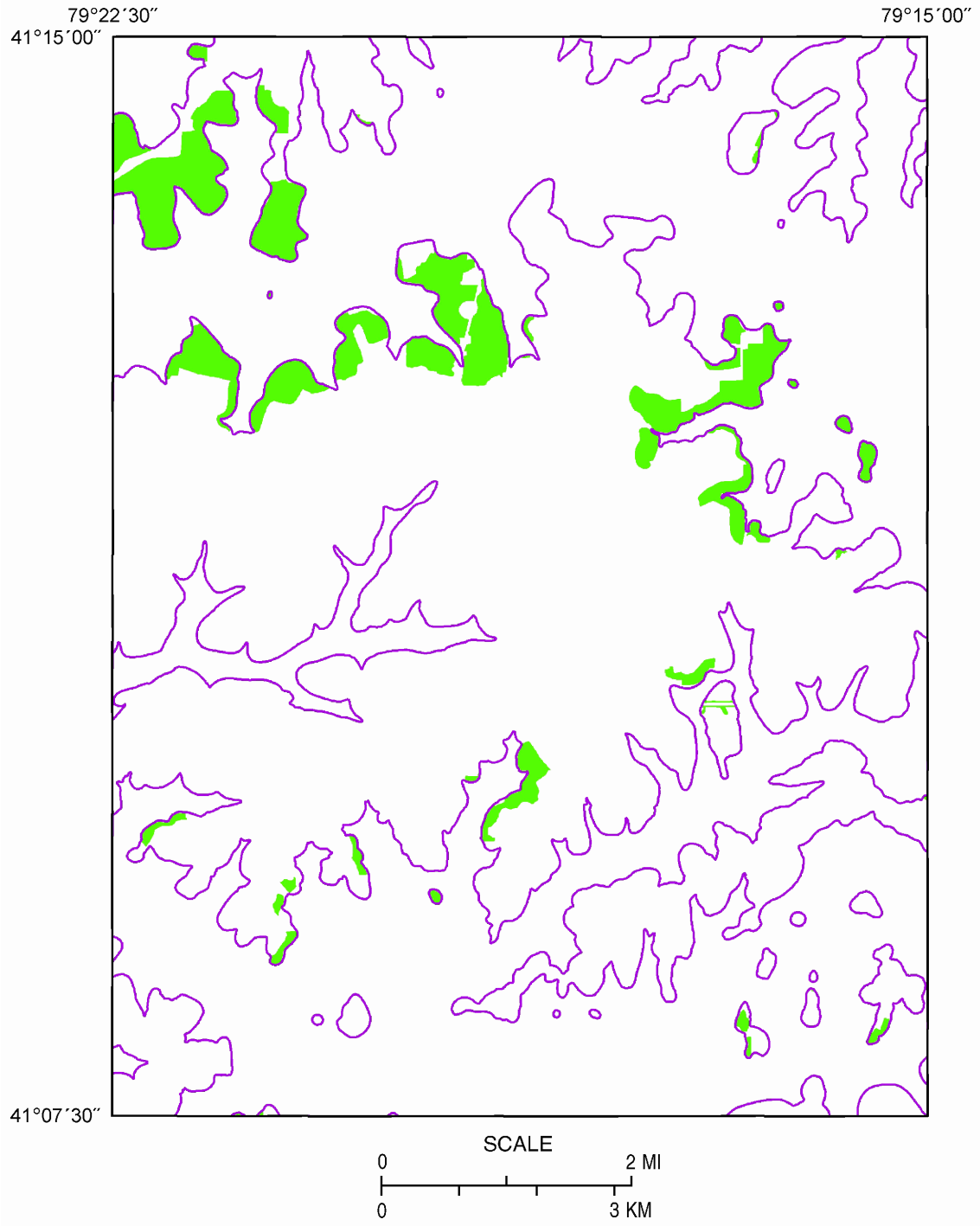


Figure 10. Upper Clarion coal crop lines (purple) with surface-mined-out areas (green).

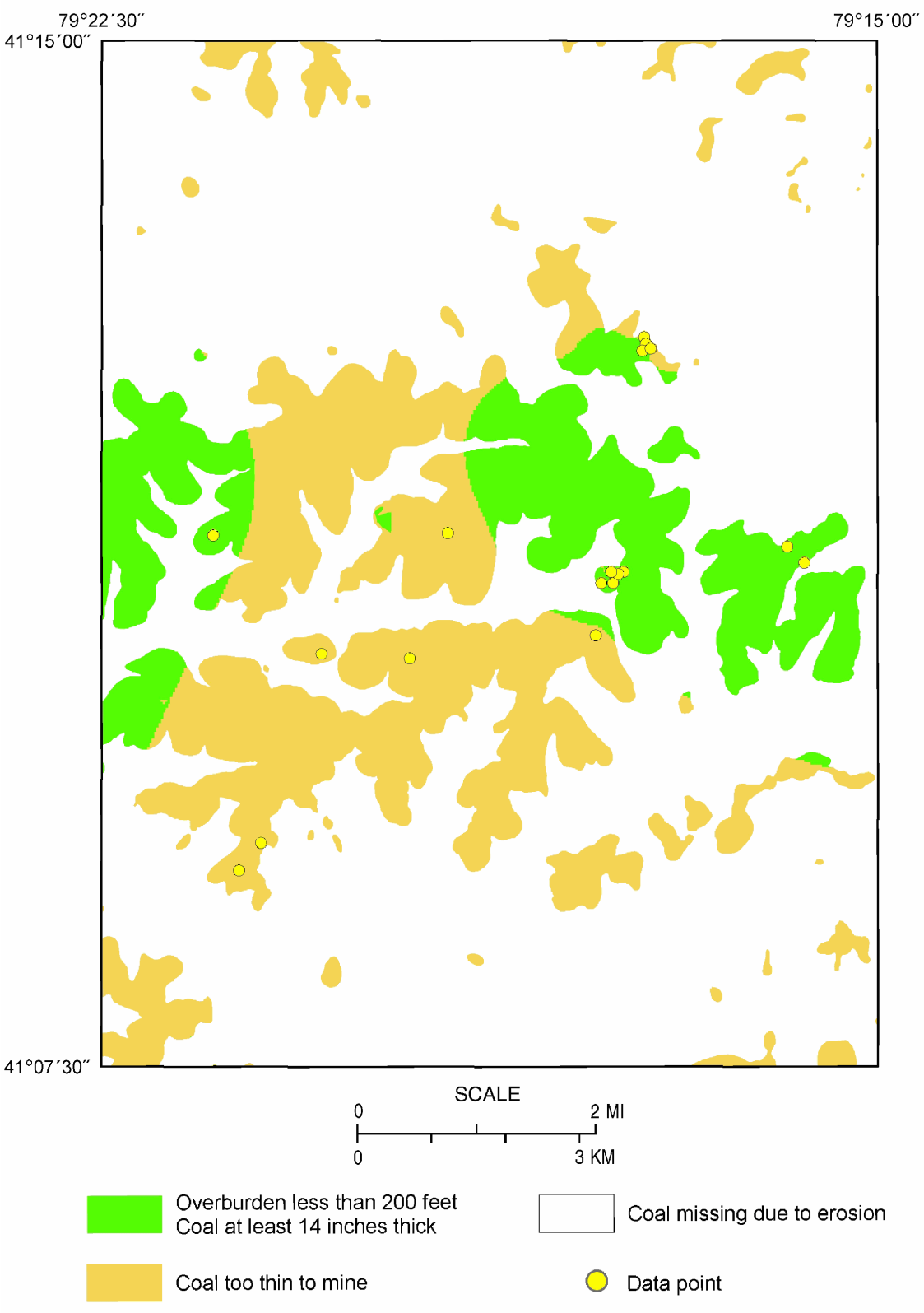


Figure 11. Outcrop extent, amount of overburden, coal thickness, and data-point locations for the Lower Kittanning leader coal.

southwestern portion of the report area but is also generally too thin to mine. Although more research needs to be done, the apparent local thinning or splitting of the coal toward a no-coal area suggests that the absence of the Lower Kittanning leader is primarily the result of nondeposition. The coal may have been deposited as peat in the interfluvial area between two distributary channels. Where present, the coal crops out throughout the quadrangle. The mean thickness of the Lower Kittanning leader is 20.6±21.6 inches for the Strattanville quadrangle and 13.7±21.9 inches for the coal availability database. The leader coal varies in thickness from 0 to 60.0 inches in the report area. The coal is lenticular where present and thick enough for resource consideration primarily in the middle third of the quadrangle.

About a half mile north of Waterson, where the leader coal is thickest for resource purposes, the coal occurs as two splits separated by 10 to 12 feet of rootworked claystone and subordinate shale. The upper coal split is the thicker of the two, ranging from around 28 to 44 inches. The lower split varies from about 12 to 18 inches. Both splits are mined together. Accordingly, wherever the splits occur, their thicknesses are combined to create a single value for each point used in this study for resource estimates. This practice differs from the procedure of Wood and others (1983, p. 36–37) in which each split (tongue) is treated as a separate coal bed. Because the areal extent of the split coals is small relative to the total area of the Lower Kittanning leader coal in the quadrangle, the need to handle the splits separately is unwarranted.

The leader coal is bony in part locally, but no persistent partings are known. The coal has been surface mined in several places, generally in conjunction with the mining of the overlying Lower Kittanning coal (Figure 12). No known underground mining of this coal has occurred. Overburden depth ranges from 0 feet to about 240 feet in the southwestern corner of the quadrangle but only up to about 180 feet where it is thick enough to be surface mined, approximately three quarters of a mile east of Stone House.

In the Strattanville quadrangle and adjacent areas, the Lower Kittanning leader coal was first recognized and mapped by Dodge (this study). Glover (1987) misidentified the leader coal, generally calling it either the Lower Kittanning coal or Upper Clarion coal. Lines (1907) and Shaw and others (1911) did note that a coal occurred about 4 to 30 feet below the main Lower Kittanning bed in the northern part of the Clarion 15-minute quadrangle (i.e., including the Strattanville 7.5-minute quadrangle) and “about midway between the Upper Clarion and the Lower Kittanning” (Shaw and others, 1911, p. 7) in the northeastern corner of the Foxburg 15-

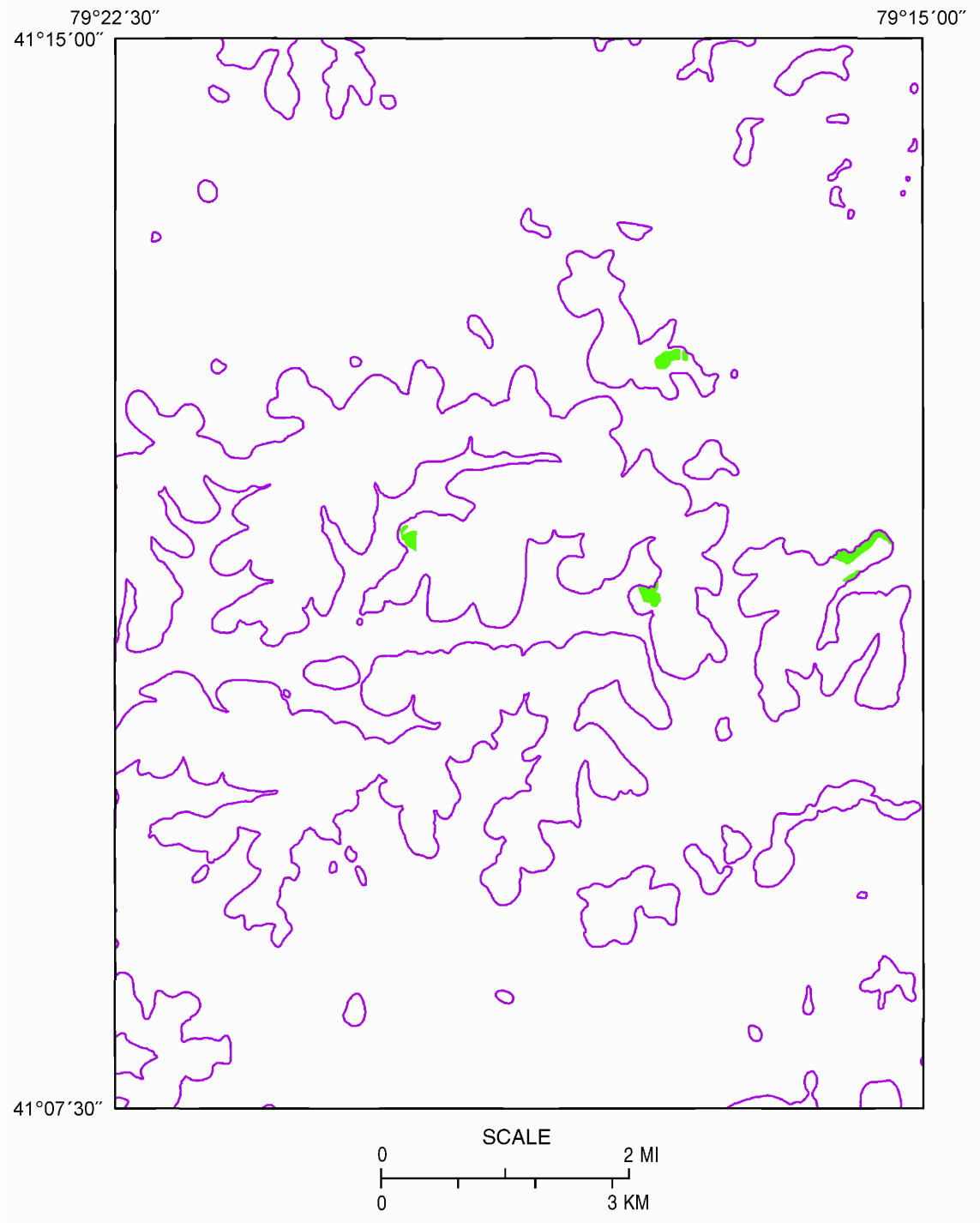


Figure 12. Lower Kittanning leader coal crop lines (purple) with surface-mined-out areas (green).

minute quadrangle farther to the west. However, though expressing some uncertainty, these workers suggested that the lower coal was a split of the main Lower Kittanning bed, which is unlikely the case for the most part. Dodge (this study), though, recognized that the Lower Kittanning leader coal splits in places, particularly in the Clarion 7.5-minute quadrangle to the south of the Clarion River. There is little evidence that the Lower Kittanning coal itself splits in the vicinity of the Strattanville quadrangle and none within the quadrangle itself. It is known to split locally at only one place—just inside Jefferson County to the east of Runaway Run in the southwestern part of the Corsica 7.5-minute quadrangle.

Lower Kittanning Coal

The Lower Kittanning coal (stratigraphically equivalent to the Lower Kittanning no. 3 coal of Clearfield County (Edmunds, 1968)) has historically been the most important bed mined in the quadrangle, based on its relative thickness, continuity, overall quality, and ease of mining (Figure 13). The coal is readily identifiable and well constrained stratigraphically through the use of adjacent marine zones as "key beds" for correlation. The Lower Kittanning is immediately overlain by the Columbiana marine shale. Where present, the distinctive Vanport marine limestone occurs about 35 to 50 feet below the coal. The coal crops out throughout the quadrangle. The outcrop area of the Lower Kittanning is mostly to the south of the Clarion River and Mill Creek. Small outliers occur to the north of these streams. The widespread occurrence and economic importance of the Lower Kittanning made it the best datum for structure contouring when mapping the geology of the Strattanville quadrangle. The mean thickness of the coal is 28.4±8.4 inches for the quadrangle and 27.1±8.0 inches for the coal availability database. The mean for the quadrangle is the highest value for any of the available coals and for the database is the second highest (i.e., only exceeded by the Lower Clarion coal). The Lower Kittanning ranges in thickness in the report area from 14.0 to 48.0 inches. The bed commonly contains one or two thin bony coal partings or benches that are not persistent. The coal was extensively deep mined for commercial purposes during the late nineteenth and early twentieth centuries (Figure 14). The major underground operations were concentrated near Strattanville and southward to Waterson and Mechanicsville. Small country-bank mines were present as well throughout the quadrangle. Significant surface mining commenced at the end of World War II and has since occurred throughout the middle third and parts of the southern third of the report area. Scattered surface mines operated elsewhere as well. Depth of cover ranges from 0 feet to

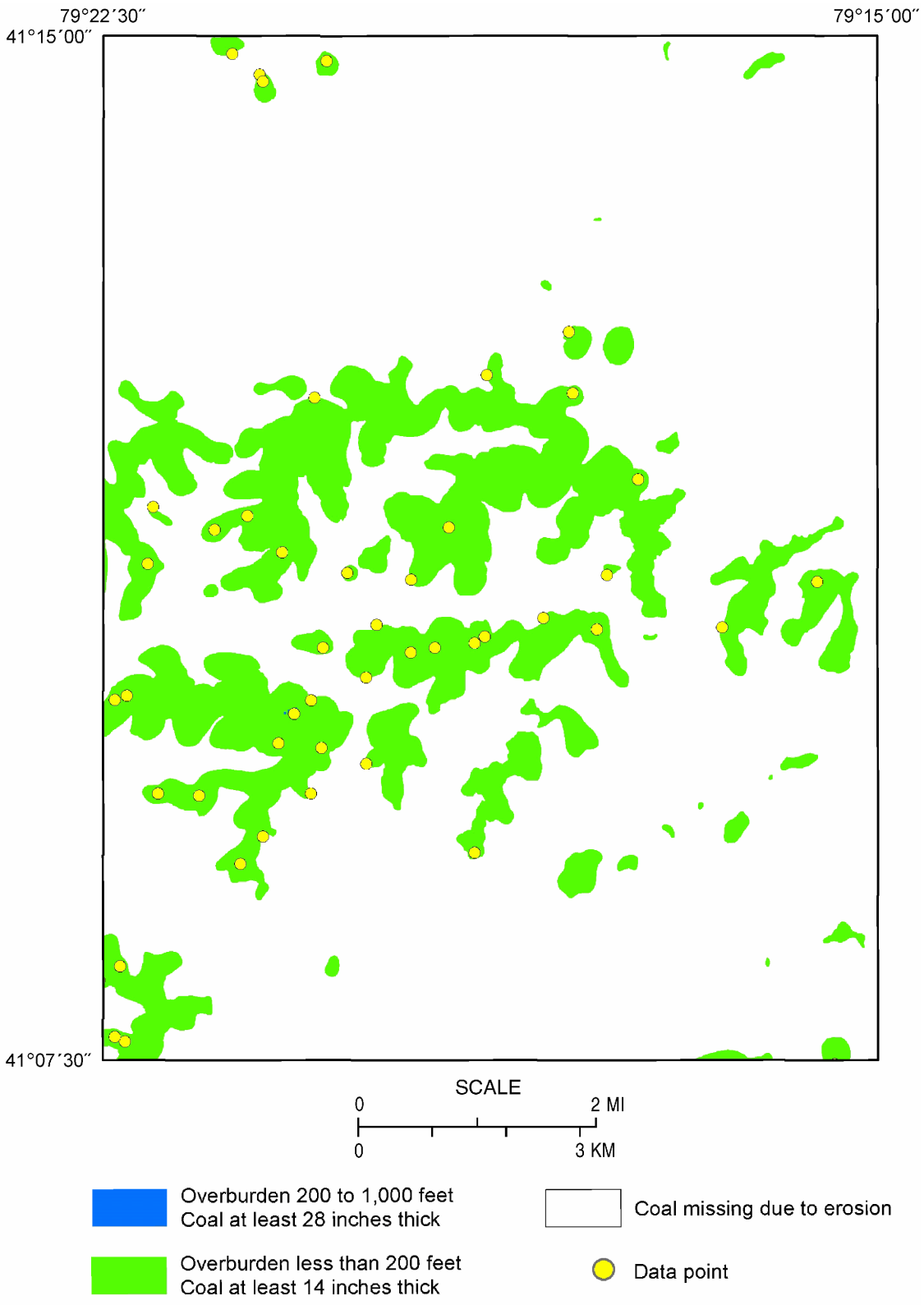


Figure 13. Outcrop extent, amount of overburden, coal thickness, and data-point locations for the Lower Kittanning coal.

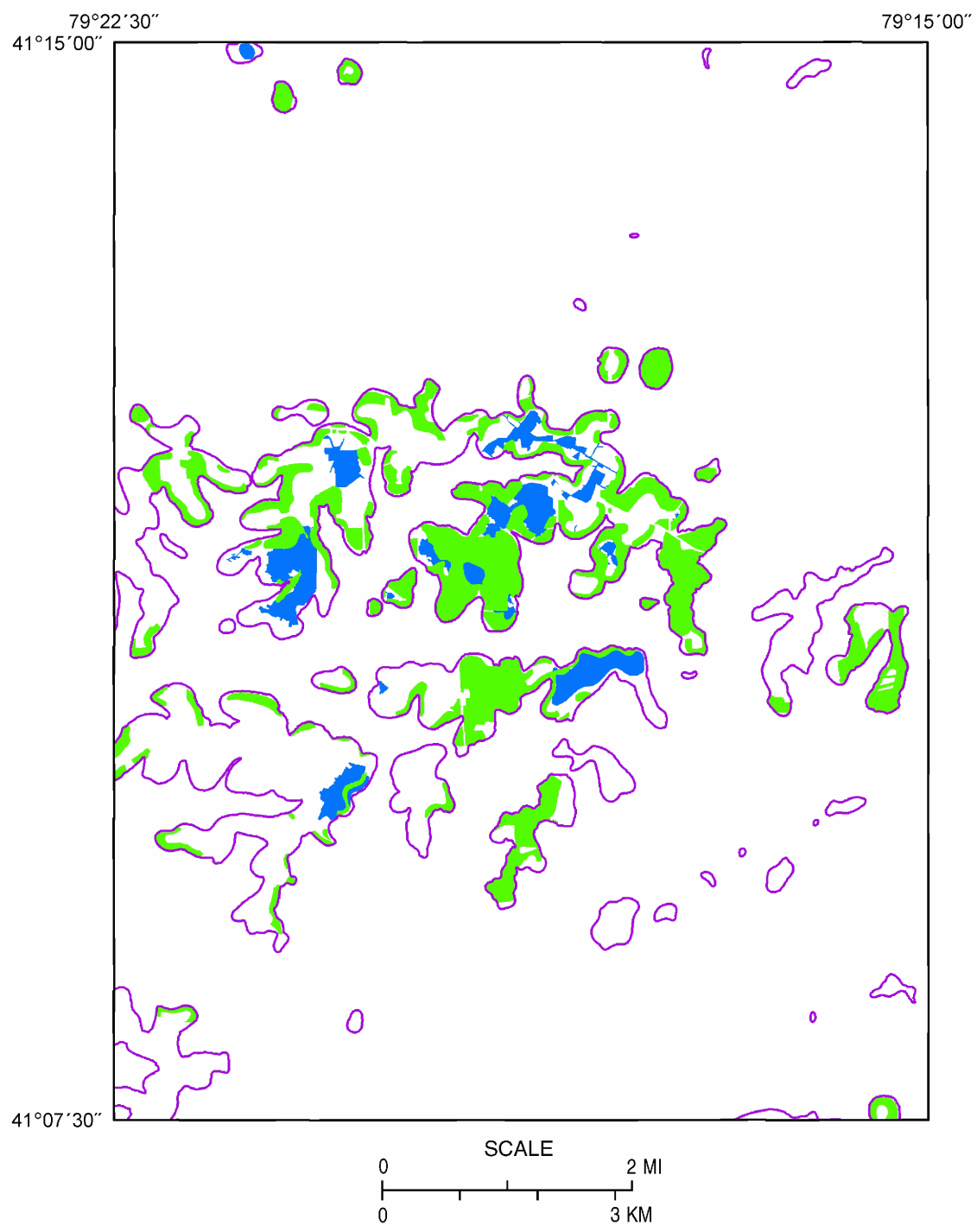


Figure 14. Lower Kittanning coal crop lines (purple) with surface-mined-out (green) and underground-mined-out (blue) areas.

over 200 feet at several isolated spots in the southwestern part of the quadrangle. The maximum depth of cover is about 230 feet at a point approximately a half mile due west of Mechanicsville.

Middle Kittanning Coal

The Middle Kittanning coal is situated about 55 to 70 feet (averages about 60 feet) above the Lower Kittanning bed. Rarely, the interval opens up to almost 90 feet—just to the west of Mechanicsville, where the interburden consists mostly of sandstone and the Middle Kittanning splits. The coal crops out throughout the quadrangle, but the main outcrop area is south of Strattanville and U. S. Route 322 (Figure 15). The mean coal thickness is 24.5±8.4 inches for the quadrangle and 20.5±11.4 inches for the database used in the coal availability study. The Middle Kittanning coal varies in thickness from 17.0 to 54.0 inches in the report area.

The coal is thickest for resource purposes where it splits locally in the southwestern part of the quadrangle, principally in an area to the south of Interstate 80, west of Mechanicsville, and north of Piney Creek. Data are insufficient to discern any general thickness trends for the coal splits. However, just to the west of Mechanicsville, the upper split predominates, ranging in thickness from about 24 to 36 inches. The lower split here varies from about 12 to 18 inches. Both farther west and just north of Piney Creek, the lower split is thicker and varies from about 12 to 20 inches, whereas the upper split ranges in thickness from about 8 to 9 inches. The interburden thickness between the two splits ranges from a thin parting up to about 15 feet. Because the two coal splits are mined together, their thicknesses are combined for resource estimates, following the same procedure described in the previous section for the Lower Kittanning leader coal.

The Middle Kittanning coal contains a few thin, discontinuous bony-coal layers or partings locally. The coal has been surface mined extensively in the middle third and southwestern part of the quadrangle (Figure 16). A few country-bank mines presumably operated in the past as well. Depth of overburden varies from 0 feet to over 100 feet in the southwestern part of the report area. Maximum cover is about 150 feet at two isolated knobs.

Upper Kittanning Coal

The Upper Kittanning coal occurs about 60 to 70 feet above the Middle Kittanning bed, or about 125 to 150 feet (averages about 130 feet) above the Lower Kittanning coal. The

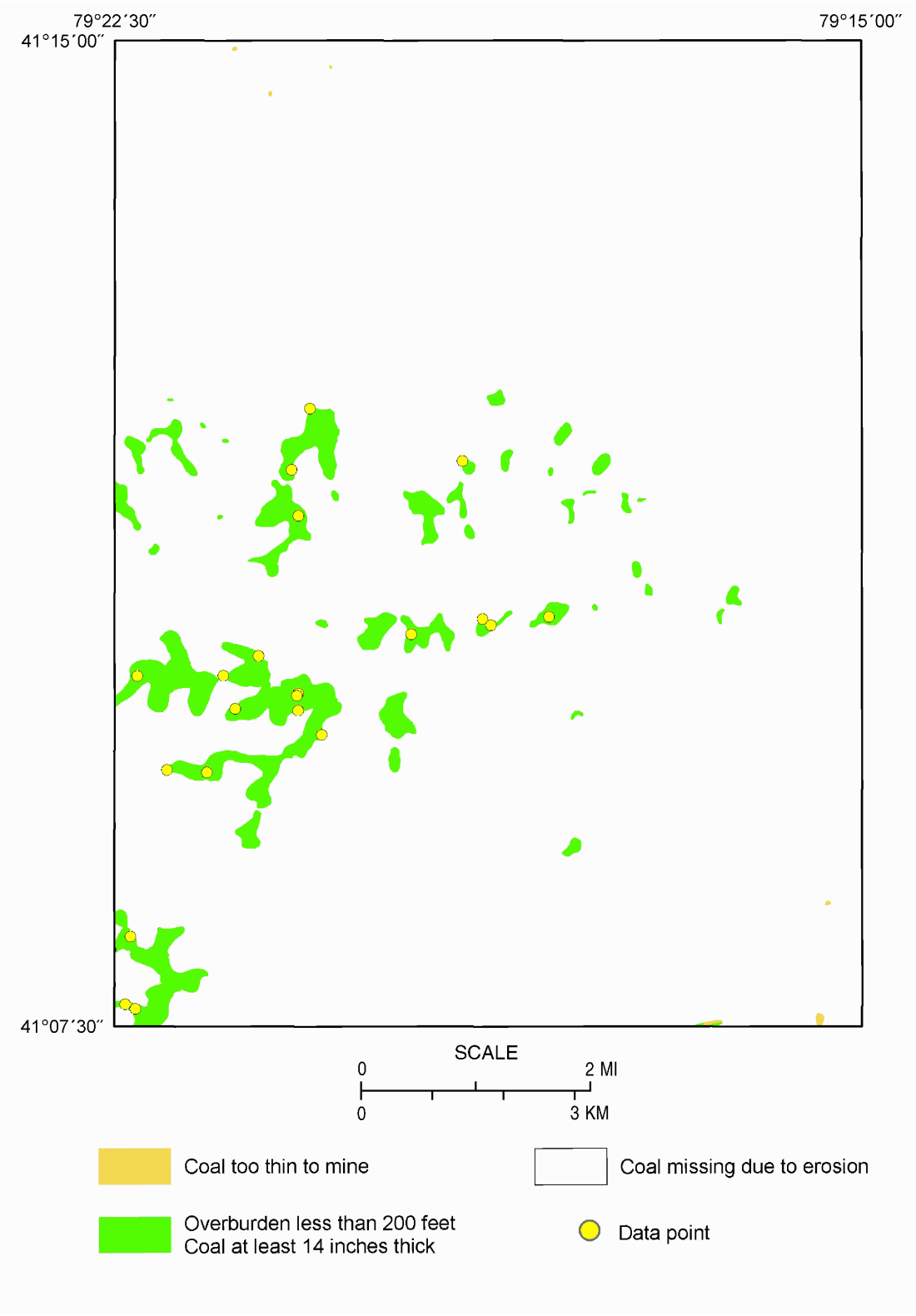


Figure 15. Outcrop extent, amount of overburden, coal thickness, and data-point locations for the Middle Kittanning coal.

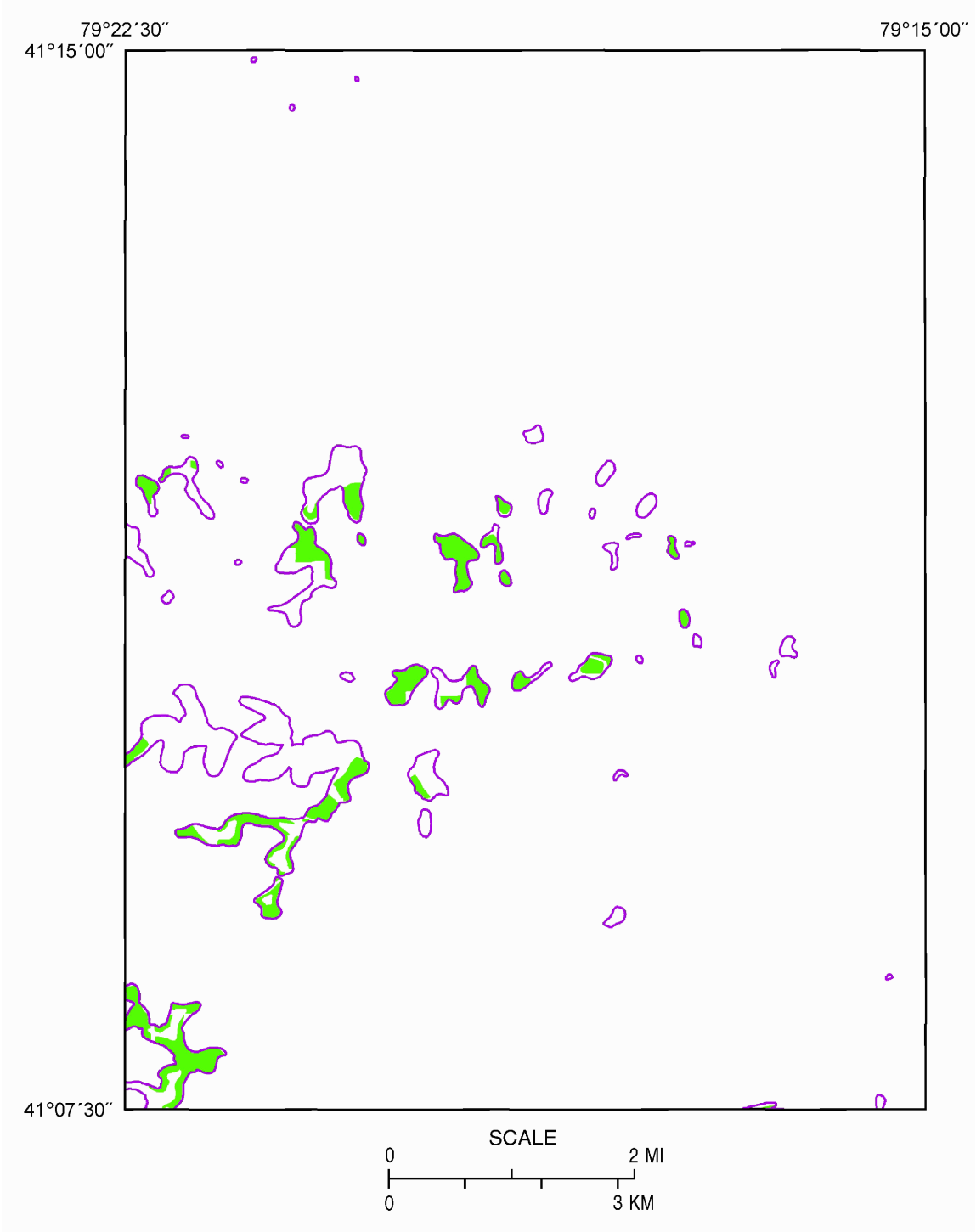


Figure 16. Middle Kittanning coal crop lines (purple) with surface-mined-out areas (green).

Upper Kittanning is confined to the southwestern part of the report area, where it crops out along the higher ridges (Figure 17). Most of the coal is present to the south of Interstate 80 and west of U. S. Route 66. The mean coal thickness is 16.8±7.4 inches for the quadrangle and 18.3±20.2 inches for the coal availability database. The Upper Kittanning coal ranges in thickness in the quadrangle from 9.0 to 24.0 inches. The bed appears to be relatively clean and free of partings. The coal was deep mined in the past in at least two country-bank operations. It has been strip mined in several places as well (Figure 18). No maps are available of the underground mine workings, but their contribution to overall mining is considered insignificant. Depth of cover ranges from 0 feet to about 70 or 80 feet in several places.

Lower Freeport Coal

The Lower Freeport coal is situated about 45 to 60 feet above the Upper Kittanning coal, or about 190 to 200 feet above the Lower Kittanning bed. The Lower Freeport is restricted to three small areas near ridge summits in the southwestern part of the quadrangle (Figure 19). The largest area is about a half mile due west of Mechanicsville. The other two locations are south of Piney Creek. From limited data, the reported coal thickness is 33.0 inches for the quadrangle (one measurement), and the mean thickness is 16.6±14.1 inches for the database used in the coal availability study. The Lower Freeport is believed to be clean and free of partings. A country-bank mine appears to have operated on the coal about a half mile west of Sloan Run and Piney Creek in the early 1900s, but no mine map is known to exist. Surface mining subsequently removed nearly all of the coal in the quadrangle (Figure 20). Overburden depth varies from 0 feet to about 30 feet.

COAL RESOURCES

Following standard convention, coal-resource estimates for the Strattanville CA Study are reported in short tons, or tons of 2,000 pounds. Resources are first calculated as volumes (area multiplied by thickness) and are then converted to tonnages using the density factor for bituminous coal of 1,800 short tons per acre-foot (based on an assumed specific gravity of 1.32). (See Wood and others, 1983.)

Resource estimates for the eight Strattanville coals investigated are summarized in Appendices A and B. The resource categories used in the estimates include original, mined out,

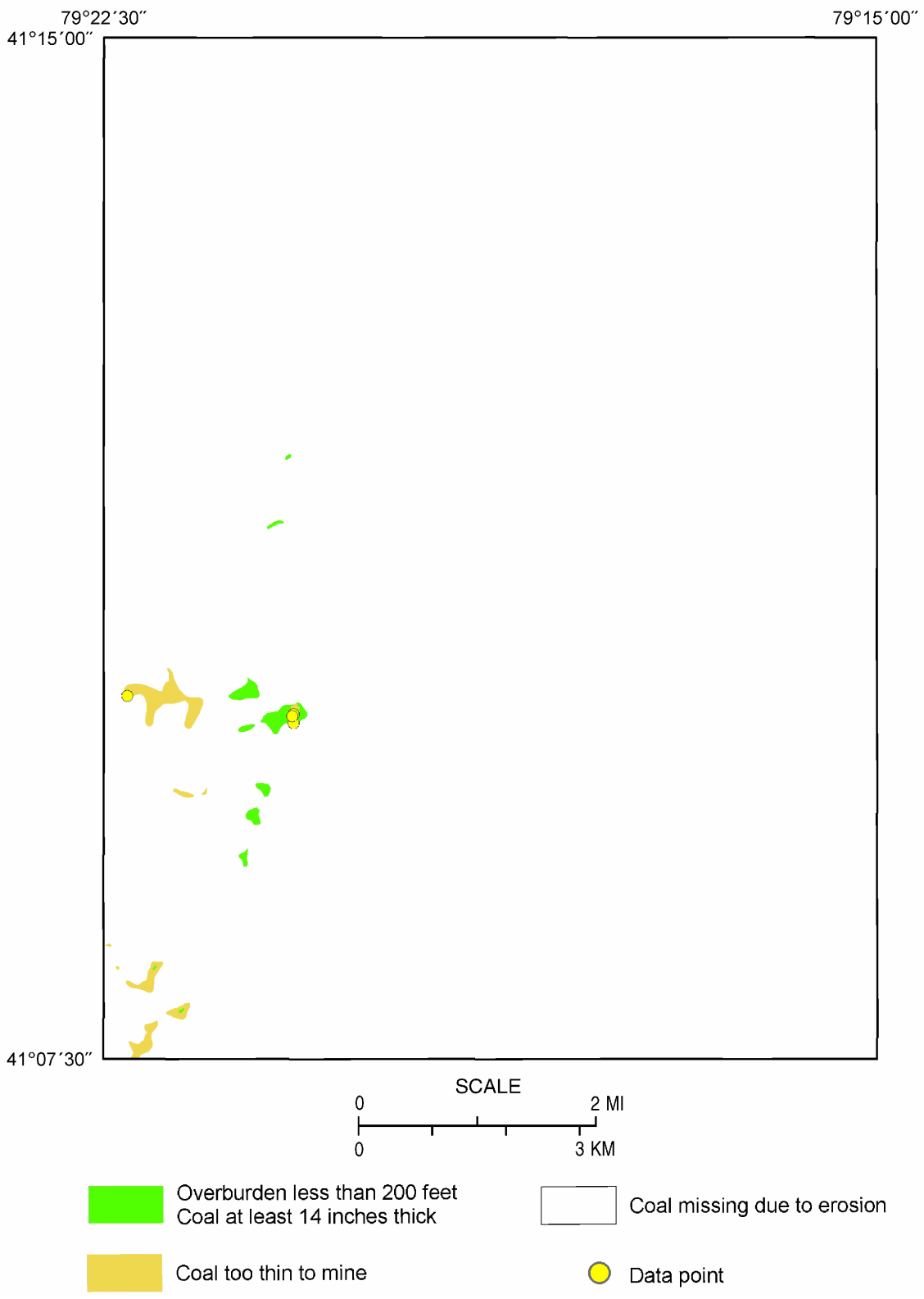


Figure 17. Outcrop extent, amount of overburden, coal thickness, and data-point locations for the Upper Kittanning coal.

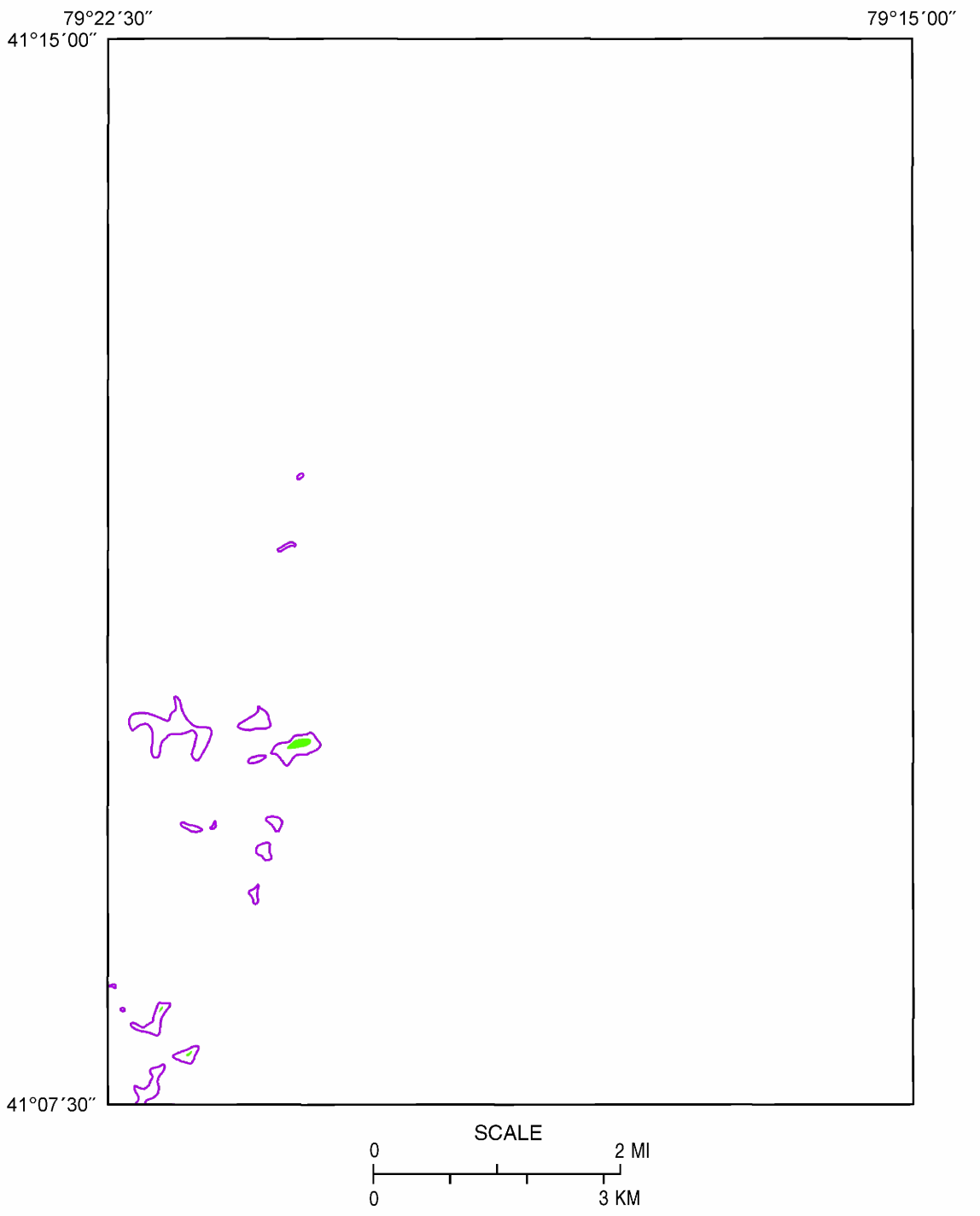


Figure 18. Upper Kittanning coal crop lines (purple) with surface-mined-out areas (green).

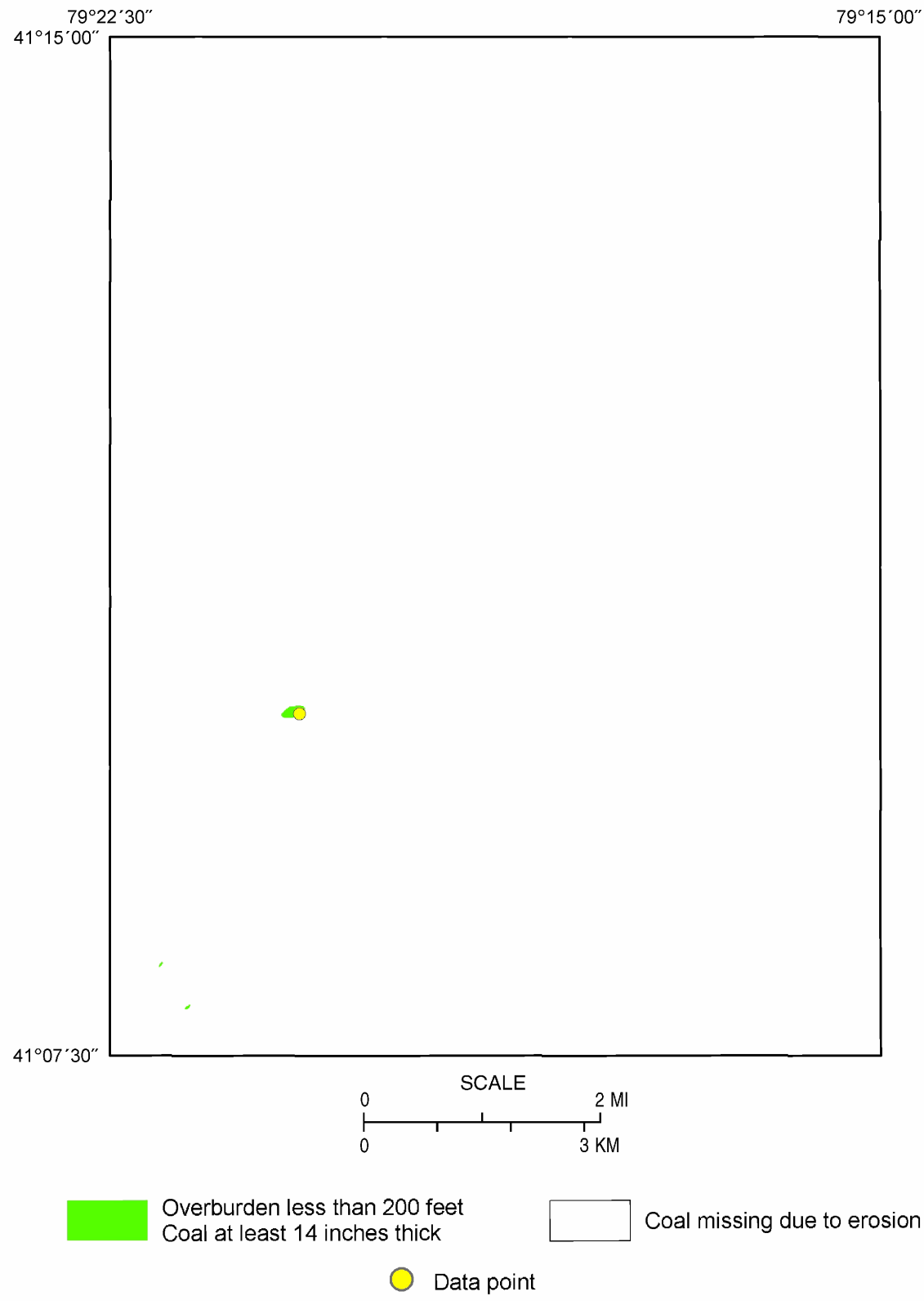


Figure 19. Outcrop extent, amount of overburden, coal thickness, and data-point locations for the Lower Freeport coal.

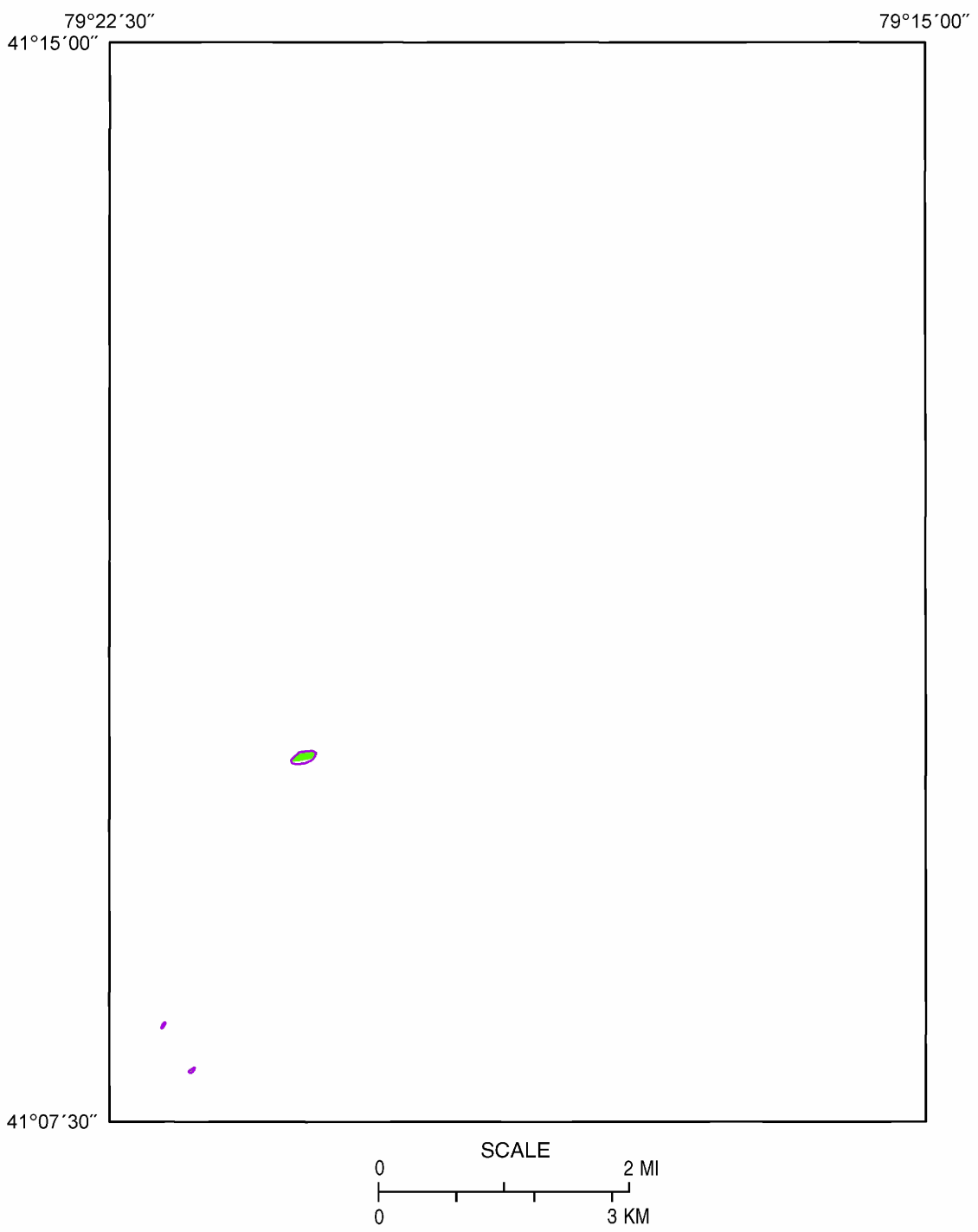


Figure 20. Lower Freeport coal crop lines (purple) with surface-mined-out areas (green).

remaining, restricted (both land use and technologic), and available. Appendix A contains both detailed summary information on the coal resources unavailable due to land-use and technologic restrictions (Table A–1) and comprehensive information on the several coal-resource categories as subdivided by overburden-thickness categories (Table A–2). Appendix B contains three tables for each coal. The first table includes information on the coal-resource categories as subdivided by categories of overburden thickness, reliability of estimate, and coal thickness. The second and third tables summarize the various resource restrictions by land use and technology, respectively, for the same three categories of overburden thickness, reliability of estimate, and coal thickness.

Coal-resource reliability categories consist of measured, indicated, inferred, and hypothetical. Reliability categories are defined as follows: measured, accessed and virgin coal that lies within a radius of 1/4 mile of a point of thickness of coal measurement (the highest degree of geologic assurance); indicated, virgin coal that lies between 1/4 mile and 3/4 mile from a point of thickness of coal measurement (a moderate degree of geologic assurance); inferred, virgin coal that lies between 3/4 mile and 3 miles from a point of thickness of coal measurement (a low degree of geologic assurance); and hypothetical, virgin coal that lies beyond a radius of 3 miles from a point of thickness of coal measurement (a very low degree of geologic assurance). (In the Strattanville study, none of the coal resources fall within the hypothetical category.) Demonstrated resources are defined as the sum of the measured and indicated categories. Identified resources include the sum of the demonstrated, measured, indicated, and inferred categories. (See Wood and others, 1983.)

The total original resources for the Strattanville quadrangle are estimated at about 195 million short tons (Figure 21, Table A–2). Total demonstrated original resources are over 141 million short tons, or more than 72 percent of the total original resources (Appendix B). The estimated original coal resources for each of the eight beds studied are summarized in Figure 22 and Table A–2. The combined total original resources of the Lower Clarion and Upper Clarion coals, which are generally mined together, are nearly 123 million short tons, or 63 percent of the total original resources of the quadrangle.

Of the total original coal resources, approximately 29 million short tons, or about 15 percent of the total, has been mined out or lost in mining (Figure 21, Table A–2). Ninety-two percent of the mined coal was from surface operations.

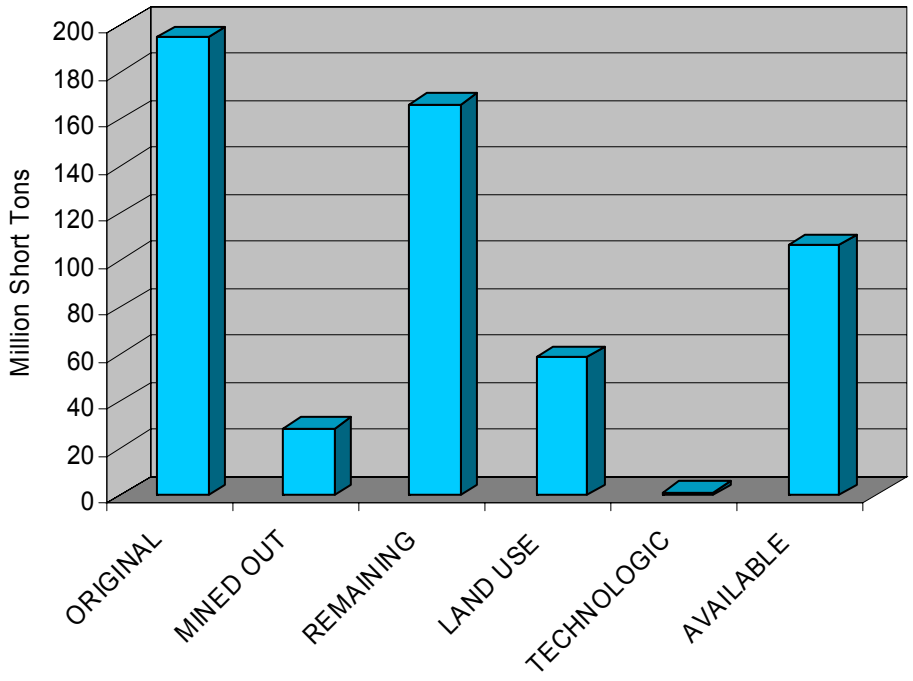


Figure 21. Cumulative tonnages for all coal-resource categories in the Strattanville quadrangle.

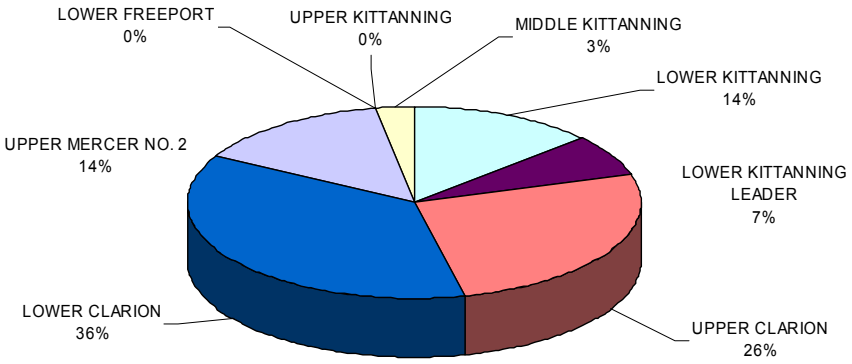


Figure 22. Summary of total original coal resources by coal bed for the Strattanville quadrangle.

The estimated total remaining resources are over 166 million short tons (Figure 21, Table A–2), representing more than 85 percent of the total original resources. Total demonstrated remaining resources are more than 114 million short tons, or nearly 69 percent of the total remaining resources and almost 59 percent of the total original resources (Appendix B).

Restrictions to mining were identified for the Strattanville quadrangle and are summarized in Table 1. Of these, 13 pertain to land-use restrictions and three to technologic constraints. (Where identified restrictions overlap for the same area, the resultant resource estimate is only counted once, and the value is apportioned equally among the identified categories.) Reference to these and other restrictions are made in several figures in this section and in several tables in Appendices A and B. The restrictions not pertinent to the Strattanville Study are included for completeness and represent other criteria that need to be considered for any Pennsylvania CA study. Land-use restrictions affect all of the coals subject to surface mining, and their areal distributions throughout the quadrangle are presented on the map in Figure 23. The most significant land-use restrictions for Strattanville include private buildings (houses), public lands (Pennsylvania State Game Lands), roads, and towns. Estimated coal resources that are unavailable due to land-use and technologic restrictions are summarized in Table A–1. Almost 59 million short tons of coal is eliminated because of land-use restrictions and an additional 1.2 million short tons owing to technologic restrictions (Figure 21, Table A–1). Therefore, mining restrictions exclude 60 million short tons, or about 31 percent of the total original resources.

Consequently, there is about 106 million short tons of coal available for future mining, representing nearly 64 percent of the total remaining resources and about 55 percent of the total original resources of the quadrangle (Figure 21, Table A–2). Of the available coal, approximately 74 million short tons, or over 69 percent, is demonstrated resources, representing nearly 38 percent of the total original resources (Appendix B).

UPPER MERCER NO. 2 COAL

The estimated original resources of the Upper Mercer no. 2 coal are over 27 million short tons, or about 14 percent of the total original coal resources of the quadrangle (Figures 22 and 24, Table B–1). About 35 percent of the original resources is greater than 28 inches thick. All of

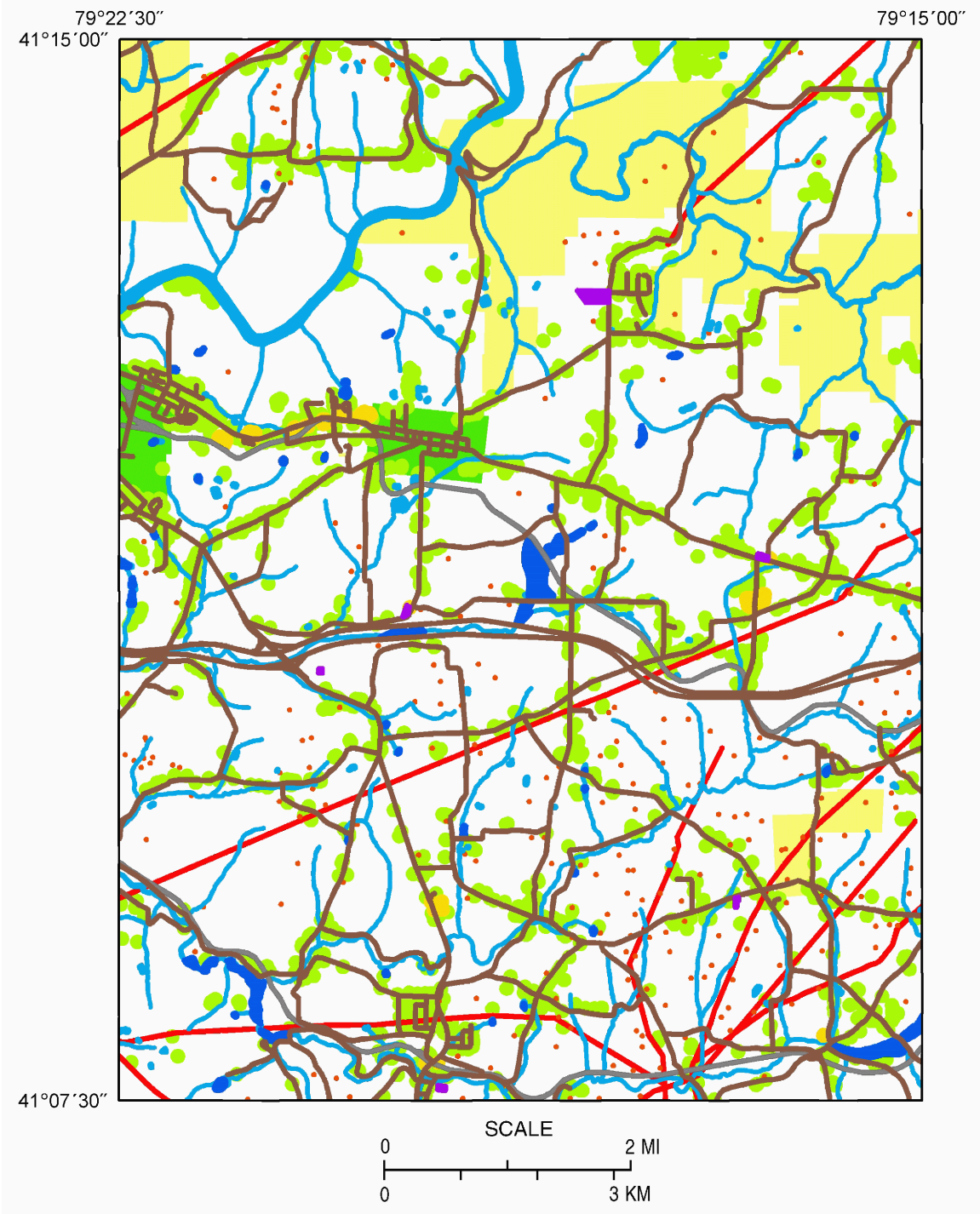


Figure 23. Spatial arrangement of all land-use restrictions for the Strattanville quadrangle Restrictions include roads (brown), railroads (gray), power lines and pipelines (red), bodies of water (blue), wetlands (dark blue), oil and gas wells (orange dots), towns (dark green), houses (light green), cemeteries (purple), public buildings (dark yellow), and public lands (yellow).

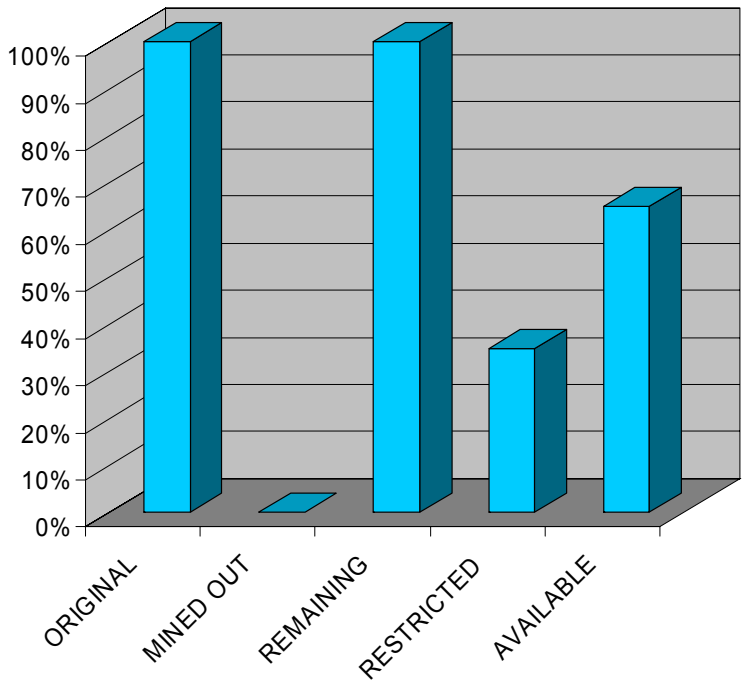


Figure 24. Original, mined-out, remaining, restricted, and available coal resources for the Upper Mercer no. 2 coal in the Strattanville quadrangle.

the original resources are classified as identified, and only about 38 percent of the original constitutes demonstrated resources.

Mining by surface methods has removed less than 23 thousand short tons (Figures 6 and 24, Table B–1). Underground mining is known to have occurred in the northern part of the quadrangle, but no maps are available showing the extent of mining. Therefore, the contribution of underground operations to the estimated mined-out resources is unknown and under-represented. However, the extent of underground mining is believed to be small. Consequently, past mining has been minimal overall, and the remaining Upper Mercer no. 2 coal resources are over 27 million short tons (Figure 24, Table B–1). A map showing the areal distribution of remaining coal is presented in Figure 25. More than 35 percent of the remaining resources is greater than 28 inches thick. Similarly, the remaining resources greater than 28 inches thick represent more than 35 percent of the original resources. The demonstrated remaining resources are over 38 percent of the remaining resources.

Eleven land-use restrictions and one technologic restriction affect future mining on the Upper Mercer no. 2 and exclude nearly 9.6 million short tons of coal from consideration, or

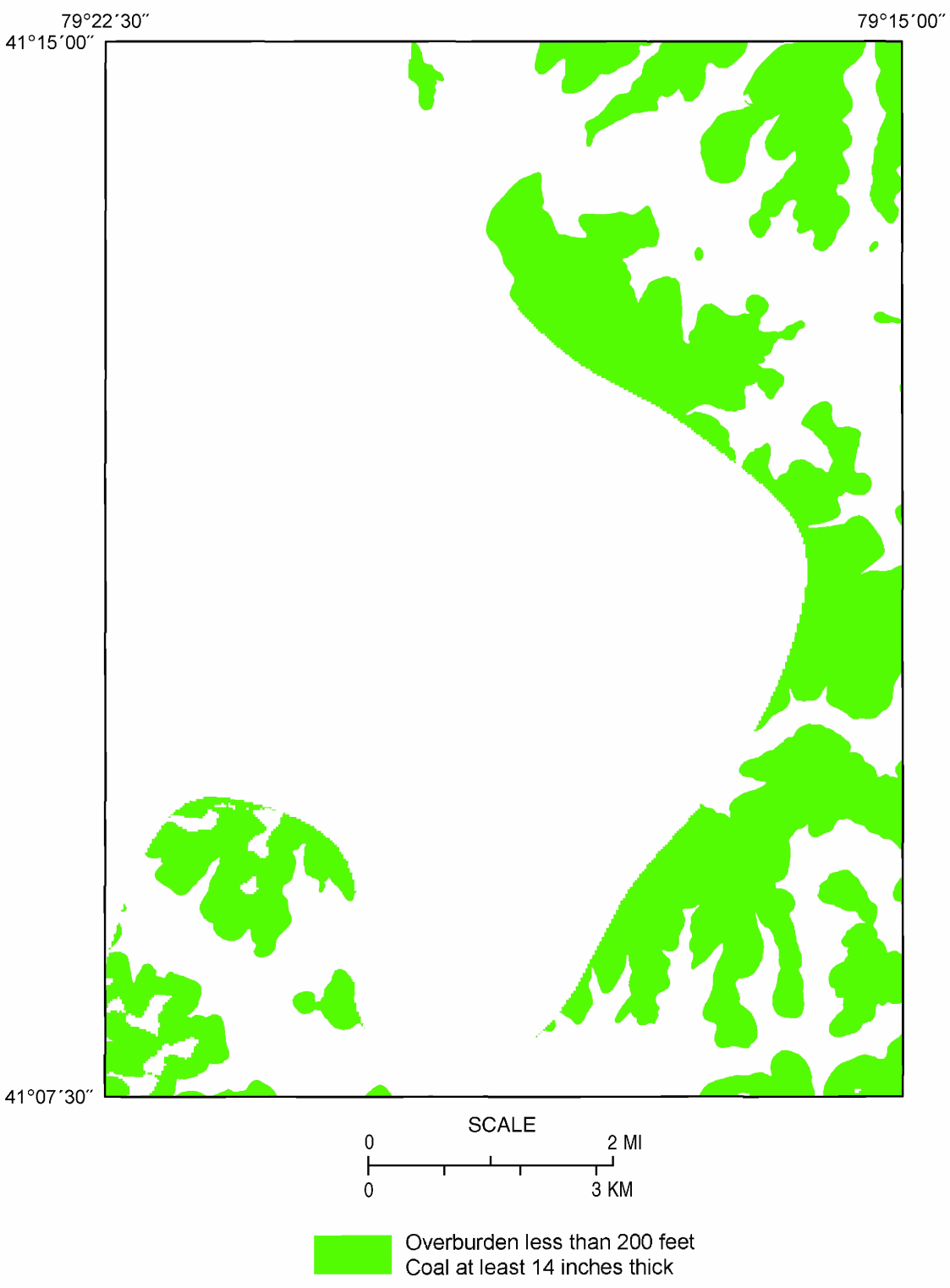


Figure 25. Distribution of remaining resources for the Upper Mercer no. 2 coal.

about 35 percent of the original resources (Figures 23, 24, 26, and 27, Tables B–2 and B–3). About 95 percent of the mining restrictions is due to land-use restrictions.

Available Upper Mercer no. 2 coal totals nearly 18 million short tons, or 65 percent of the estimated original resources (Figure 24, Table B–1). A map of the areal distribution of available coal is shown in Figure 28. All available coal is classified as strippable (i.e., overburden category of 0 to 200 feet). The available coal greater than 28 inches thick is over 6.2 million short tons, representing about 35 percent of the available resources and nearly 23 percent of the original resources. Of the coal available for mining, approximately 7.0 million short tons, or about 39 percent, is demonstrated resources, and the remainder is inferred. The demonstrated available resources greater than 28 inches are about 3.2 million short tons, constituting 46 percent of the demonstrated available resources, about 18 percent of the available resources, and nearly 12 percent of the original resources.

LOWER CLARION COAL

The original resources of the Lower Clarion coal are estimated at nearly 72 million short tons, which represents nearly 37 percent of the total original coal resources of the Strattanville quadrangle (Figures 22 and 29, Table B–4). Nearly 56 percent of the original resources is greater than 28 inches thick. All of the original resources are classified as identified, and over 72 percent of this consists of demonstrated resources.

Surface mining accounts for the elimination of nearly 11 million short tons of coal, or 15 percent of the original resources (Figures 8 and 29, Table B–4). In estimating coal resources, the contribution of underground operations to past mining is insignificant and consists of a few small country banks in the northern part of the quadrangle.

The remaining Lower Clarion coal resources total about 61 million short tons, or 85 percent of the estimated original resources (Figure 29, Table B–4). The distribution of the remaining coal is portrayed in Figure 30. The remaining resources greater than 28 inches thick are nearly 32 million short tons, which represents over 52 percent of the remaining resources and more than 44 percent of the original resources. The demonstrated remaining resources constitute over 69 percent of the remaining resources.

The mining restrictions exclude about 24 million short tons of coal, which represents a third of the original resources (Figures 23, 29, 31, and 32; Tables B–5 and B–6). Thirteen land-

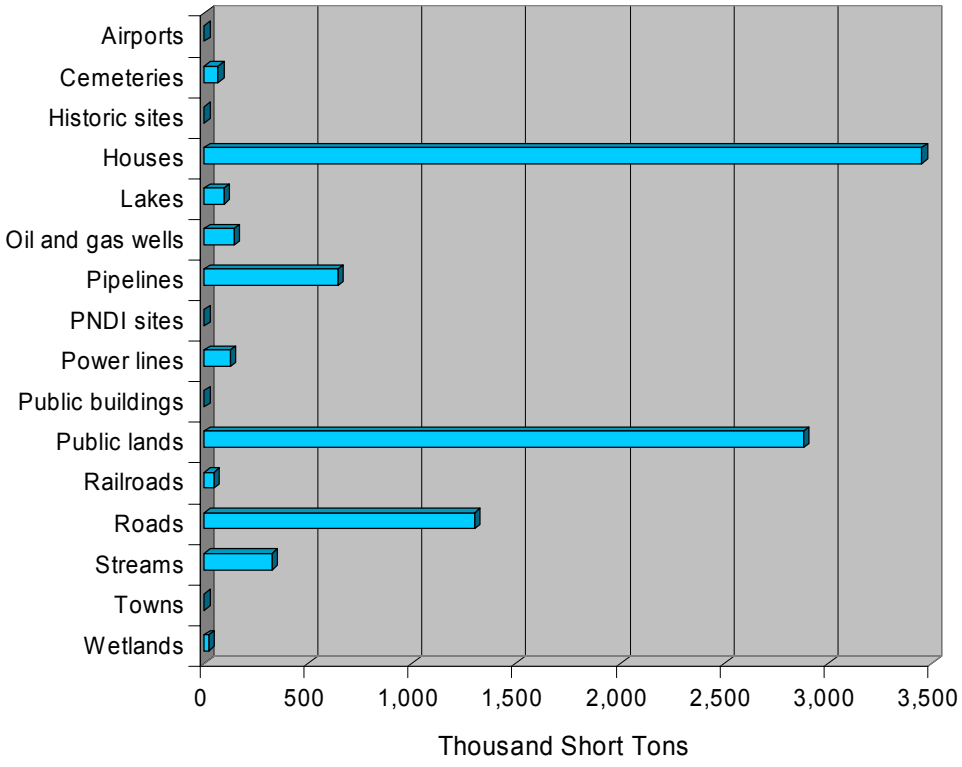


Figure 26. Impact of individual land-use restrictions on the Upper Mercer no. 2 coal.

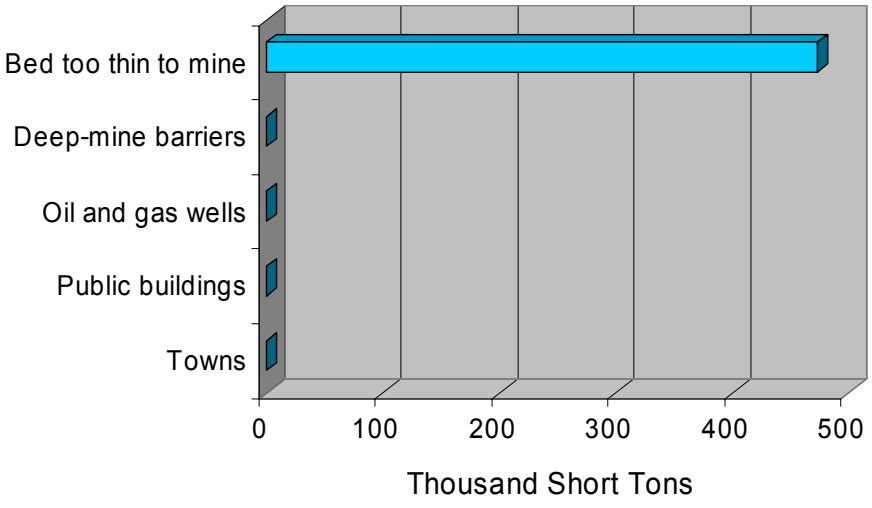


Figure 27. Impact of individual technologic restrictions on the Upper Mercer no. 2 coal.

Figure 28. Distribution of available resources for the Upper Mercer no. 2 coal.

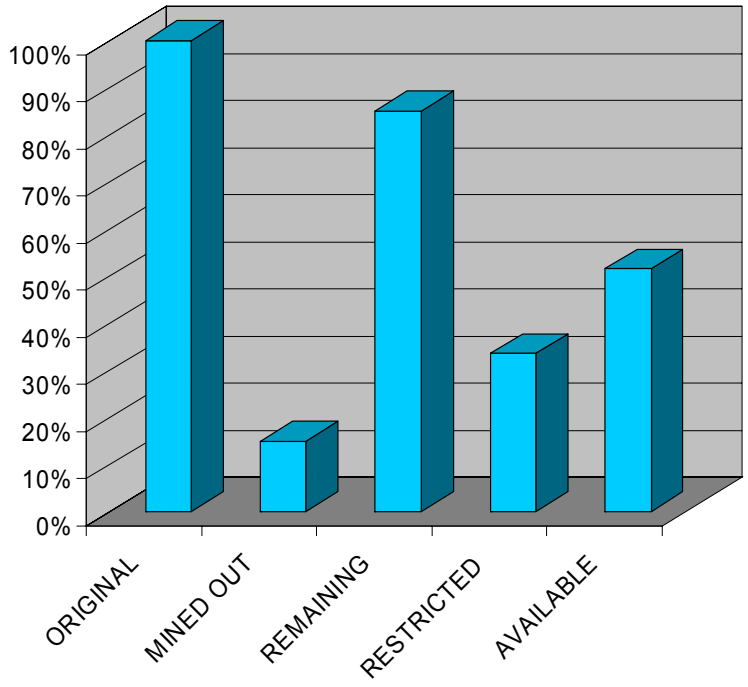


Figure 29. Original, mined-out, remaining, restricted, and available coal resources for the Lower Clarion coal in the Strattanville quadrangle.

use restrictions apply to the Lower Clarion coal and make up almost 98 percent of the mining restrictions. Only one technologic restriction contributes to the total.

Available coal for the Lower Clarion is nearly 37 million short tons, representing approximately 52 percent of the original resources (Figure 29, Table B–4). The areal distribution of available coal is shown on the map in Figure 33. Almost 100 percent of the available coal is classified as strippable. Of the available coal, nearly 17 million short tons is greater than 28 inches thick, which constitutes 45 percent of the available resources and over 23 percent of the original resources. Demonstrated available resources total over 25 million short tons, or more than 68 percent of the available resources. The demonstrated available resources greater than 28 inches thick amount to over 11 million short tons, which represents over 44 percent of the demonstrated available resources, more than 30 percent of the available resources, and almost 16 percent of the original resources.

UPPER CLARION COAL

The estimated original resources of the Upper Clarion coal are over 51 million short tons, which constitutes about 26 percent of the total original coal resources of the study area (Figure

Figure 30. Distribution of remaining resources for the Lower Clarion coal.

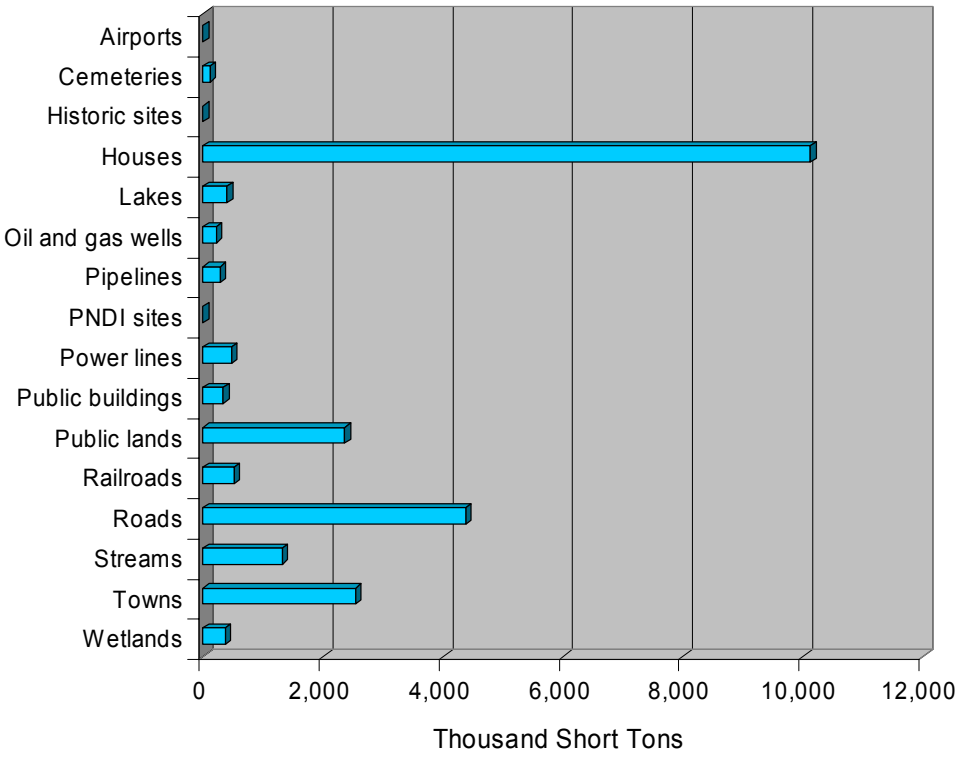


Figure 31. Impact of individual land-use restrictions on the Lower Clarion coal.

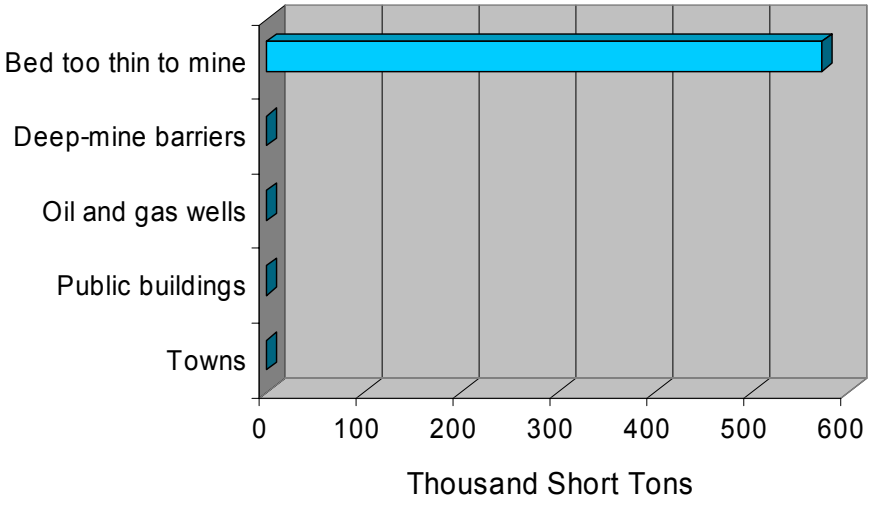


Figure 32. Impact of individual technologic restrictions on the Lower Clarion coal.

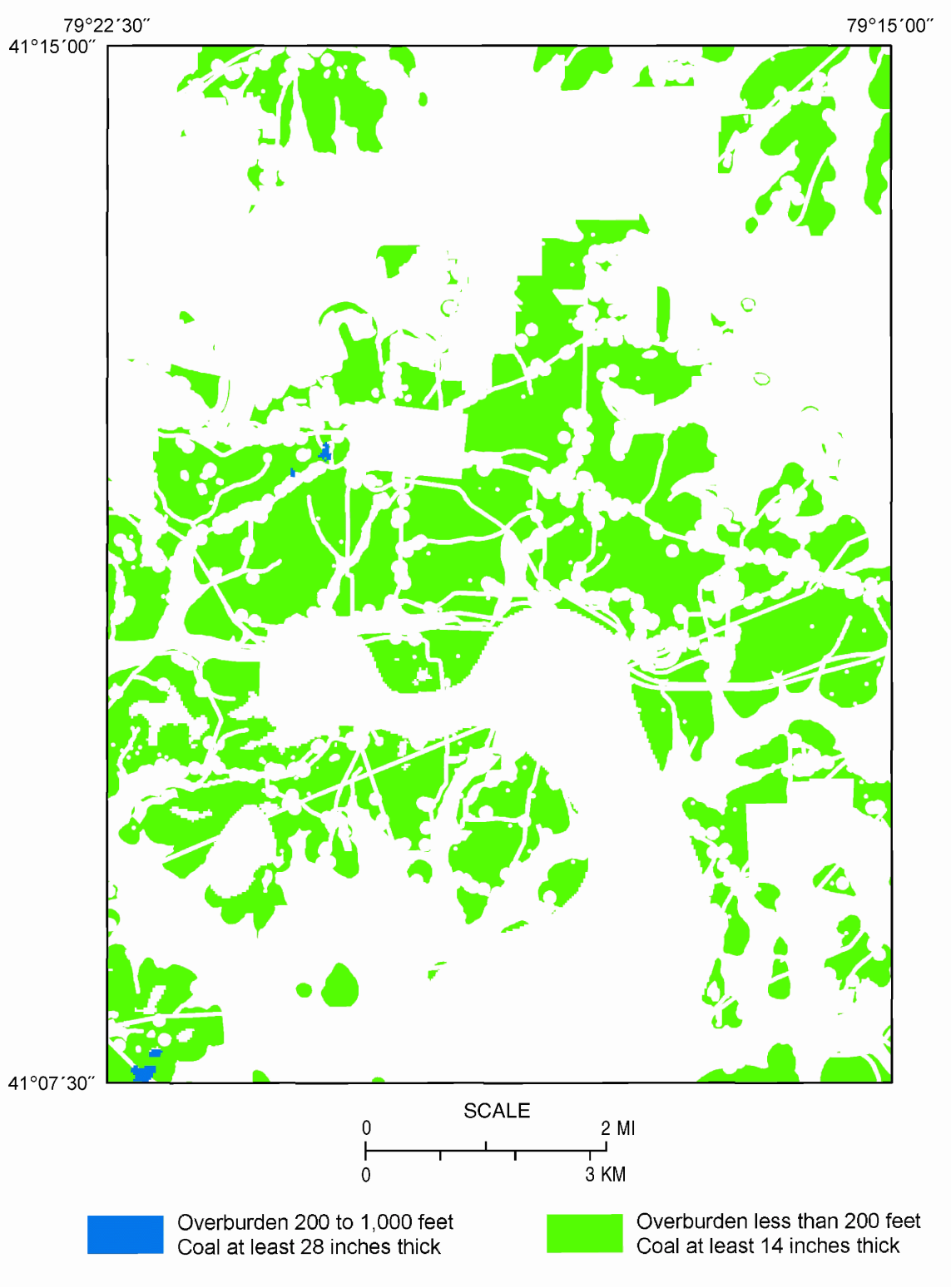


Figure 33. Distribution of available resources for the Lower Clarion coal.

34, Table B–7). More than 45 percent of the original resources is greater than 28 inches thick. All of the original resources are classified as identified, and more than 80 percent of this falls within the demonstrated-resources category.

Mining has essentially all been by surface methods and has removed over 4.3 million short tons of coal, representing nearly 9 percent of the original resources (Figures 10 and 34, Table B–7).

The remaining coal resources of the Upper Clarion are almost 47 million short tons, or over 91 percent of the estimated original resources (Figure 34, Table B–7). A map showing the areal distribution of the remaining coal is presented in Figure 35. The remaining resources greater than 28 inches thick exceed 21 million short tons, signifying more than 45 percent of the remaining resources and over 41 percent of the original resources. The demonstrated remaining resources are 79 percent of the remaining resources.

Thirteen land-use restrictions and one technologic restriction impact on future Upper Clarion mining and exclude nearly 17 million short tons of coal from consideration, or 33

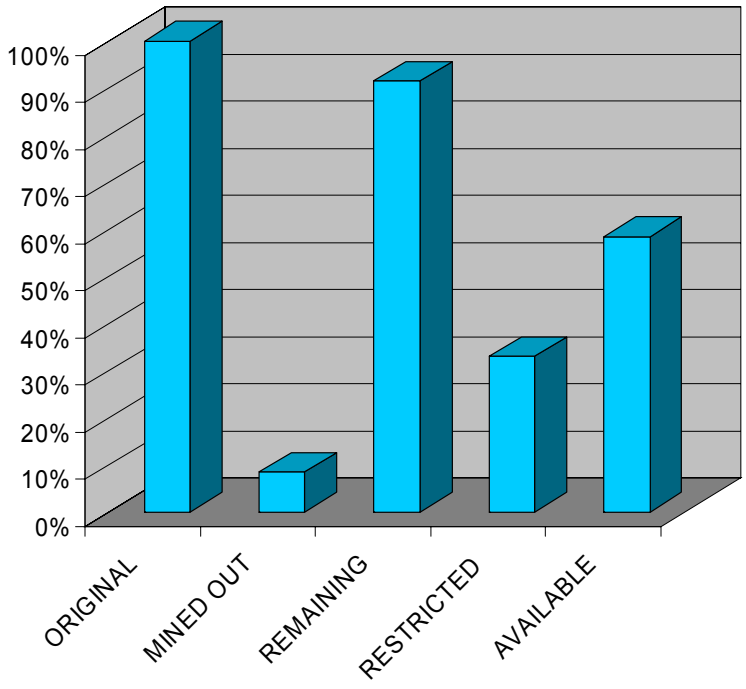


Figure 34. Original, mined-out, remaining, restricted, and available coal resources for the Upper Clarion coal in the Strattanville quadrangle.

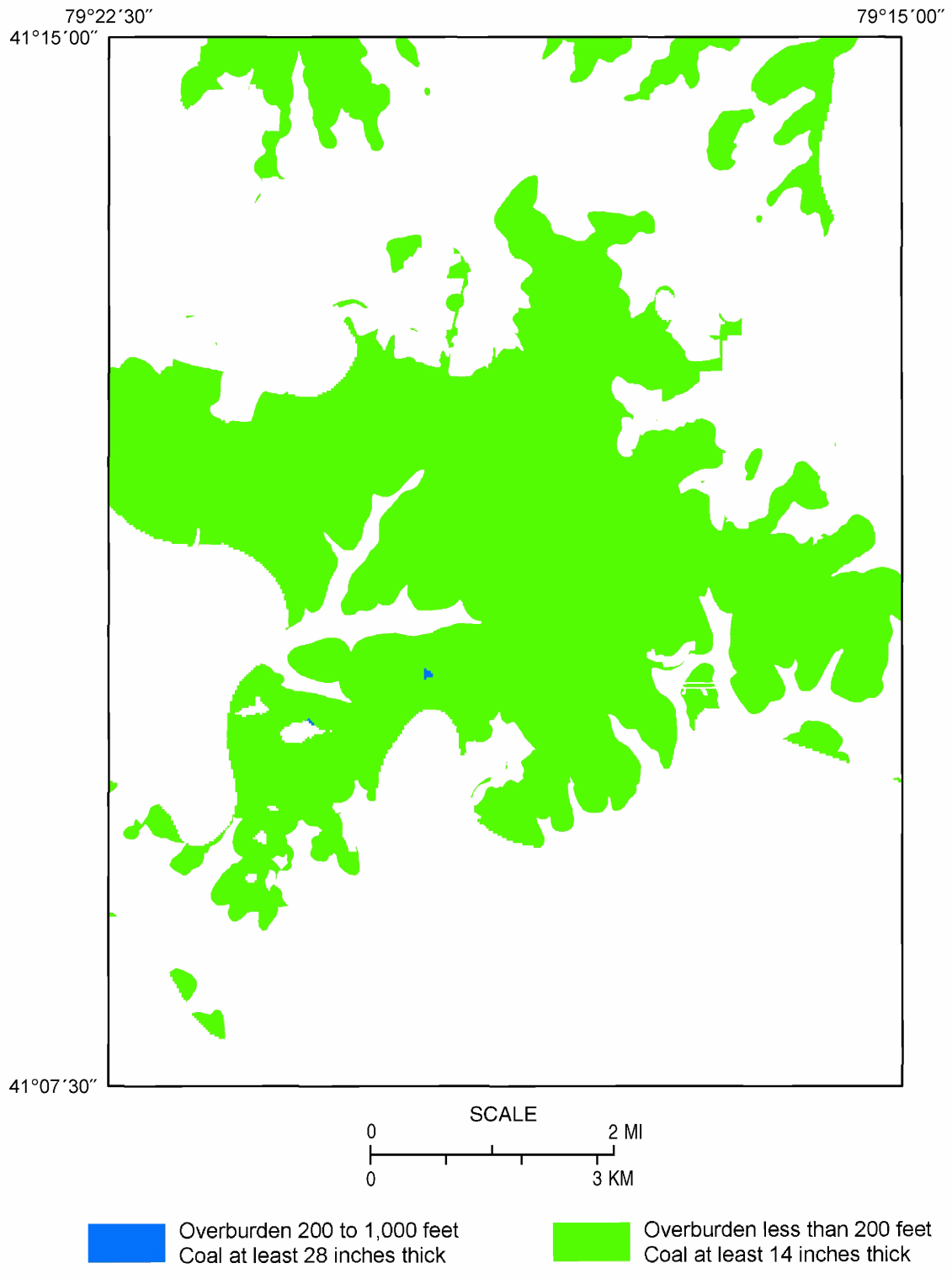


Figure 35. Distribution of remaining resources for the Upper Clarion coal.

percent of the original resources (Figures 23, 34, 36, and 37; Tables B–8 and B–9). Ninety-nine percent of the mining restrictions is due to land-use limitations.

Available Upper Clarion coal is almost 30 million short tons, representing over 58 percent of the original resources (Figure 34, Table B–7). A map showing the distribution of available coal for the study area is given in Figure 38. Nearly 100 percent of the available coal is classified as strippable. The available coal greater than 28 inches thick is over 14 million short tons, constituting about 48 percent of the available resources and 28 percent of the original resources. Of the coal available for mining, 24 million short tons, or over 80 percent, is demonstrated resources. The demonstrated available resources greater than 28 inches are nearly 13 million short tons, representing almost 53 percent of the demonstrated available resources, over 42 percent of the available resources, and nearly 25 percent of the original resources.

LOWER KITTANNING LEADER COAL

The estimated original resources of the Lower Kittanning leader coal are 13 million short tons, or nearly 7 percent of the total original coal resources of the quadrangle (Figure 39, Table B–10). Of the original resources, almost 41 percent is greater than 28 inches thick. All of the original resources are classified as identified, and about 64 percent of this consists of demonstrated resources.

Surface operations are responsible for all significant mining and have removed over 240 thousand short tons of coal, representing only about 2 percent of the original resources (Figures 12 and 39, Table B–10).

The remaining resources of the Lower Kittanning leader coal total nearly 13 million short tons, or about 98 percent of the original resources (Figure 39, Table B–10). The areal distribution of the remaining coal is shown in Figure 40. The remaining resources greater than 28 inches thick are over 5.2 million short tons, representing approximately 41 percent of the remaining resources and nearly 40 percent of the original resources. The demonstrated remaining resources are more than 63 percent of the remaining resources.

Thirteen land-use restrictions and one technologic restriction constitute all of the restrictions to mining and eliminate nearly 4.5 million short tons of coal from consideration (Figures 23, 39, 41, and 42; Tables B–11 and B–12). Restricted resources amount to 34 percent of the original resources. Virtually 100 percent of the mining restrictions is due to land use.

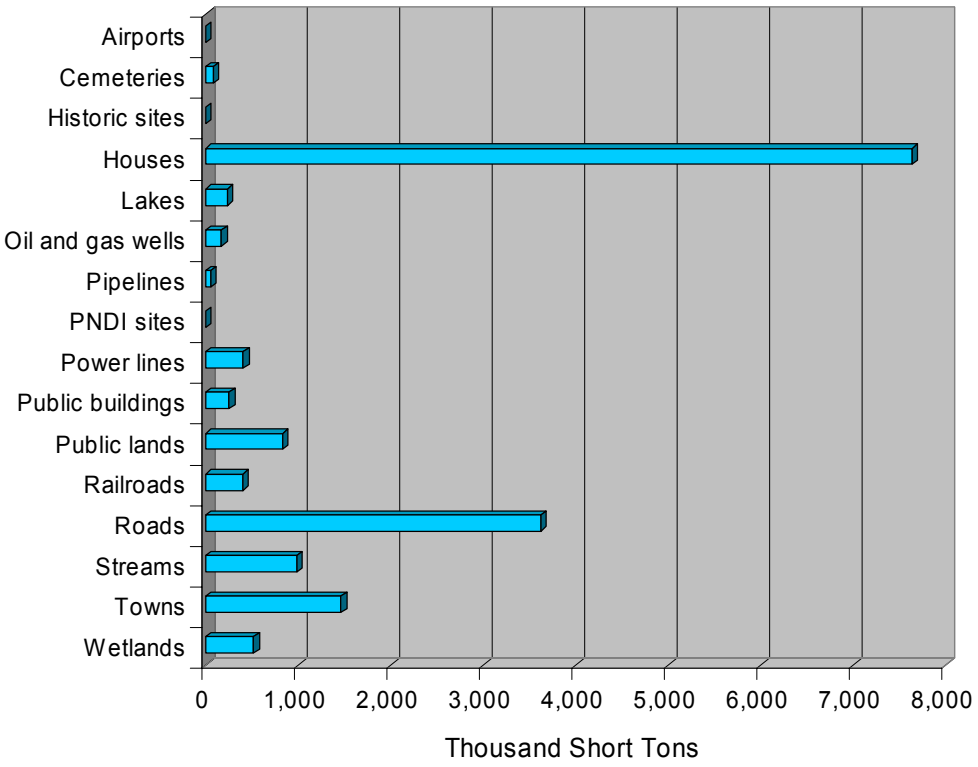


Figure 36. Impact of individual land-use restrictions on the Upper Clarion coal.

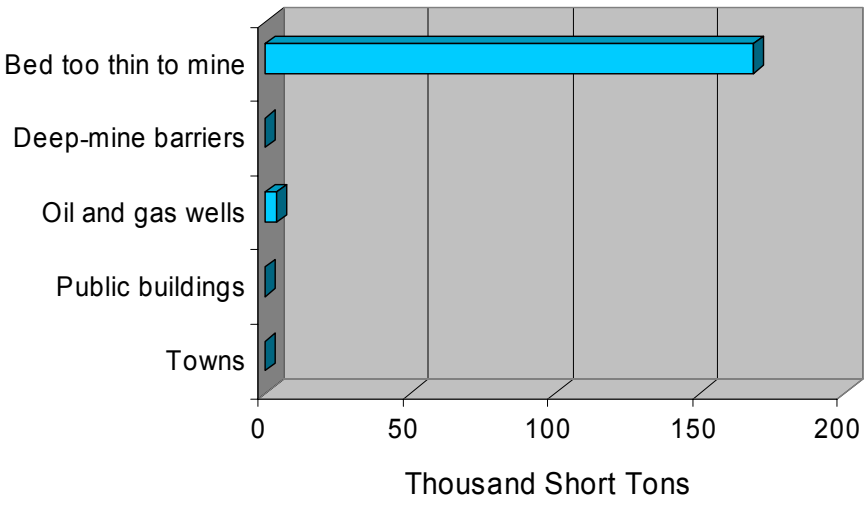


Figure 37. Impact of individual technologic restrictions on the Upper Clarion coal.

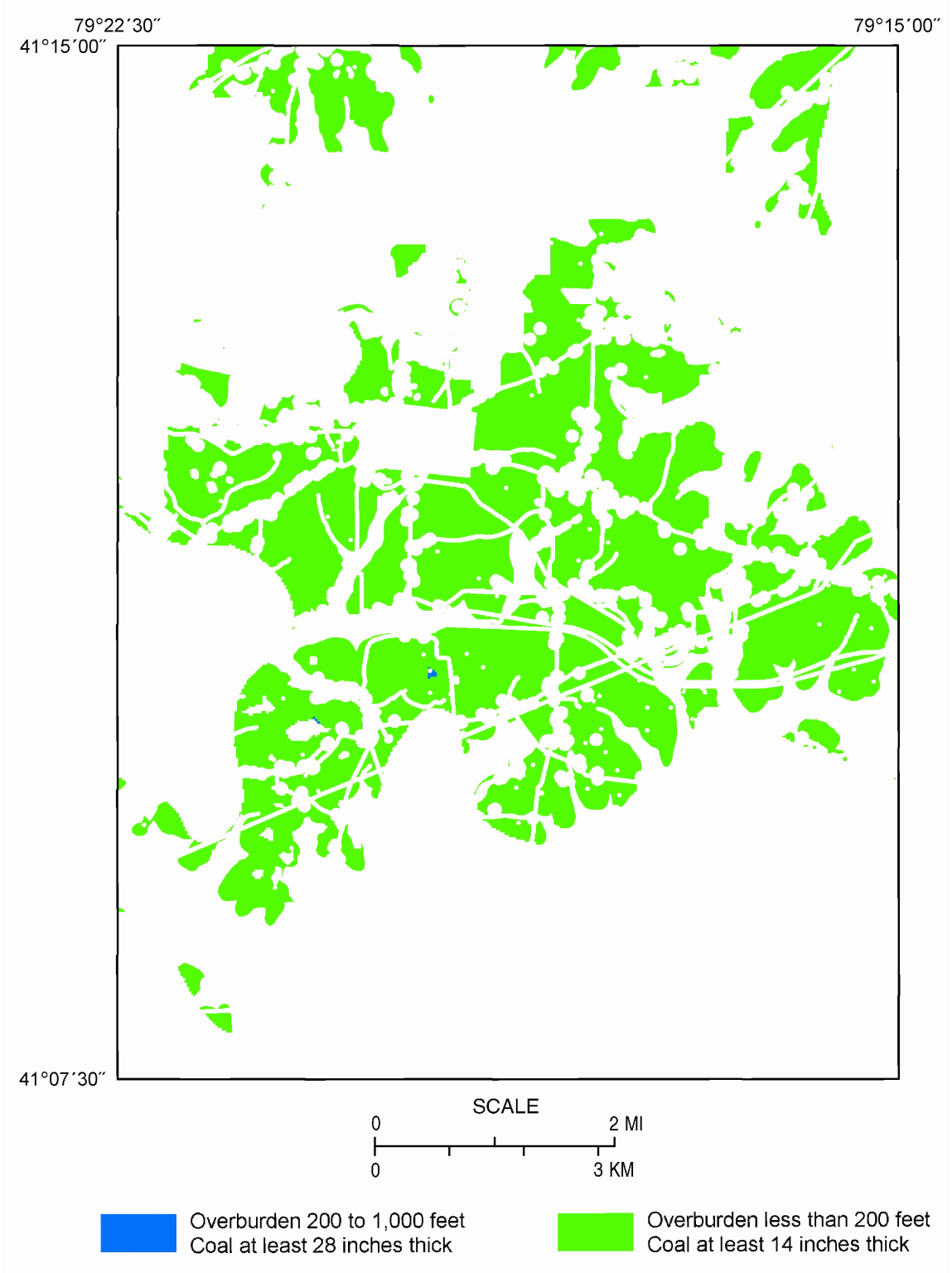


Figure 38. Distribution of available resources for the Upper Clarion coal.

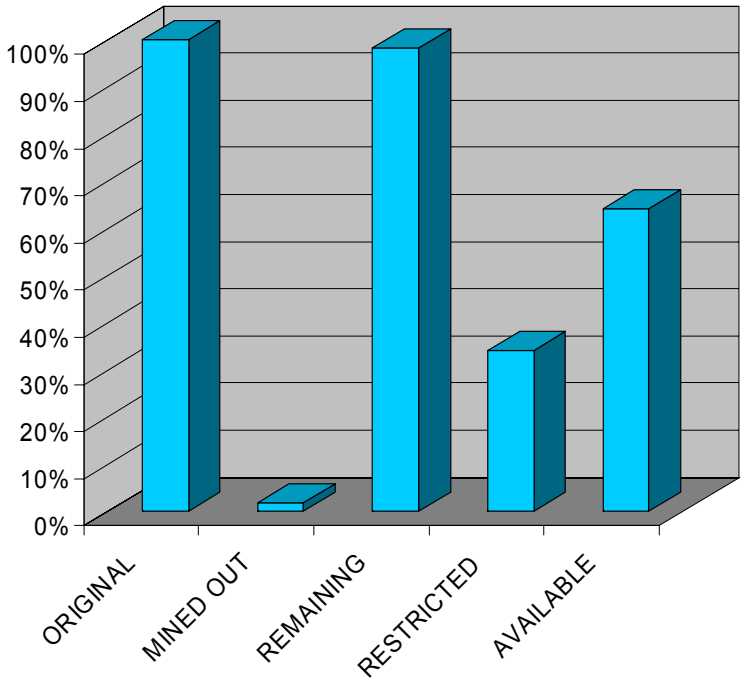


Figure 39. Original, mined-out, remaining, restricted, and available coal resources for the Lower Kittanning leader coal in the Strattanville quadrangle.

Available coal for the Lower Kittanning leader is about 8.4 million short tons, representing more than 64 percent of the original resources (Figure 39, Table B–10). The areal distribution of available coal is shown on the map in Figure 43. All available coal is classified as strippable. Of the available coal, nearly 3.5 million short tons is greater than 28 inches thick, which constitutes over 41 percent of the available resources and approximately 27 percent of the original resources. Demonstrated available resources total about 5.4 million short tons, or over 64 percent of the available resources. The demonstrated available resources greater than 28 inches thick amount to over 3.1 million short tons, which represents 58 percent of the demonstrated available resources, more than 37 percent of the available resources, and about 24 percent of the original resources.

LOWER KITTANNING COAL

The original resources of the Lower Kittanning coal are estimated at over 26 million short tons, which represents approximately 14 percent of the total original coal resources of the Strattanville quadrangle (Figure 44, Table B–13). Approximately 61 percent of the original

Figure 40. Distribution of remaining resources for the Lower Kittanning leader coal.

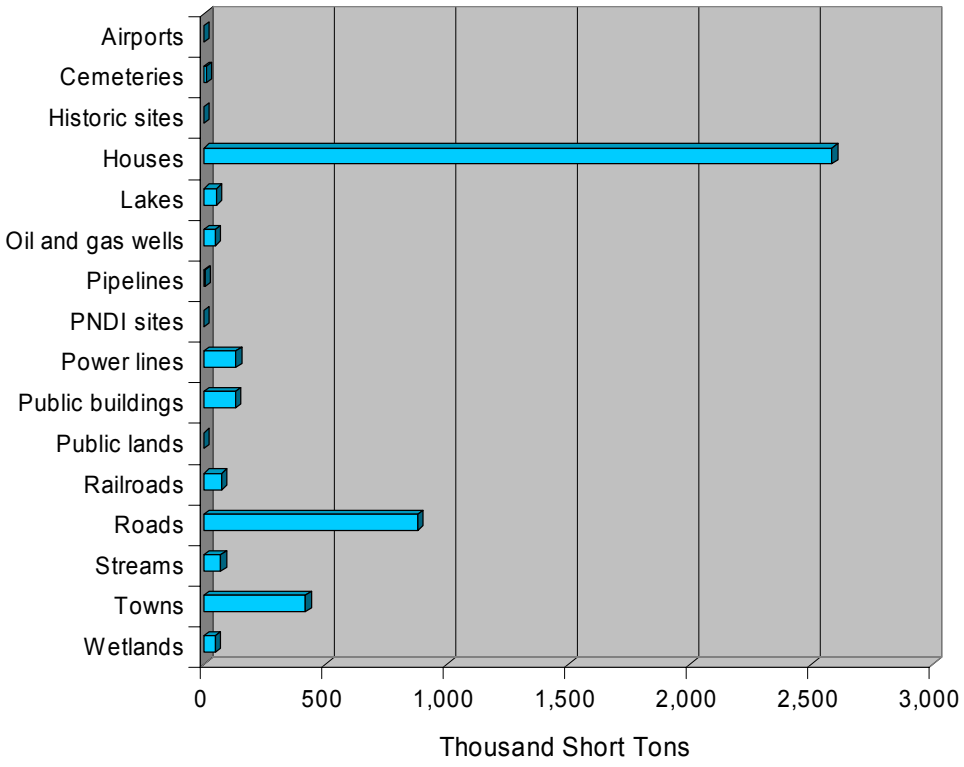


Figure 41. Impact of individual land-use restrictions on the Lower Kittanning leader coal.

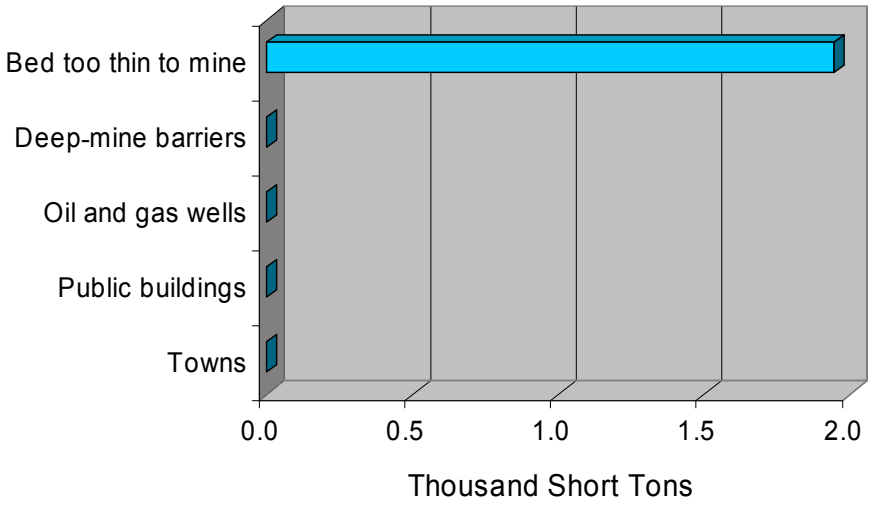


Figure 42. Impact of individual technologic restrictions on the Lower Kittanning leader coal.

Figure 43. Distribution of available resources for the Lower Kittanning leader coal.

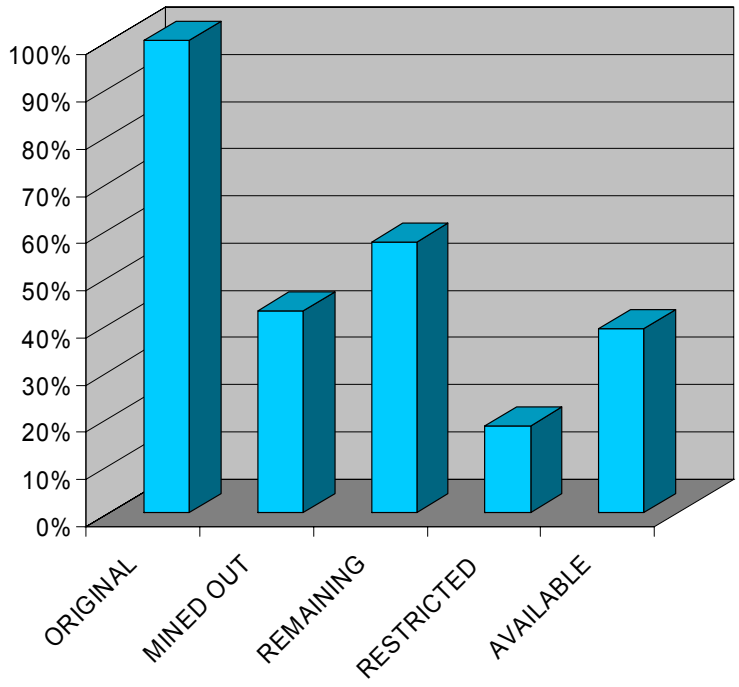


Figure 44. Original, mined-out, remaining, restricted, and available coal resources for the Lower Kittanning coal in the Strattanville quadrangle.

resources is greater than 28 inches thick. All of the original resources are classified as identified, and 93 percent of this constitutes demonstrated resources.

Past mining has removed over 11 million short tons of coal, or nearly 43 percent of the original resources (Figures 14 and 44, Table B–13). The Lower Kittanning is the one bed in the report area that has had appreciable deep mining, as well as surface mining (although the thickness of overburden associated with the old underground operations is less than 200 feet). Deep mining removed almost 2.3 million short tons, or 20 percent of the total production. Where subsequent strip mining has occurred through older underground workings (i.e., called "daylighting"), the entire production for such areas in this study is considered surface-mined-out resources for purposes of classification.

The remaining Lower Kittanning coal resources are more than 15 million short tons, which constitutes over 57 percent of the estimated original resources (Figure 44, Table B–13). The areal distribution of the remaining coal is portrayed on the map in Figure 45. The remaining resources greater than 28 inches thick are about 8.3 million short tons, which represents nearly

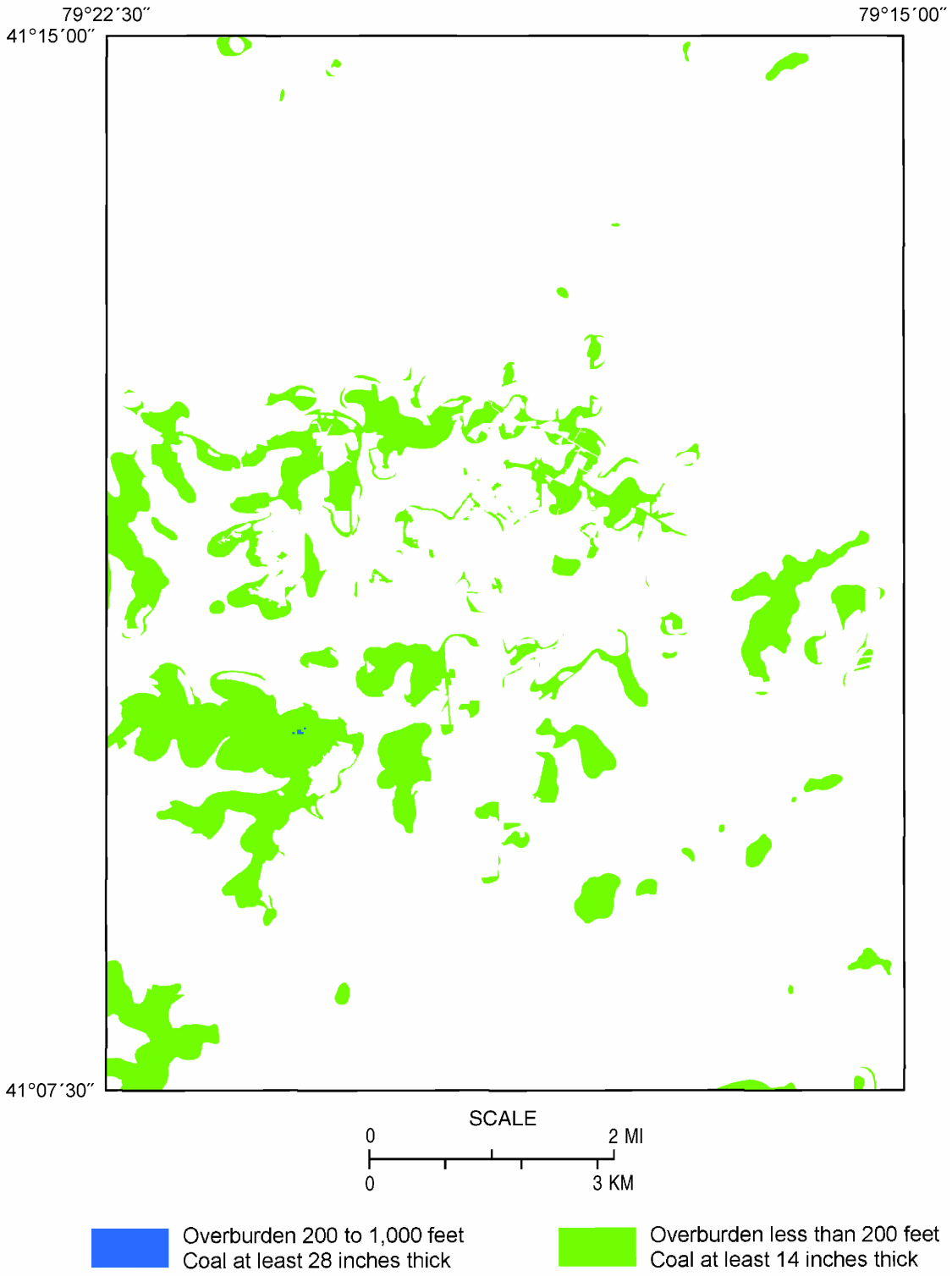


Figure 45. Distribution of remaining resources for the Lower Kittanning coal.

55 percent of the remaining resources and over 31 percent of the original resources. The demonstrated remaining resources constitute 90 percent of the remaining resources.

The mining restrictions exclude 4.8 million short tons of coal, which represents over 18 percent of the original resources (Figures 23, 44, 46, and 47; Tables B–14 and B–15). Thirteen land-use restrictions and one technologic restriction apply to the Lower Kittanning coal. Practically 100 percent of the restrictions is due to land use.

Available Lower Kittanning coal is more than 10 million short tons, which represents 39 percent of the original resources (Figure 44, Table B–13). The areal distribution of available coal is shown on the map in Figure 48. Virtually 100 percent of the available coal is classified as strippable. Of the available coal, over 4.8 million short tons is greater than 28 inches thick, which constitutes about 47 percent of the available resources and over 18 percent of the original resources. Demonstrated available resources total 9.3 million short tons, or approximately 91

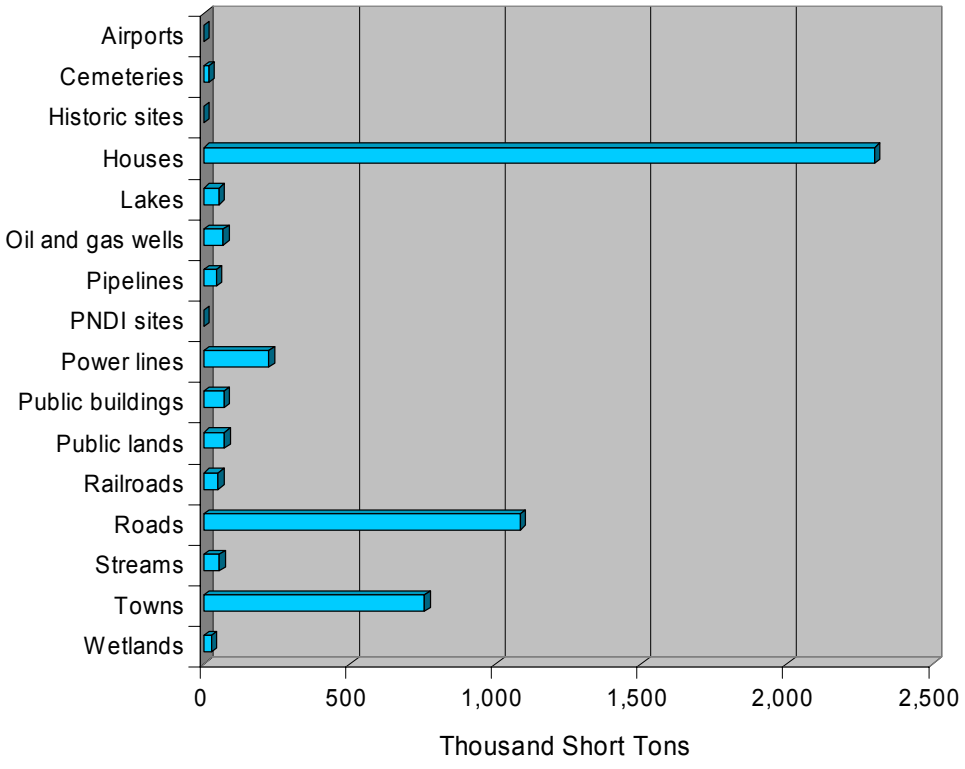


Figure 46. Impact of individual land-use restrictions on the Lower Kittanning coal.

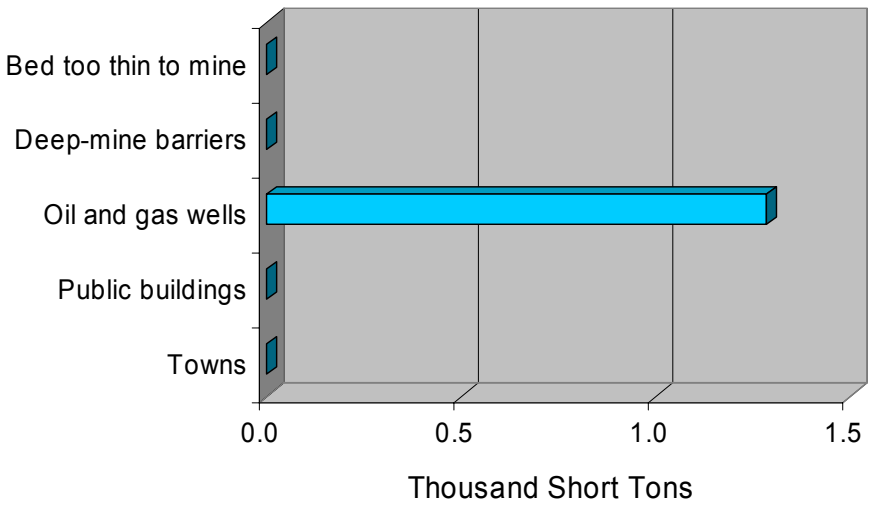


Figure 47. Impact of individual technologic restrictions on the Lower Kittanning coal.

percent of the available resources. The demonstrated available resources greater than 28 inches thick amount to over 4.3 million short tons, which represents nearly 47 percent of the demonstrated available resources, over 42 percent of the available resources, and approximately 17 percent of the original resources.

MIDDLE KITTANNING COAL

The estimated original resources of the Middle Kittanning coal are 5.0 million short tons, constituting approximately 3 percent of the total original coal resources of the study area (Figure 49, Table B–16). Fourteen percent of the original resources is greater than 28 inches thick. All of the original resources are classified as identified, and almost 92 percent of this falls within the category of demonstrated resources.

Mining has been by surface operations and has resulted in the extraction of over 1.8 million short tons of coal, representing over 36 percent of the original resources (Figures 16 and 49, Table B–16). Deep mining has been inconsequential.

The remaining coal resources of the Middle Kittanning are almost 3.2 million short tons, or nearly 64 percent of the estimated original resources (Figure 49, Table B–16). A map showing the areal distribution of the remaining coal is presented in Figure 50. The remaining resources greater than 28 inches thick are about 500 thousand short tons, representing nearly 16

Figure 48. Distribution of available resources for the Lower Kittanning coal.

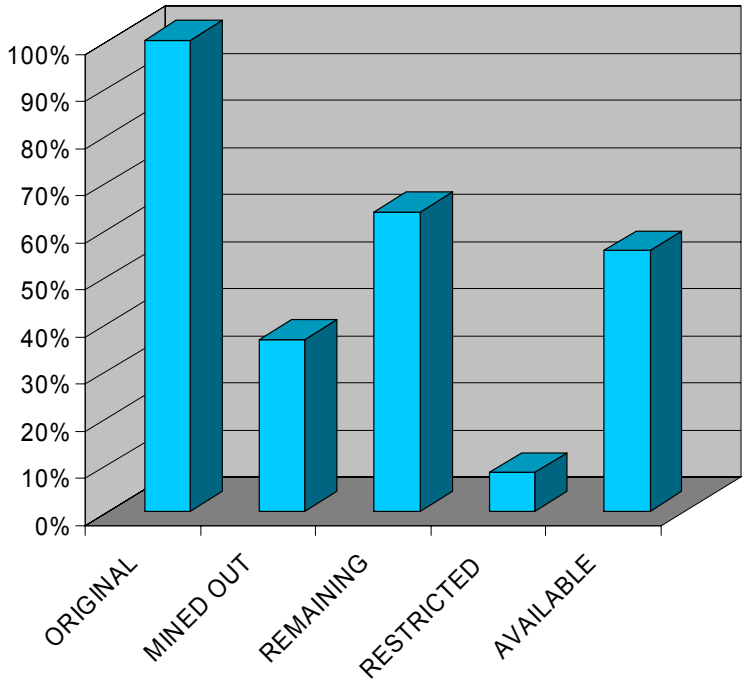


Figure 49. Original, mined-out, remaining, restricted, and available coal resources for the Middle Kittanning coal in the Strattanville quadrangle.

percent of the remaining resources and 10 percent of the original resources. The demonstrated remaining resources are nearly 91 percent of the remaining resources.

Seven land-use restrictions constitute all of the applicable mining restrictions to the Middle Kittanning and exclude over 410 thousand short tons of coal from consideration, or over 8 percent of the original resources (Figures 23, 49, 51, and 52; Tables B–17 and B–18).

Available Middle Kittanning coal is approximately 2.8 million short tons, representing over 55 percent of the original resources (Figure 49, Table B–16). A map showing the distribution of available coal for the study area is given in Figure 53. All of the available coal is classified as strippable. The available coal greater than 28 inches thick is about 430 thousand short tons, constituting approximately 16 percent of the available resources and nearly 9 percent of the original resources. Of the coal available for mining, over 2.5 million short tons, or more than 91 percent, is demonstrated resources. All of the available resources greater than 28 inches thick also fall within the demonstrated category and therefore total about 430 thousand short tons. Accordingly, the demonstrated available resources greater than 28 inches thick represent

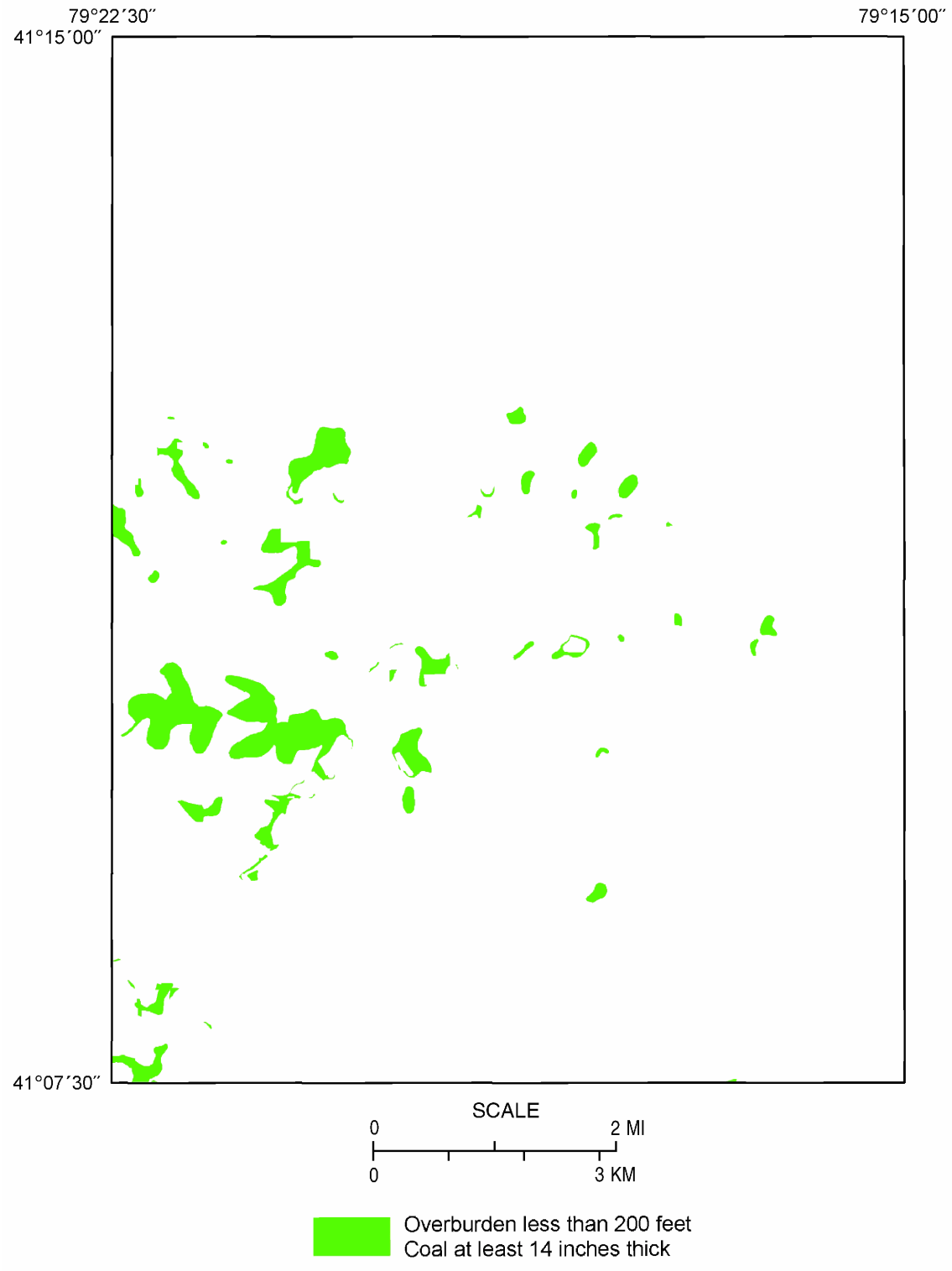


Figure 50. Distribution of remaining resources for the Middle Kittanning coal.

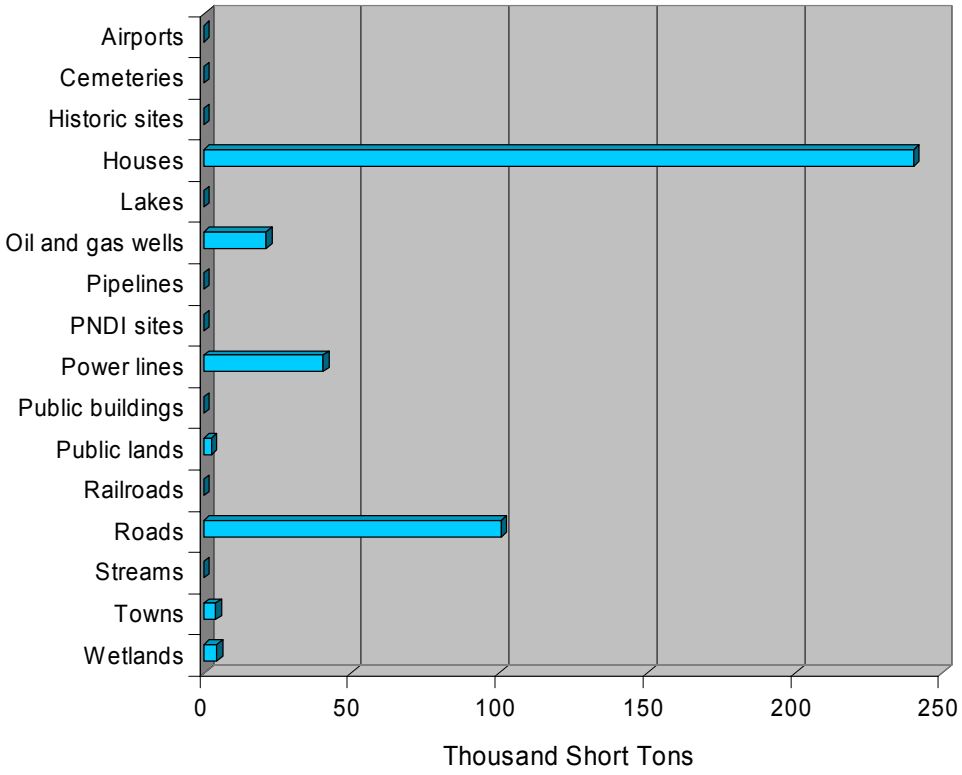


Figure 51. Impact of individual land-use restrictions on the Middle Kittanning coal.

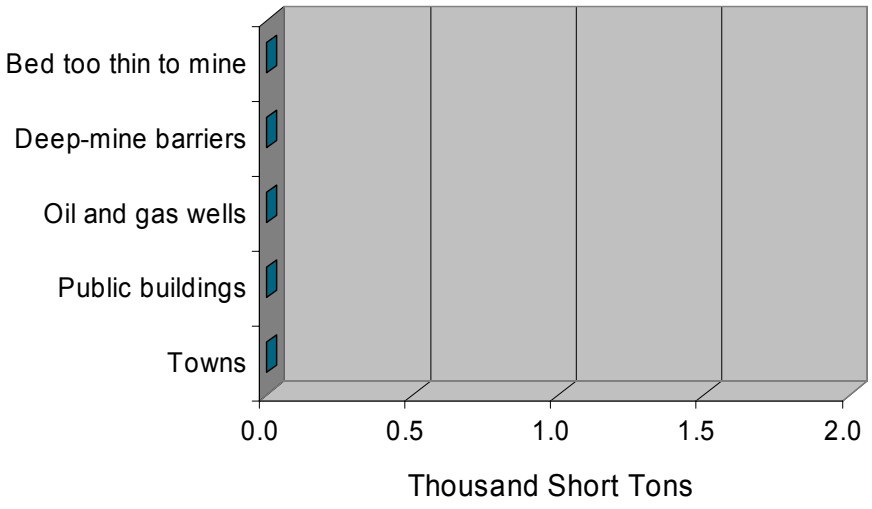


Figure 52. Impact of individual technologic restrictions on the Middle Kittanning coal.

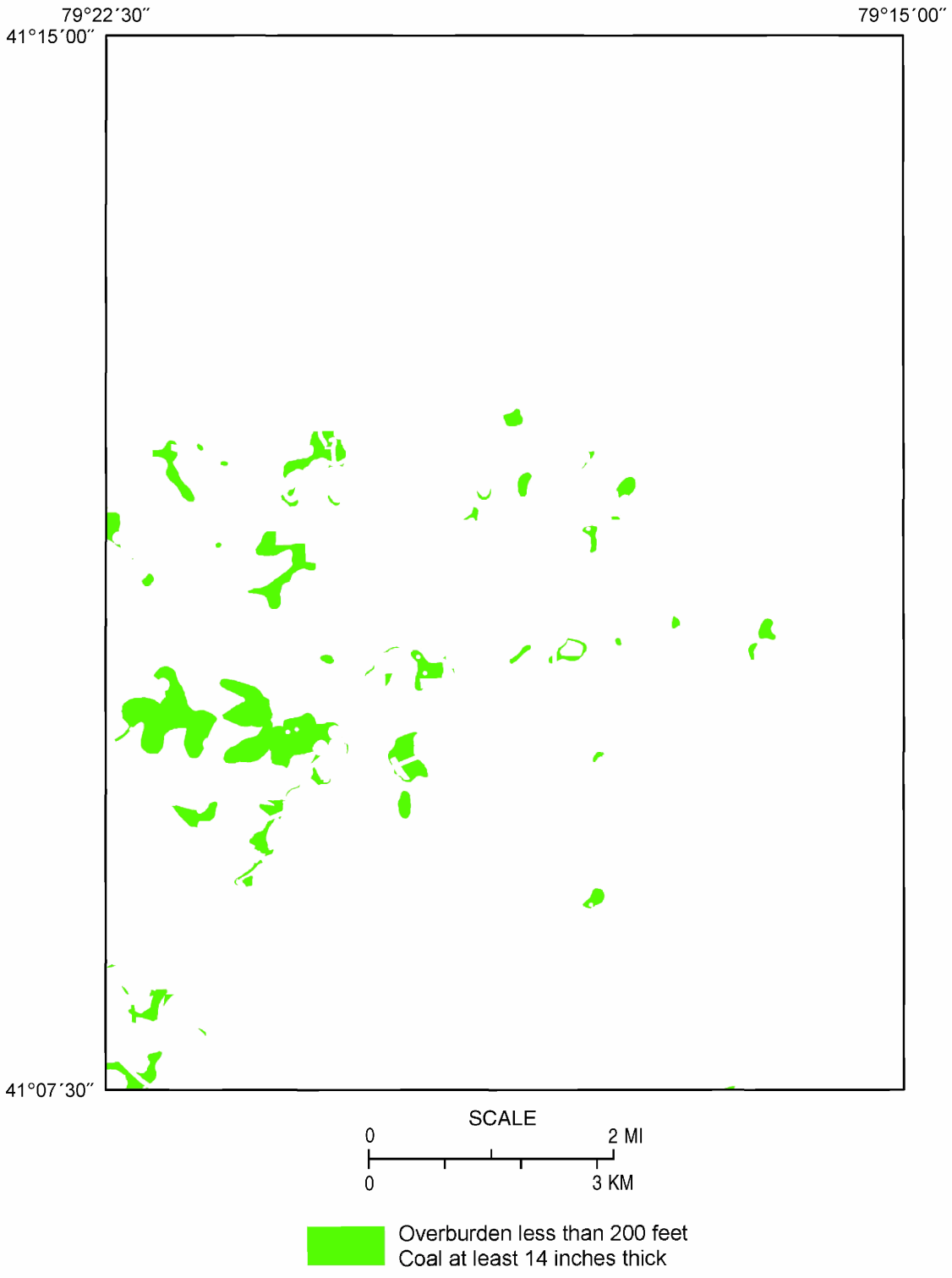


Figure 53. Distribution of available resources for the Middle Kittanning coal.

17 percent of the demonstrated available resources, approximately 16 percent of the available resources, and nearly 9 percent of the original resources.

UPPER KITTANNING COAL

The original resources of the Upper Kittanning coal are included for completeness and are estimated at about 170 thousand short tons, which represents only about 0.1 percent of the total original coal resources of the Strattanville quadrangle (Figure 54, Table B–19). None of the original resources is greater than 28 inches thick. All of the original resources are classified as identified, and 81 percent of this consists of demonstrated resources.

Surface mining operations have removed over 15 thousand short tons of coal, or about 9 percent of the original resources (Figures 18 and 54, Table B–19). Underground operations have been insignificant.

The remaining Upper Kittanning coal resources are almost 160 thousand short tons, which represents 91 percent of the estimated original resources (Figure 54, Table B–19). The areal distribution of the remaining coal is portrayed on the map in Figure 55. The demonstrated remaining resources constitute over 79 percent of the remaining resources.

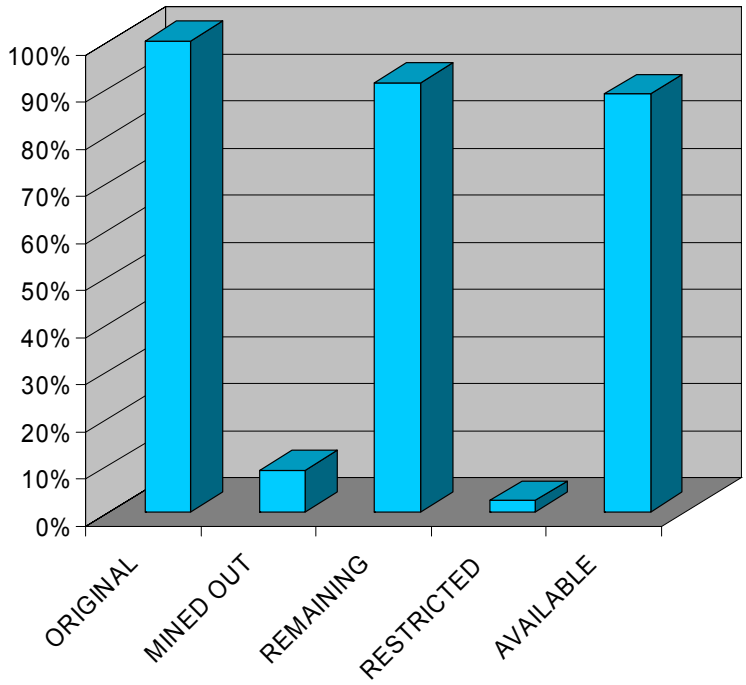


Figure 54. Original, mined-out, remaining, restricted, and available coal resources for the Upper Kittanning coal in the Strattanville quadrangle.

Figure 55. Distribution of remaining resources for the Upper Kittanning coal.

The mining restrictions exclude about 4,200 short tons of coal, which represents only about 2 percent of the original resources (Figures 23, 54, 56, and 57; Tables B–20 and B–21). Three land-use restrictions apply to the Upper Kittanning coal and constitute all of the mining restrictions.

Available Upper Kittanning coal is more than 150 thousand short tons, which represents nearly 89 percent of the original resources (Figure 54, Table B–19). The areal distribution of available coal is shown on the map in Figure 58. All of the available coal is classified as strippable. Demonstrated available resources total more than 120 thousand short tons, or 79 percent of the available resources.

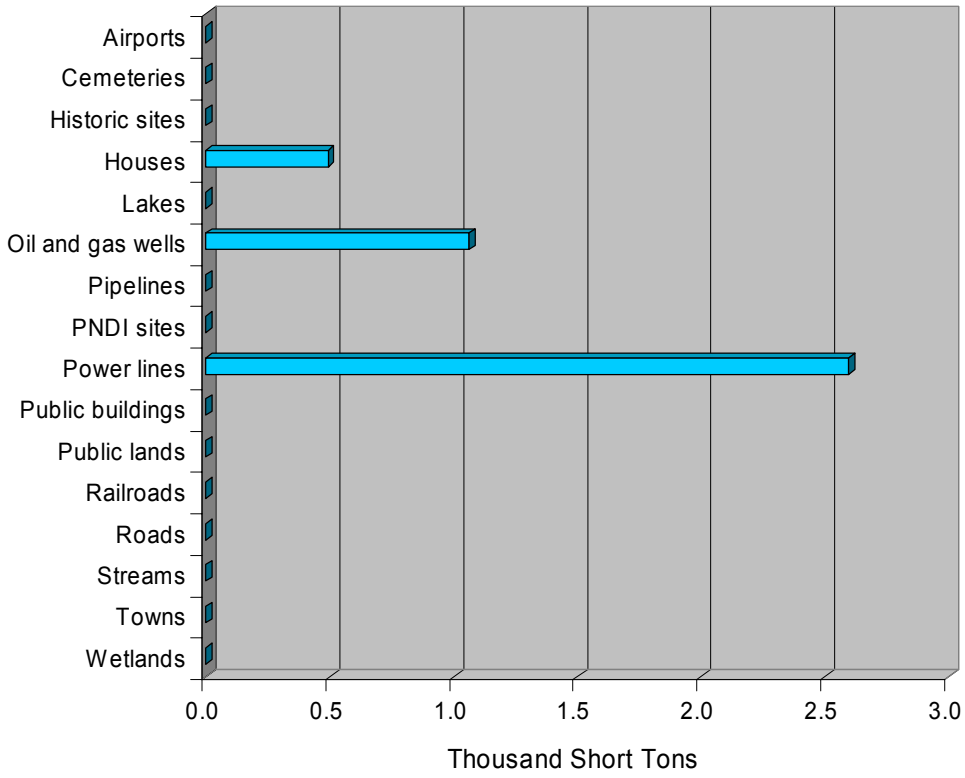


Figure 56. Impact of individual land-use restrictions on the Upper Kittanning coal.

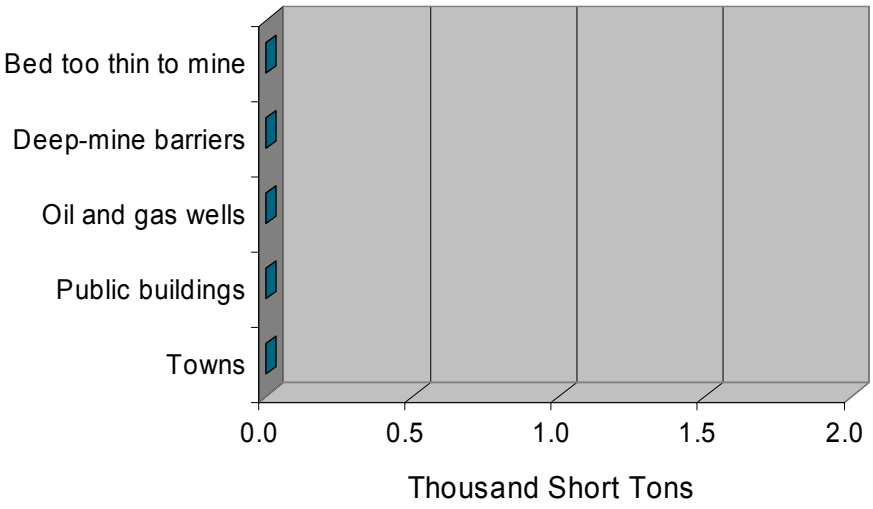


Figure 57. Impact of individual technologic restrictions on the Upper Kittanning coal.

LOWER FREEPORT COAL

The estimated original resources of the Lower Freeport coal are also included for completeness and are only about 44 thousand short tons, constituting an insignificant percentage of the total original coal resources of the study area (Figure 59, Table B–22). Over 95 percent of the original resources is greater than 28 inches thick. All of the original resources are classified as identified, and more than 95 percent of this falls within the category of demonstrated resources. That is, all of the demonstrated original resources are greater than 28 inches thick.

Mining has been by surface operations and has resulted in the extraction of over 34 thousand short tons of coal, representing nearly 78 percent of the original resources (Figures 20 and 59, Table B–22). Deep mining has been negligible.

The remaining coal resources of the Lower Freeport are only about 9,800 short tons, or just over 22 percent of the estimated original resources (Figure 59, Table B–22). A map showing the areal distribution of the remaining coal is presented in Figure 60. The remaining resources greater than 28 inches thick total the same—about 9,800 short tons—representing all of the remaining resources. Moreover, the demonstrated remaining resources make up all of the remaining resources.

Figure 58. Distribution of available resources for the Upper Kittanning coal.

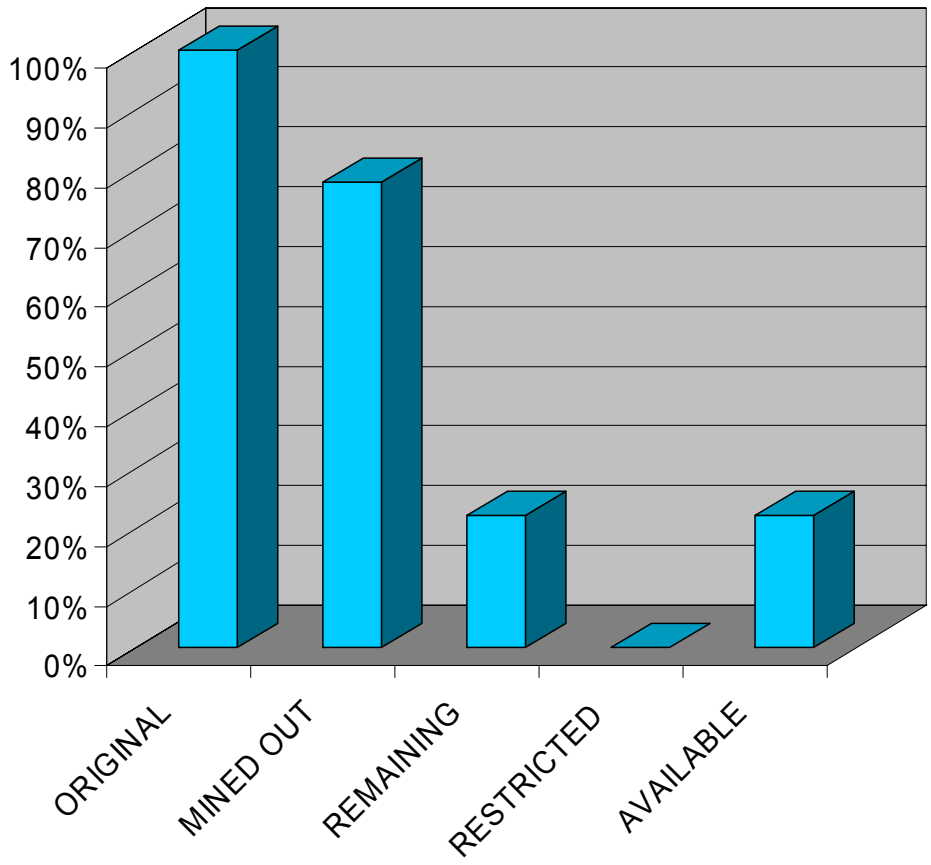


Figure 59. Original, mined-out, remaining, restricted, and available coal resources for the Lower Freeport coal in the Strattanville quadrangle.

There are no mining restrictions that apply to the Lower Freeport coal (Figures 23, 59, 61, and 62; Tables B–23 and B–24). Consequently, the remaining resources and available resources are the same.

Available Lower Freeport coal is only about 9,800 short tons, representing just over 22 percent of the original resources (Figure 59, Table B–22). A map showing the distribution of available coal for the study area is given in Figure 63. All of the available coal is classified as strippable. The available coal greater than 28 inches thick is also about 9,800 short tons, thus constituting all of the available resources. The demonstrated available resources make up all of the coal available for mining. Likewise, all of the available resources greater than 28 inches thick fall within the demonstrated category. Consequently, the demonstrated available resources greater than 28 inches thick are the same as both the demonstrated available resources and available resources.

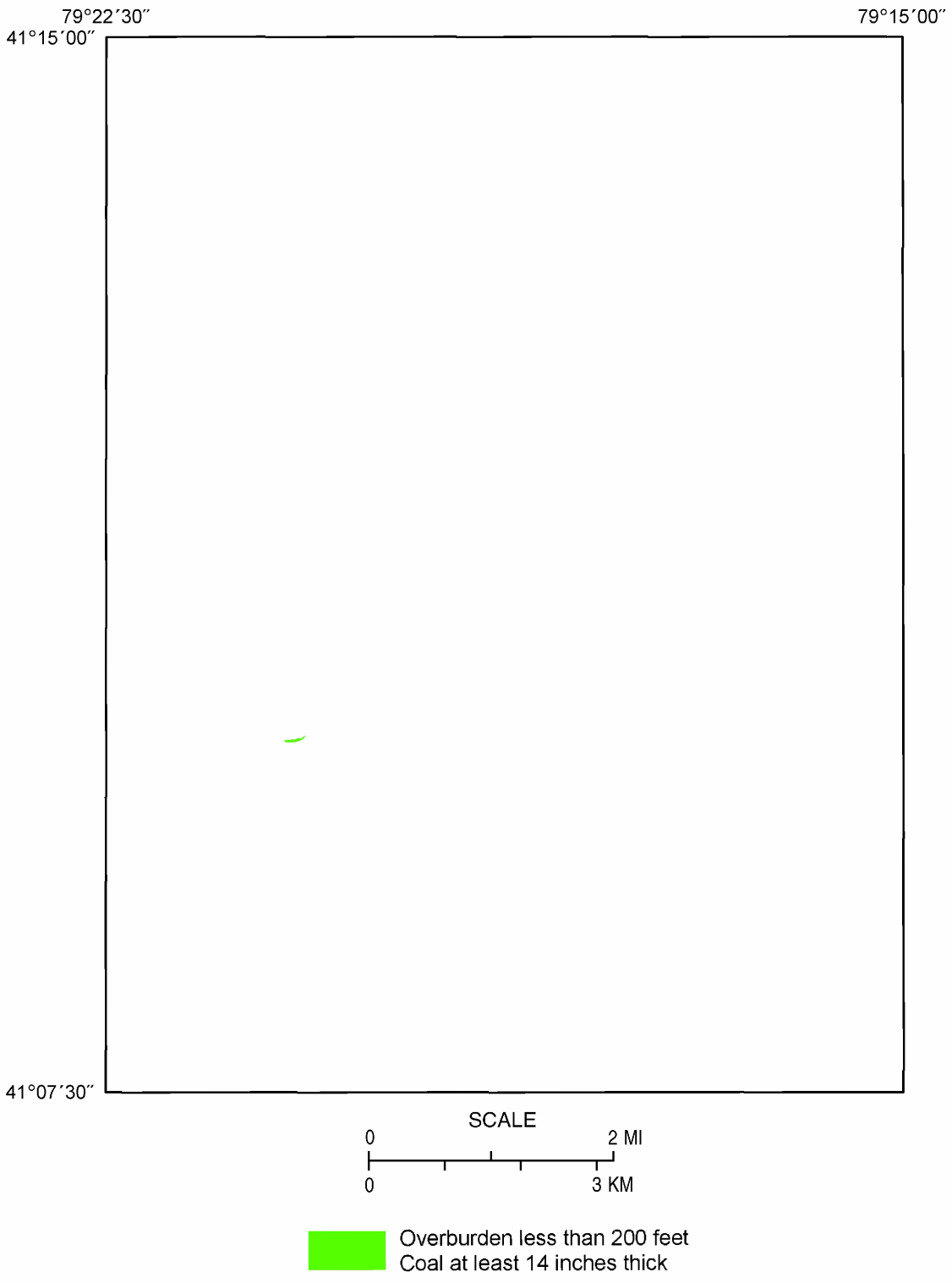


Figure 60. Distribution of remaining resources for the Lower Freeport coal.

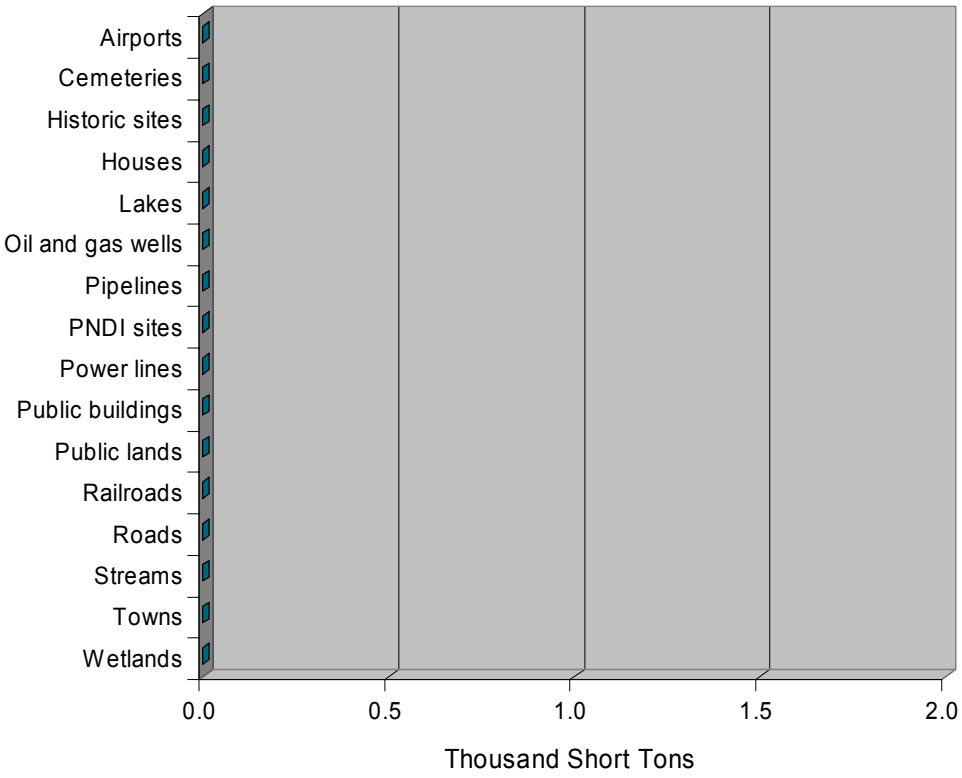


Figure 61. Impact of individual land-use restrictions on the Lower Freeport coal.

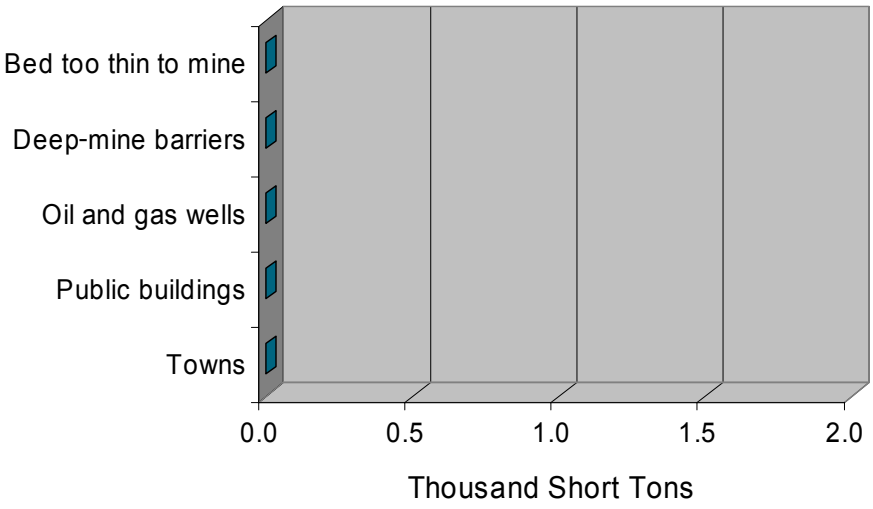


Figure 62. Impact of individual technologic restrictions on the Lower Freeport coal.

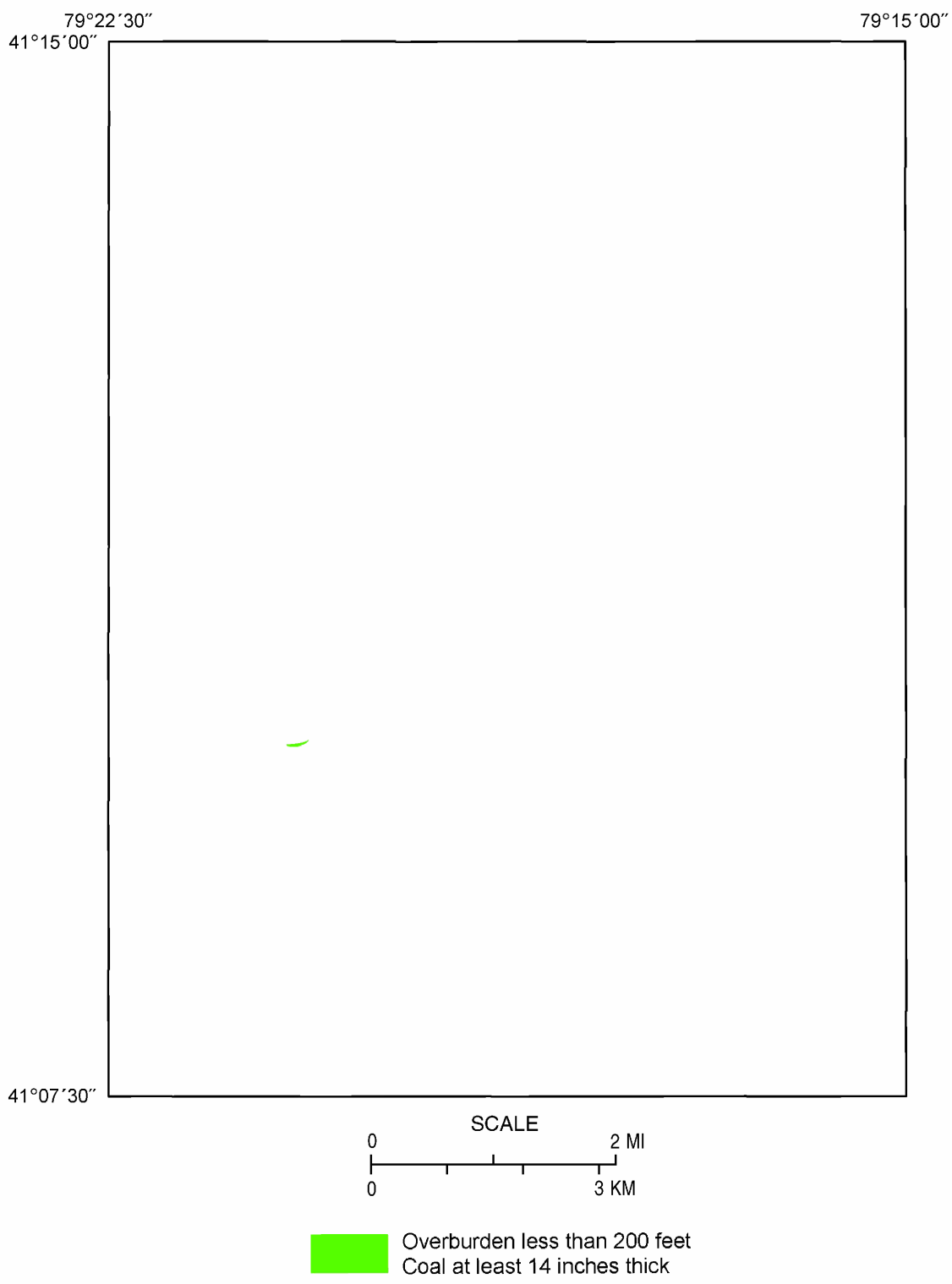


Figure 63. Distribution of available resources for the Lower Freeport coal.

COAL QUALITY

Some geochemical analyses are available for the coals of the Strattanville CA Study area. Three parameters that particularly affect coal quality and therefore minability are ash content, sulfur content, and heat (gross calorific) value. Available analyses commonly include one or more of these parameters above all others. Consequently, this discussion is limited to these three important coal-quality parameters. For consistency, the analyses are for point data (whole-seam samples) from the designated area used in the Strattanville Study to determine coal-resource estimates based on reliability categories (i.e., extending 3 miles outside of the Strattanville 7.5-minute quadrangle). A total of 96 analyses were selected for this area. Of the total analyses, 75 percent is from outside the Strattanville quadrangle itself and about one third is from the designated portion of the Corsica quadrangle. Thus, the quality data are not evenly distributed.

According to the USGS, ash content of coal is classified into categories on the as-received basis as low (less than 8 weight percent total ash), medium (8 to 15 weight percent total ash), and high (greater than 15 weight percent total ash). Sulfur content of coal is classified on the as-received basis as low (1 weight percent or less total sulfur), medium (more than 1 weight percent and less than 3 weight percent total sulfur), and high (3 weight percent or more total sulfur). (See Wood and others, 1983.)

Coal-quality data for the Strattanville area are summarized in Tables 4 to 6, for ash content, sulfur content, and heat value, respectively. The coals are mostly medium in ash and medium to high in sulfur. Zeilinger and Deurbrouck (1968) have reported on the preparation characteristics of coals from Clarion County and have classified the coals as generally medium to high in ash and sulfur. For use in steam or power generation, most of the coals in Clarion County require cleaning. In 1966, for example, nearly three quarters of all the coal mined was mechanically cleaned (Zeilinger and Deurbrouck, 1968). Although total Clarion County production is now considerably lower, the relative amount of coal cleaned today is nearly the same—about 70 percent of the total in 2001 (T. J. Gillen, Pennsylvania Department of Environmental Protection, written commun., 2002). Some of the production may be blended with coal from other counties to improve the quality for marketing. Because of their relatively high ash and sulfur content, most Clarion County coals are considered weakly coking

Table 4. *Ash-Content Means, Ranges, and Standard Deviations by Coal Bed for Selected Samples From Area Used in the Strattanville Coal Availability Study to Determine Coal-Resource Estimates Based on Reliability Categories*[1,2]

[Measurements are in weight percent, as-received whole-coal basis.]

Coal name	Mean	Minimum	Maximum	Standard deviation	Number of samples
Lower Freeport	N.A.	7.5	7.5	N.A.	1
Upper Kittanning	11.4	10.7	12.1	1.0	2
Middle Kittanning	9.3	4.8	17.3	5.5	4
Lower Kittanning	10.3	5.8	16.3	3.4	11
Lower Kittanning leader	6.3	4.4	7.5	1.7	3
Upper Clarion	15.2	10.4	19.7	3.4	9
Lower Clarion	10.7	5.4	17.3	3.2	13
Upper Mercer no. 2	N.D.	N.D.	N.D.	N.D.	0

[1]Data used in statistical analysis from Lord and others (1913a), Skema and others (1975), Sponseller (1973), Zeilinger and Deurbrouck (1968), and unpublished records on file at the Pennsylvania Geological Survey.
[2]Include point data up to 3 miles outside the Strattanville 7.5-minute quadrangle. Some of the coal-quality data are for samples not used to estimate coal resources. N.A., not applicable; N.D., no data.

Table 5. *Sulfur-Content Means, Ranges, and Standard Deviations by Coal Bed for Selected Samples From Area Used in the Strattanville Coal Availability Study to Determine Coal-Resource Estimates Based on Reliability Categories*[1,2]

[Measurements are in weight percent, as-received whole-coal basis.]

Coal name	Mean	Minimum	Maximum	Standard deviation	Number of samples
Lower Freeport	1.5	0.8	2.3	1.1	2
Upper Kittanning	1.6	0.8	2.9	0.9	6
Middle Kittanning	2.0	0.7	3.1	1.0	18
Lower Kittanning	2.5	0.7	6.4	1.5	25
Lower Kittanning leader	1.2	1.0	1.3	0.1	3
Upper Clarion	5.7	2.8	11.8	2.4	17
Lower Clarion	5.9	3.2	16.5	3.5	21
Upper Mercer no. 2	3.4	1.6	4.2	1.2	4

[1]Data used in statistical analysis from Lord and others (1913a), Skema and others (1975), Sponseller (1973), Zeilinger and Deurbrouck (1968), and unpublished records on file at the Pennsylvania Geological Survey.
[2]Include point data up to 3 miles outside the Strattanville 7.5-minute quadrangle. Some of the coal-quality data are for samples not used to estimate coal resources.

Table 6. *Heat-Value Means, Ranges, and Standard Deviations by Coal Bed for Selected Samples From Area Used in the Strattanville Coal Availability Study to Determine Coal-Resource Estimates Based on Reliability Categories*[1,2]

[Measurements are in British thermal units per pound, as-received whole-coal basis.]

Coal name	Mean	Minimum	Maximum	Standard deviation	Number of samples
Lower Freeport	N.A.	13,241	13,241	N.A.	1
Upper Kittanning	12,794	12,772	12,815	30	2
Middle Kittanning	12,995	12,324	14,120	981	3
Lower Kittanning	13,162	12,270	13,859	535	9
Lower Kittanning leader	13,056	12,960	13,188	118	3
Upper Clarion	12,512	11,375	13,547	642	9
Lower Clarion	13,009	11,777	13,938	599	13
Upper Mercer no. 2	N.D.	N.D.	N.D.	N.D.	0

[1]Data used in statistical analysis from Skema and others (1975), Sponseller (1973), Zeilinger and Deurbrouck (1968), and unpublished records on file at the Pennsylvania Geological Survey.
[2]Include point data up to 3 miles outside the Strattanville 7.5-minute quadrangle. Some of the coal-quality data are for samples not used to estimate coal resources. N.A., not applicable; N.D., no data.

(Birge and others, 1963) and generally cannot be upgraded by cleaning to metallurgical quality (Zeilinger and Deurbrouck, 1968).

All of the coals in the Strattanville quadrangle and elsewhere as well in Clarion County are high-volatile A bituminous in rank (Birge and others, 1963). Coals of this rank contain less than 69 weight percent fixed carbon on the dry, mineral-matter-free basis; more than 31 weight percent volatile matter on the dry, mineral-matter-free basis; and a heat value of 14,000 or more British thermal units (Btu) per pound on the moist, mineral-matter-free basis (American Society for Testing and Materials, 2001). On the as-received basis, Pennsylvania coal will generally yield about 1,000 to 3,000 Btu per pound less than the moist, mineral-matter-free value. As-received heat values for coals in the Strattanville study area consistently fall within this range.

COAL DESCRIPTIONS

Coal-quality data exist for each of the eight coals studied for availability. However, information is generally lacking for the Upper Mercer no. 2 coal and most abundant for the heavily mined beds, including the Lower Clarion, Upper Clarion, Lower Kittanning, and Middle Kittanning coals.

Upper Mercer No. 2 Coal

There are no data on ash content and heat value for the Upper Mercer no. 2 coal in the Strattanville area (Tables 4 and 6, respectively). However, their values are likely to be comparable to those of the overlying Lower and Upper Clarion coals because all three coals were deposited as peat in similar depositional settings. Therefore, it is likely that the Upper Mercer no. 2 is mostly medium in ash and has heat values on an as-received basis in the range of 12,500 to 13,500 Btu per pound. The coal is generally high in sulfur. The mean sulfur content of the Upper Mercer no. 2 is 3.4±1.6 weight percent on an as-received basis (Table 5).

Lower Clarion Coal

The Lower Clarion coal is mostly medium in ash, having a mean ash content of 10.7±3.2 weight percent (Table 4). It is high in sulfur and has a mean sulfur content of 5.9±3.5 weight percent (Table 5). The highest reported values of sulfur are from overburden test-hole data. These values are probably excessive and reflect the inclusion of thick pyrite lenses that normally would be excluded from the coal using standard sampling practices (e.g., see Schopf, 1960). The mean heat value of the Lower Clarion is 13,009±599 Btu per pound (Table 6).

Upper Clarion Coal

The Upper Clarion coal is medium to high in ash and high in sulfur (Tables 4 and 5). The mean ash content is 15.2±3.4 weight percent, and the mean sulfur content is 5.7±2.4 weight percent. As is the case for the Lower Clarion coal, the highest reported sulfur values for the Upper Clarion are from overburden data. The mean heat value of the Upper Clarion is 12,512±642 Btu per pound (Table 6).

Lower Kittanning Leader Coal

From limited data (three samples), the Lower Kittanning leader coal appears to be low in ash (Table 4). The mean ash content is 6.3±1.7 weight percent. It is medium in sulfur, having a mean sulfur content of 1.2±0.1 weight percent (Table 5). This is the lowest mean sulfur value for any of the coals. The mean heat value of the Lower Kittanning leader is 13,056±118 Btu per pound (Table 6).

Lower Kittanning Coal

The Lower Kittanning coal is low to medium in ash and medium to high in sulfur (Tables 4 and 5). It has a mean ash content of 10.3±3.4 weight percent and a mean sulfur content of 2.5±1.5 weight percent. The mean heat value of the Lower Kittanning is 13,162±535 Btu per pound (Table 6), the highest reported mean for any of the coals.

Middle Kittanning Coal

The Middle Kittanning coal is mostly medium in both ash and sulfur (Tables 4 and 5). The mean ash content is 9.3±5.5 weight percent, and the mean sulfur value is 2.0±1.0 weight percent. The heat value of the Middle Kittanning has a mean of 12,995±981 Btu per pound (Table 6).

Upper Kittanning Coal

Although data are limited, the Upper Kittanning coal is medium in ash (Table 4). The mean ash content is 11.4±1.0 weight percent. The sulfur content is mostly medium, having a mean value of 1.6±0.9 weight percent (Table 5). The mean heat value of the Upper Kittanning is 12,794±30 Btu per pound (Table 6).

Lower Freeport Coal

There is very little coal-quality information available for the Lower Freeport coal. The ash content is probably low to mostly medium (Table 4). The one value reported is 7.5 weight percent. The coal appears to be mostly medium in sulfur (Table 5). The mean sulfur content is 1.5±1.1 weight percent. The reported low sulfur value is from a site with little cover. Consequently, the sulfur content may be somewhat lower than normal because the coal was probably slightly weathered. The one reported heat value for the Lower Freeport is 13,241 Btu per pound (Table 6).

SUMMARY

The Strattanville CA Study is based on information that is current to 1993. Eight coals were identified for consideration and investigation to determine their availability for future mining. The coals include, in ascending stratigraphic order (oldest to youngest), the Upper Mercer no. 2, Lower Clarion, Upper Clarion, Lower Kittanning leader, Lower Kittanning,

Middle Kittanning, Upper Kittanning, and Lower Freeport. Only the Upper Mercer no. 2 coal occurs within the Pottsville Formation; all others are in the Allegheny Formation. The most important coals are the thickest and most laterally persistent, and have been mined extensively in the past. These coals include the Lower Clarion, Upper Clarion, Lower Kittanning, and Middle Kittanning.

For each of the eight coals, estimates are made for five resource categories—original, mined out, remaining, restricted (both land use and technologic), and available. In addition, estimated coal resources are determined for categories of overburden thickness (0–200 feet, 200–1000 feet, and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). None of the coals have any resources that fall within the hypothetical category. All of the detailed information is summarized in Appendices A and B.

Of the estimated 195 million short tons of bituminous coal originally present in the Strattanville 7.5-minute quadrangle, approximately 29 million short tons, or about 15 percent, has been mined out and lost in mining. An additional 60 million short tons of coal, or about 31 percent, is excluded due to resource restrictions, leaving only about 106 million short tons available for mining, or about 55 percent of the original coal resources (Figure 21). From the standpoint of availability, the most important coals are the Lower Clarion and Upper Clarion, which are generally mined together. Together, they contribute almost 67 million short tons, or nearly 63 percent of the total available coal (Appendix B).

Most of the coals in Clarion County are medium to high in ash and sulfur, and require cleaning for use in steam or power generation. Overall, the coals are considered weakly coking and generally cannot be upgraded by cleaning to metallurgical quality. For the study area, the coals are mostly medium in ash and medium to high in sulfur. The same conclusions regarding overall coal quality are expected to apply to the Strattanville quadrangle as they do elsewhere in the county.

ACKNOWLEDGMENTS

This study has been a team effort, involving a number of Pennsylvania Geological Survey staff members. John C. Neubaum gathered information on resource restrictions; digitized most of the coal crop lines and mined-out areas using ArcInfo software; created point, line, and

polygon coverages of the restrictions; and prepared many of the graphics used in the report. Thomas G. Whitfield created the buffers for the resource-restriction coverages, attributed and "cleaned up" various GIS files, and did any other necessary work to prepare the coverages prior to running the AMLs. Michael E.Moore worked as liaison with the contractor who redesigned the AMLs for several of our coal availability studies, including this one. Moore also created the Access database for the stratigraphic information on coal that was used for the resource estimates, processed the data using the AMLs, designed procedures for the graphic output of map illustrations, and prepared several of the maps. Rodger T. Faill compiled much of the information for the tables in Appendices A and B. Helen L. Delano produced many of the maps for the final report. Christine E. Miles provided advice and training in software and GIS applications throughout the project, and subsequently helped revise and reformat many of the illustrations. To all of the staff, my sincerest thanks and appreciation.

Thanks to Caleb Conrad, my summer intern, for inputting much of the coal information into the Access stratigraphic database. Joseph M. Tarantino, Knox District Office, Bureau of District Mining Operations, Pennsylvania Department of Environmental Protection, generously gave of his time and helped me find and copy numerous drill-hole records and accompanying location maps used in this study.

Andrew Ross of Advanced Technology Solutions, Inc. (ATS) was contracted by the Pennsylvania Geological Survey to redesign a series of AML commands for use in our studies, based on methods and procedures developed by the Montana Bureau of Mines and Geology and the Illinois Geological Survey. His assistance and expertise are gratefully acknowledged.

This report benefited from thorough reviews by Joseph M. Tarantino, P.G., Knox District Office, Bureau of District Mining Operations, Pennsylvania Department of Environmental Protection, and by Keith B. C. Brady, P.G., Bureau of Mining and Reclamation, Pennsylvania Department of Environmental Protection. Their comments and suggestions are greatly appreciated.

REFERENCES

American Society for Testing and Materials, 2001, Annual book of ASTM standards; volume 05.06, gaseous fuels; coal and coke: Philadelphia, Pennsylvania, 638 p.

Ashley, G. H., 1928, Bituminous coal fields of Pennsylvania—Part I, General information on coal: Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 6, 241 p.

———, 1944, Part II, Mineral resources, in Pennsylvania Department of Internal Affairs, and The Pennsylvania State College, Pennsylvania's mineral heritage: Commonwealth of Pennsylvania, Department of Internal Affairs, p. 73–200.

Birge, G. W., Wolfson, D. E., and Lynch, J. H., Jr., 1963, Carbonizing properties of coals from Elk, Clarion, Jefferson, Clearfield, and Centre Counties, Pa.: U.S. Bureau of Mines Report of Investigations 6261, 22 p.

Blaylock, D. W., Dowd, J. J., Abernethy, R. F., and Reynolds, D. A., 1956, Estimate of known recoverable reserves of coking coal in Clarion County, Pa.: U.S. Bureau of Mines Report of Investigations 5231, 27 p.

Carter, M. D., Rohrbacher, T. J., Teeters, D. D., and others, 2001, Chapter J—Coal availability, recoverability, and economic evaluations of coal resources in the northern and central Appalachian basin coal regions, in Northern and Central Appalachian Basin Coal Regions Assessment Team, 2000 resource assessment of selected coal beds and zones in the northern and central Appalachian basin coal regions: U.S. Geological Survey Professional Paper 1625–C, version 1.0, CD–ROM.

Cecil, C. B., Stanton, R. W., Neuzil, S. G., and others, 1985, Paleoclimate controls on late Paleozoic sedimentation and peat formation in the central Appalachian basin (U.S.A.), in Phillips, T. L., and others, eds., Paleoclimatic controls on coal resources of the Pennsylvanian System of North America: International Journal of Coal Geology, v. 5, p. 195–230.

Chance, H. M., 1880, The geology of Clarion County: Pennsylvania Geological Survey, 2nd ser., Report VV, 232 p.

Dodge, C. H., 1992, Mode of occurrence of the Luthersburg coal, Allegheny Formation (Middle Pennsylvanian), in Elk County, Pennsylvania, and some regional implications [abs.]:

Geological Society of America Abstracts with Programs, Northeastern Section, v. 24, no. 3, p. 17.

Edmunds, W. E., 1968, Geology and mineral resources of the northern half of the Houtzdale 15-minute quadrangle, Pennsylvania, 4th ser., Atlas 85ab, 150 p.

———, 1972, Coal reserves of Pennsylvania: total, recoverable, and strippable (January 1, 1970): Pennsylvania Geological Survey, 4th ser., Information Circular 72, 40 p.

Glover, A. D., 1987, compiler, Coal resources of Clarion County, Pennsylvania—Part 1, Coal crop lines, mined-out areas, and structure contours: Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 92, 116 p.

Lines, E. F., 1907, Coals of the Clarion quadrangle, Clarion County, Pa., in Campbell, M. R., Contributions to economic geology, 1906—Part II, Coal, lignite, and peat: U.S. Geological Survey Bulletin 316, p. 13–19.

Lord, N. W., Holmes, J. A., Stanton, F. M., and others, 1913a, Analyses of coals in the United States, with descriptions of mine and field samples collected between July 1, 1904, and June 30, 1910—Part I, Analyses: U.S. Bureau of Mines Bulletin 22, p. 3–321.

———, 1913b, Analyses of coals in the United States, with descriptions of mine and field samples collected between July 1, 1904, and June 30, 1910—Part II, Descriptions of samples: U.S. Bureau of Mines Bulletin 22, p. 323–1200.

Patterson, E. D., 1963, Coal resources of Beaver County, Pennsylvania: U.S. Geological Survey Bulletin 1143–A, p. A1–A33.

Patterson, E. D., and Van Lieu, J. A., 1971, Coal resources of Butler County, Pennsylvania: U.S. Geological Survey Bulletin 1143–C, p. C1–C43.

———, 1972, Geologic and coal-bed map of Clarion County, Pennsylvania: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–715, scale 1:62,500.

Reese, J. F., and Sisler, J. D., 1928, Bituminous coal fields of Pennsylvania—Part III, Coal resources: Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 6, 153 p.

Rogers, H. D., 1858, The geology of Pennsylvania—A government survey: Philadelphia, J. B. Lippincott, v. 2, 1,045 p.

Schopf, J. M., 1960, Field description and sampling of coal beds: U.S. Geological Survey Bulletin 1111–B, p. 25–70.

Sevon, W. D., 2000, Physiographic provinces of Pennsylvania (4th ed.): Pennsylvania Geological Survey, 4th ser., Map 13, scale 1:2,000,000.

Shaw, E. W., Lines, E. F., and Munn, M. J., 1911, Foxburg-Clarion folio, Pennsylvania [Clarion, Armstrong, Butler, and Venango Counties]: U.S. Geological Survey Geologic Atlas of the U.S., Folio 178, 17 p.

Sholes, M. A., and Skema, V. W., 1974, Bituminous coal resources in western Pennsylvania: Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 68, 13 coal distribution maps, scale 1:250,000.

Sisler, J. D., 1926, Bituminous coal fields of Pennsylvania—Part II, Detailed description of coal fields: Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 6, Pt. 2, 511 p.

Skema, V. W., Berg, T. M., Bragonier, W. A., and others, 1975, Analyses and measured sections of Pennsylvania bituminous coals, Part II: Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 69, 306 p.

Sponseller, R. D., 1973, Analyses and measured sections of Pennsylvania bituminous coals: Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 66, 479 p.

U.S. Bureau of Mines, 1928, Bituminous coal fields of Pennsylvania—Part IV, Coal analyses (2nd ed.): Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 6, Pt. 4, 268 p.

Van Lieu, J. A., and Patterson, E. D., 1964, Coal resources of Lawrence County, Pennsylvania: U.S. Geological Survey Bulletin 1143–B, p. B1–B33.

Williams, E. G., 1960, Marine and fresh water fossiliferous beds in the Pottsville and Allegheny Groups of western Pennsylvania: Journal of Paleontology, v. 34, no. 5, p. 908–922.

Wood, G. H., Jr., Kehn, T. M., Carter, M. D., and Culbertson, W. C., 1983, Coal resource classification system of the U.S. Geological Survey: U.S. Geological Survey Circular 891, 65 p.

Zeilinger, J. E., and Deurbrouck, A. W., 1968, Preparation characteristics of coal from Clarion County, Pa.: U.S. Bureau of Mines Report of Investigations 7174, 34 p.

[PAGE INTENTIONALLY BLANK]

APPENDICES

APPENDIX A. SUMMARY COAL-RESOURCE TABLES FOR ALL INVESTIGATED COAL BEDS IN THE STRATTANVILLE QUADRANGLE

Table A–1. *Estimated Coal Resources Unavailable due to Land-Use and Technologic Restrictions for All Investigated Coal Beds*

[Numbers may not total exactly because of independent rounding. Quantities are in short tons.]

LAND-USE RESTRICTIONS—SURFACE (0 to 200 feet)									
Coal bed	Airports	Ceme-teries	Historic sites	Houses	Lakes	Oil and gas wells	Pipelines	PNDI sites	Power lines
Lower Freeport	0	0	0	0	0	0	0	0	0
Upper Kittanning	0	0	0	493	0	1,062	0	0	2,597
Middle Kittanning	0	0	0	240,144	0	21,132	0	0	40,388
Lower Kittanning	0	16,366	0	2,299,503	51,679	66,612	42,522	0	223,597
Lower Kittanning leader	0	11,226	0	2,586,534	50,948	45,725	5,855	0	132,391
Upper Clarion	0	86,371	0	7,640,726	237,018	175,665	56,921	0	408,108
Lower Clarion	0	119,762	0	10,122,595	400,047	227,482	291,913	0	481,707
Upper Mercer no. 2	0	65,963	0	3,451,811	94,861	143,221	643,405	0	123,098
TOTALS	0	299,688	0	26,341,806	834,553	680,899	1,040,616	0	1,411,886

LAND-USE RESTRICTIONS—SURFACE (0 to 200 feet)								
Public buildings	Public lands	Railroads	Roads	Streams	Towns	Wetlands	TOTALS	Coal bed
0	0	0	0	0	0	0	0	Lower Freeport
0	0	0	0	0	0	0	4,152	Upper Kittanning
0	2,611	0	100,579	0	4,006	4,442	413,302	Middle Kittanning
69,202	72,364	50,692	1,085,285	54,522	757,090	26,158	4,815,592	Lower Kittanning
128,966	1,136	72,952	880,211	71,199	419,990	47,670	4,454,803	Lower Kittanning leader
257,550	834,372	403,567	3,626,527	986,652	1,465,022	519,290	16,697,789	Upper Clarion
335,727	2,363,168	515,169	4,369,802	1,318,321	2,546,960	366,050	23,458,703	Lower Clarion
0	2,882,798	45,292	1,300,402	324,354	0	23,176	9,098,381	Upper Mercer no. 2
791,445	6,156,449	1,087,672	11,362,806	2,755,048	5,193,068	986,786	58,942,722	TOTALS

Table A–1. *(Continued)*

TECHNOLOGIC RESTRICTIONS—DEEP (>200 feet)						
Coal bed	Bed too thin to mine	Deep-mine barriers	Oil and gas wells	Public buildings	Towns	TOTALS
Lower Freeport	0	0	0	0	0	0
Upper Kittanning	0	0	0	0	0	0
Middle Kittanning	0	0	0	0	0	0
Lower Kittanning	0	0	1,286	0	0	1,286
Lower Kittanning leader	1,945	0	0	0	0	1,945
Upper Clarion	168,466	0	4,019	0	0	172,485
Lower Clarion	572,833	0	0	0	0	572,833
Upper Mercer no. 2	473,548	0	0	0	0	473,548
TOTALS	1,216,792	0	5,305	0	0	1,222,097

COMBINED RESTRICTIONS			
Coal bed	Land Use	Technologic	GRAND TOTAL
Lower Freeport	0	0	0
Upper Kittanning	4,152	0	4,152
Middle Kittanning	413,302	0	413,302
Lower Kittanning	4,815,592	1,286	4,816,878
Lower Kittanning leader	4,454,803	1,945	4,456,748
Upper Clarion	16,697,789	172,485	16,870,274
Lower Clarion	23,458,703	572,833	24,031,536
Upper Mercer no. 2	9,098,381	473,548	9,571,929
TOTALS	58,942,722	1,222,097	60,164,819

Table A–2. *Estimated Original, Mined, Remaining, Restricted, and Available Coal Resources for All Investigated Coal Beds*

[Numbers may not total exactly because of independent rounding. Quantities are in short tons.]

SUMMARY TABLE OF RESOURCE CATEGORIES									
	ORIGINAL RESOURCES			MINED-OUT RESOURCES			REMAINING RESOURCES		
Coal bed	0–200 FT	>200 FT	TOTAL	0–200 FT	>200 FT	TOTAL	0–200 FT	>200 FT	TOTAL
Lower Freeport	44,076	0	44,076	34,298	0	34,298	9,778	0	9,778
Upper Kittanning	172,560	0	172,560	15,367	0	15,367	157,193	0	157,193
Middle Kittanning	4,996,555	0	4,996,555	1,821,131	0	1,821,131	3,175,424	0	3,175,424
Lower Kittanning	26,395,287	8,124	26,403,411	11,300,350	0	11,300,350	15,094,937	8,124	15,103,061
Lower Kittanning leader	13,094,440	1,945	13,096,385	244,734	0	244,734	12,849,706	1,945	12,851,651
Upper Clarion	50,919,486	190,439	51,109,925	4,371,799	0	4,371,799	46,547,687	190,439	46,738,126
Lower Clarion	70,951,615	688,059	71,639,674	10,714,692	0	10,714,692	60,236,923	688,059	60,924,982
Upper Mercer no. 2	26,975,633	473,548	27,449,181	22,578	0	22,578	26,953,055	473,548	27,426,603
TOTALS	193,549,652	1,362,115	194,911,767	28,524,949	0	28,524,949	165,024,703	1,362,115	166,386,818

SUMMARY TABLE OF RESOURCE CATEGORIES						
RESTRICTED RESOURCES			AVAILABLE RESOURCES			
0–200 FT	>200 FT	TOTAL	0–200 FT	>200 FT	TOTAL	Coal bed
0	0	0	9,778	0	9,778	Lower Freeport
4,152	0	4,152	153,041	0	153,041	Upper Kittanning
413,302	0	413,302	2,762,122	0	2,762,122	Middle Kittanning
4,815,592	1,286	4,816,878	10,279,345	6,838	10,286,183	Lower Kittanning
4,454,803	1,945	4,456,748	8,394,903	0	8,394,903	Lower Kittanning leader
16,697,789	172,485	16,870,274	29,849,898	17,954	29,867,852	Upper Clarion
23,458,703	572,833	24,031,536	36,778,220	115,226	36,893,446	Lower Clarion
9,098,381	473,548	9,571,929	17,854,674	0	17,854,674	Upper Mercer no. 2
58,942,722	1,222,097	60,164,819	106,081,981	140,018	106,221,999	TOTALS

APPENDIX B. INDIVIDUAL COAL-RESOURCE TABLES FOR EACH INVESTIGATED COAL BED IN THE STRATTANVILLE QUADRANGLE

Table B–1. *Estimated Coal Resources of the Upper Mercer No. 2 Coal*

[Estimated coal resources are subdivided into categories of overburden thickness (0–200 feet, 200–1000 feet, and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). Numbers may not total exactly because of independent rounding. Quantities are in short tons.]

		Overburden intervals (feet)	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
			MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
			14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Original		0–200	1,044,982	759,094	1,804,076	3,910,885	4,419,302	8,330,187	12,312,810	4,528,560	16,841,370	0	0	0	17,268,677	9,706,956	26,975,633
		200–1000	99,773	0	99,773	306,348	0	306,348	67,427	0	67,427	0	0	0	473,548	0	473,548
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	1,144,755	759,094	1,903,849	4,217,233	4,419,302	8,636,535	12,380,237	4,528,560	16,908,797	0	0	0	17,742,225	9,706,956	27,449,181
Mined Out	Surface	0–200	0	20,864	20,864	0	0	0	1,714	0	1,714	0	0	0	1,714	20,864	22,578
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	20,864	20,864	0	0	0	1,714	0	1,714	0	0	0	1,714	20,864	22,578
	Deep	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0–200	0	20,864	20,864	0	0	0	1,714	0	1,714	0	0	0	1,714	20,864	22,578
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	20,864	20,864	0	0	0	1,714	0	1,714	0	0	0	1,714	20,864	22,578
Remaining		0–200	1,044,982	738,230	1,783,212	3,910,885	4,419,302	8,330,187	12,311,096	4,528,560	16,839,656	0	0	0	17,266,963	9,686,092	26,953,055
		200–1000	99,773	0	99,773	306,348	0	306,348	67,427	0	67,427	0	0	0	473,548	0	473,548
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	1,144,755	738,230	1,882,985	4,217,233	4,419,302	8,636,535	12,378,523	4,528,560	16,907,083	0	0	0	17,740,511	9,686,092	27,426,603

Table B–1. *(Continued)*

		Overburden intervals (feet)	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
			MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
			14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Remaining		0–200	1,044,982	738,230	1,783,212	3,910,885	4,419,302	8,330,187	12,311,096	4,528,560	16,839,656	0	0	0	17,266,963	9,686,092	26,953,055
		200–1000	99,773	0	99,773	306,348	0	306,348	67,427	0	67,427	0	0	0	473,548	0	473,548
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	1,144,755	738,230	1,882,985	4,217,233	4,419,302	8,636,535	12,378,523	4,528,560	16,907,083	0	0	0	17,740,511	9,686,092	27,426,603
Restrictions	Land Use	0–200	138,846	114,263	253,109	1,020,973	1,804,167	2,825,140	4,517,808	1,502,324	6,020,132	0	0	0	5,677,627	3,420,754	9,098,381
		200–1000	Land-use restrictions do not apply for overburden thicknesses >200 feet														
		>1000															
		TOTAL	138,846	114,263	253,109	1,020,973	1,804,167	2,825,140	4,517,808	1,502,324	6,020,132	0	0	0	5,677,627	3,420,754	9,098,381
	Technologic	0–200	Technologic restrictions do not apply for overburden thicknesses ≤200 feet														
		200–1000	99,773	0	99,773	306,348	0	306,348	67,427	0	67,427	0	0	0	473,548	0	473,548
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	99,773	0	99,773	306,348	0	306,348	67,427	0	67,427	0	0	0	473,548	0	473,548
	Total	0–200	138,846	114,263	253,109	1,020,973	1,804,167	2,825,140	4,517,808	1,502,324	6,020,132	0	0	0	5,677,627	3,420,754	9,098,381
		200–1000	99,773	0	99,773	306,348	0	306,348	67,427	0	67,427	0	0	0	473,548	0	473,548
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	238,619	114,263	352,882	1,327,321	1,804,167	3,131,488	4,585,235	1,502,324	6,087,559	0	0	0	6,151,175	3,420,754	9,571,929
Available		0–200	906,136	623,967	1,530,103	2,889,912	2,615,135	5,505,047	7,793,288	3,026,236	10,819,524	0	0	0	11,589,336	6,265,338	17,854,674
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	906,136	623,967	1,530,103	2,889,912	2,615,135	5,505,047	7,793,288	3,026,236	10,819,524	0	0	0	11,589,336	6,265,338	17,854,674

Table B–2. *Estimated Remaining Coal Resources of the Upper Mercer No. 2 Coal Unavailable Due to Land-Use Restrictions*

[Land-use restrictions apply only where overburden thickness is from 0 to 200 feet (subject to surface mining). The remaining coal resources are subdivided into categories of reliability of estimate (measured, indicated, inferred, and hypothetical) and coal thickness (14–28 inches and >28 inches). Numbers may not total exactly because of independent rounding. Quantities are in short tons.]

LAND-USE RESTRICTIONS	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
	MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Airports	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cemeteries	0	0	0	0	0	0	65,963	0	65,963	0	0	0	65,963	0	65,963
Historic sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	53,400	6,284	59,684	470,022	780,350	1,250,372	1,575,825	565,930	2,141,755	0	0	0	2,099,247	1,352,564	3,451,811
Lakes	10,607	0	10,607	20,856	7,802	28,658	55,596	0	55,596	0	0	0	87,059	7,802	94,861
Oil and gas wells	4,019	0	4,019	7,743	12,547	20,290	112,237	6,675	118,912	0	0	0	123,999	19,222	143,221
Pipelines	17,239	29,173	46,412	28,958	185,027	213,985	339,895	43,112	383,008	0	0	0	386,092	257,312	643,405
PNDI sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power lines	14,883	0	14,883	49,438	0	49,438	58,778	0	58,778	0	0	0	123,098	0	123,098
Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public lands	308	6,397	6,705	248,147	694,922	943,068	1,272,649	660,376	1,933,025	0	0	0	1,521,103	1,361,695	2,882,798
Railroads	0	0	0	0	0	0	45,292	0	45,292	0	0	0	45,292	0	45,292
Roads	23,668	71,655	95,323	133,643	60,393	194,035	787,745	223,299	1,011,044	0	0	0	945,055	355,347	1,300,402
Streams	9,268	754	10,022	54,931	63,127	118,058	193,344	2,931	196,275	0	0	0	257,542	66,812	324,354
Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	5,457	0	5,457	7,234	0	7,234	10,485	0	10,485	0	0	0	23,176	0	23,176
Total	138,846	114,263	253,109	1,020,973	1,804,167	2,825,140	4,517,808	1,502,324	6,020,132	0	0	0	5,677,627	3,420,754	9,098,381

Table B–3. *Estimated Remaining Coal Resources of the Upper Mercer No. 2 Coal Unavailable Due to Technologic Restrictions*

[Technologic restrictions apply only where overburden thickness is >200 feet (subject to underground mining). The remaining coal resources are subdivided into categories of overburden thickness (200–1000 feet and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). Quantities are in short tons.]

Overburden	TECHNOLOGIC RESTRICTIONS	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
		MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
		14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
200–1000 feet	Bed too thin to mine	99,773	—	99,773	306,348	—	306,348	67,427	—	67,427	0	—	0	473,548	—	473,548
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	99,773	0	99,773	306,348	0	306,348	67,427	0	67,427	0	0	0	473,548	0	473,548
>1000 feet	Bed too thin to mine	0	—	0	0	—	0	0	—	0	0	—	0	0	—	0
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	Bed too thin to mine	99,773	—	99,773	306,348	—	306,348	67,427	—	67,427	0	—	0	473,548	—	473,548
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	99,773	0	99,773	306,348	0	306,348	67,427	0	67,427	0	0	0	473,548	0	473,548

Table B–4. *Estimated Coal Resources of the Lower Clarion Coal*

[Estimated coal resources are subdivided into categories of overburden thickness (0–200 feet, 200–1000 feet, and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). Numbers may not total exactly because of independent rounding. Quantities are in short tons.]

		Overburden intervals (feet)	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
			MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
			14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Original		0–200	4,585,894	6,312,895	10,898,789	17,194,397	23,368,512	40,562,909	9,376,093	10,113,824	19,489,917	0	0	0	31,156,384	39,795,231	70,951,615
		200–1000	61,502	0	61,502	267,411	105,614	373,025	243,920	9,612	253,532	0	0	0	572,833	115,226	688,059
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	4,647,396	6,312,895	10,960,291	17,461,808	23,474,126	40,935,934	9,620,013	10,123,436	19,743,449	0	0	0	31,729,217	39,910,457	71,639,674
Mined Out	Surface	0–200	883,691	2,896,904	3,780,595	1,291,141	4,628,169	5,919,310	342,063	672,724	1,014,787	0	0	0	2,516,895	8,197,797	10,714,692
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	883,691	2,896,904	3,780,595	1,291,141	4,628,169	5,919,310	342,063	672,724	1,014,787	0	0	0	2,516,895	8,197,797	10,714,692
	Deep	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0–200	883,691	2,896,904	3,780,595	1,291,141	4,628,169	5,919,310	342,063	672,724	1,014,787	0	0	0	2,516,895	8,197,797	10,714,692
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	883,691	2,896,904	3,780,595	1,291,141	4,628,169	5,919,310	342,063	672,724	1,014,787	0	0	0	2,516,895	8,197,797	10,714,692
Remaining		0–200	3,702,203	3,415,991	7,118,194	15,903,256	18,740,343	34,643,599	9,034,030	9,441,100	18,475,130	0	0	0	28,639,489	31,597,434	60,236,923
		200–1000	61,502	0	61,502	267,411	105,614	373,025	243,920	9,612	253,532	0	0	0	572,833	115,226	688,059
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	3,763,705	3,415,991	7,179,696	16,170,667	18,845,957	35,016,624	9,277,950	9,450,712	18,728,662	0	0	0	29,212,322	31,712,660	60,924,982

Table B–4. *(Continued)*

		Overburden intervals (feet)	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
			MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
			14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Remaining		0–200	3,702,203	3,415,991	7,118,194	15,903,256	18,740,343	34,643,599	9,034,030	9,441,100	18,475,130	0	0	0	28,639,489	31,597,434	60,236,923
		200–1000	61,502	0	61,502	267,411	105,614	373,025	243,920	9,612	253,532	0	0	0	572,833	115,226	688,059
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	3,763,705	3,415,991	7,179,696	16,170,667	18,845,957	35,016,624	9,277,950	9,450,712	18,728,662	0	0	0	29,212,322	31,712,660	60,924,982
Restrictions	Land Use	0–200	916,098	1,624,454	2,540,552	4,640,750	9,444,912	14,085,662	2,801,857	4,030,632	6,832,489	0	0	0	8,358,705	15,099,998	23,458,703
		200–1000	Land-use restrictions do not apply for overburden thicknesses >200 feet														
		>1000															
		TOTAL	916,098	1,624,454	2,540,552	4,640,750	9,444,912	14,085,662	2,801,857	4,030,632	6,832,489	0	0	0	8,358,705	15,099,998	23,458,703
	Technologic	0–200	Technologic restrictions do not apply for overburden thicknesses ≤200 feet														
		200–1000	61,502	0	61,502	267,411	0	267,411	243,920	0	243,920	0	0	0	572,833	0	572,833
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	61,502	0	61,502	267,411	0	267,411	243,920	0	243,920	0	0	0	572,833	0	572,833
	Total	0–200	916,098	1,624,454	2,540,552	4,640,750	9,444,912	14,085,662	2,801,857	4,030,632	6,832,489	0	0	0	8,358,705	15,099,998	23,458,703
		200–1000	61,502	0	61,502	267,411	0	267,411	243,920	0	243,920	0	0	0	572,833	0	572,833
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	977,600	1,624,454	2,602,054	4,908,161	9,444,912	14,353,073	3,045,777	4,030,632	7,076,409	0	0	0	8,931,538	15,099,998	24,031,536
Available		0–200	2,786,105	1,791,537	4,577,642	11,262,506	9,295,431	20,557,937	6,232,173	5,410,468	11,642,641	0	0	0	20,280,784	16,497,436	36,778,220
		200–1000	0	0	0	0	105,614	105,614	0	9,612	9,612	0	0	0	0	115,226	115,226
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	2,786,105	1,791,537	4,577,642	11,262,506	9,401,045	20,663,551	6,232,173	5,420,080	11,652,253	0	0	0	20,280,784	16,612,662	36,893,446

Table B–5. *Estimated Remaining Coal Resources of the Lower Clarion Coal Unavailable Due to Land-Use Restrictions*

[Land-use restrictions apply only where overburden thickness is from 0 to 200 feet (subject to surface mining). The remaining coal resources are subdivided into categories of reliability of estimate (measured, indicated, inferred, and hypothetical) and coal thickness (14–28 inches and >28 inches). Numbers may not total exactly because of independent rounding. Quantities are in short tons.]

LAND-USE RESTRICTIONS	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
	MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Airports	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cemeteries	0	0	0	17,196	67,982	85,178	4,767	29,817	34,584	0	0	0	21,963	97,799	119,762
Historic sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	441,005	817,542	1,258,547	1,983,813	4,202,530	6,186,343	1,237,884	1,439,821	2,677,705	0	0	0	3,662,702	6,459,893	10,122,595
Lakes	7,550	91,510	99,059	115,055	126,569	241,624	30,391	28,974	59,364	0	0	0	152,996	247,052	400,047
Oil and gas wells	10,972	13,815	24,787	71,436	37,471	108,906	54,725	39,064	93,789	0	0	0	137,133	90,349	227,482
Pipelines	55,887	0	55,887	139,070	0	139,070	96,956	0	96,956	0	0	0	291,913	0	291,913
PNDI sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power lines	23,580	30,164	53,743	130,441	144,168	274,609	24,605	128,750	153,355	0	0	0	178,625	303,081	481,707
Public buildings	0	1,590	1,590	28,644	305,025	333,669	0	468	468	0	0	0	286,44	307,082	335,727
Public lands	82,345	175,173	257,518	156,866	631,860	788,726	489,128	827,797	1,316,925	0	0	0	728,339	1,634,829	2,363,168
Railroads	19,241	67,366	86,607	134,366	212,290	346,656	26,268	55,637	81,906	0	0	0	179,876	335,293	515,169
Roads	240,053	223,572	463,625	1,162,708	1,616,964	2,779,672	696,971	429,534	1,126,505	0	0	0	2,099,732	2,270,071	4,369,802
Streams	33,247	99,645	132,893	475,221	431,619	906,840	108,449	170,140	278,589	0	0	0	616,917	701,404	1,318,321
Towns	0	97,404	97,404	0	1,579,475	1,579,475	0	870,081	870,081	0	0	0	0	2,546,960	2,546,960
Wetlands	2,219	6,674	8,893	225,933	88,961	314,893	31,715	10,549	42,264	0	0	0	259,866	106,184	366,050
Total	916,098	1,624,454	2,540,552	4,640,750	9,444,912	14,085,662	2,801,857	4,030,632	6,832,489	0	0	0	8,358,705	15,099,998	23,458,703

Table B–6. *Estimated Remaining Coal Resources of the Lower Clarion Coal Unavailable Due to Technologic Restrictions*

[Technologic restrictions apply only where overburden thickness is >200 feet (subject to underground mining). The remaining coal resources are subdivided into categories of overburden thickness (200–1000 feet and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). Quantities are in short tons.]

Overburden	TECHNOLOGIC RESTRICTIONS	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
		MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
		14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
200–1000 feet	Bed too thin to mine	61,502	—	61,502	267,411	—	267,411	243,920	—	243,920	0	—	0	572,833	—	572,833
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	61,502	0	61,502	267,411	0	267,411	243,920	0	243,920	0	0	0	572,833	0	572,833
>1000 feet	Bed too thin to mine	0	—	0	0	—	0	0	—	0	0	—	0	0	—	0
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	Bed too thin to mine	61,502	—	61,502	267,411	—	267,411	243,920	—	243,920	0	—	0	572,833	—	572,833
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	61,502	0	61,502	267,411	0	267,411	243,920	0	243,920	0	0	0	572,833	0	572,833

Table B–7. *Estimated Coal Resources of the Upper Clarion Coal*

[Estimated coal resources are subdivided into categories of overburden thickness (0–200 feet, 200–1000 feet, and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). Numbers may not total exactly because of independent rounding. Quantities are in short tons.]

		Overburden intervals (feet)	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
			MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
			14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Original		0–200	3,672,076	5,493,989	9,166,065	16,512,478	15,172,456	31,684,934	7,528,634	2,539,853	10,068,487	0	0	0	27,713,188	23,206,298	50,919,486
		200–1000	28,798	17,844	46,642	131,787	4,129	135,916	7,881	0	7,881	0	0	0	168,466	21,973	190,439
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	3,700,874	5,511,833	9,212,707	16,644,265	15,176,585	31,820,850	7,536,515	2,539,853	10,076,368	0	0	0	27,881,654	23,228,271	51,109,925
Mined Out	Surface	0–200	632,188	1,157,595	1,789,783	1,507,928	818,265	2,326,193	158,438	97,385	255,823	0	0	0	2,298,554	2,073,245	4,371,799
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	632,188	1,157,595	1,789,783	1,507,928	818,265	2,326,193	158,438	97,385	255,823	0	0	0	2,298,554	2,073,245	4,371,799
	Deep	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0–200	632,188	1,157,595	1,789,783	1,507,928	818,265	2,326,193	158,438	97,385	255,823	0	0	0	2,298,554	2,073,245	4,371,799
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	632,188	1,157,595	1,789,783	1,507,928	818,265	2,326,193	158,438	97,385	255,823	0	0	0	2,298,554	2,073,245	4,371,799
Remaining		0–200	3,039,888	4,336,394	7,376,282	15,004,550	14,354,191	29,358,741	7,370,196	2,442,468	9,812,664	0	0	0	25,414,634	21,133,053	46,547,687
		200–1000	28,798	17,844	46,642	131,787	4,129	135,916	7,881	0	7,881	0	0	0	168,466	21,973	190,439
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	3,068,686	4,354,238	7,422,924	15,136,337	14,358,320	29,494,657	7,378,077	2,442,468	9,820,545	0	0	0	25,583,100	21,155,026	46,738,126

Table B–7. *(Continued)*

		Overburden intervals (feet)	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
			MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
			14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Remaining		0–200	3,039,888	4,336,394	7,376,282	15,004,550	14,354,191	29,358,741	7,370,196	2,442,468	9,812,664	0	0	0	25,414,634	21,133,053	46,547,687
		200–1000	28,798	17,844	46,642	131,787	4,129	135,916	7,881	0	7,881	0	0	0	168,466	21,973	190,439
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	3,068,686	4,354,238	7,422,924	15,136,337	14,358,320	29,494,657	7,378,077	2,442,468	9,820,545	0	0	0	25,583,100	21,155,026	46,738,126
Restrictions	Land Use	0–200	963,808	1,038,985	2,002,793	5,719,304	5,025,455	10,744,759	3,163,710	786,527	3,950,237	0	0	0	9,846,822	6,850,967	16,697,789
		200–1000	Land-use restrictions do not apply for overburden thicknesses >200 feet														
		>1000															
		TOTAL	963,808	1,038,985	2,002,793	5,719,304	5,025,455	10,744,759	3,163,710	786,527	3,950,237	0	0	0	9,846,822	6,850,967	16,697,789
	Technologic	0–200	Technologic restrictions do not apply for overburden thicknesses ≤200 feet														
		200–1000	28,798	4,019	32,817	131,787	0	131,787	7,881	0	7,881	0	0	0	168,466	4,019	172,485
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	28,798	4,019	32,817	131,787	0	131,787	7,881	0	7,881	0	0	0	168,466	4,019	172,485
	Total	0–200	963,808	1,038,985	2,002,793	5,719,304	5,025,455	10,744,759	3,163,710	786,527	3,950,237	0	0	0	9,846,822	6,850,967	16,697,789
		200–1000	28,798	4,019	32,817	131,787	0	131,787	7,881	0	7,881	0	0	0	168,466	4,019	172,485
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	992,606	1,043,004	2,035,610	5,851,091	5,025,455	10,876,546	3,171,591	786,527	3,958,118	0	0	0	10,015,288	6,854,986	16,870,274
Available		0–200	2,076,080	3,297,409	5,373,489	9,285,246	9,328,736	18,613,982	4,206,486	1,655,941	5,862,427	0	0	0	15,567,812	14,282,086	29,849,898
		200–1000	0	13,825	13,825	0	4,129	4,129	0	0	0	0	0	0	0	17,954	17,954
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	2,076,080	3,311,234	5,387,314	9,285,246	9,332,865	18,618,111	4,206,486	1,655,941	5,862,427	0	0	0	15,567,812	14,300,040	29,867,852

Table B–8. *Estimated Remaining Coal Resources of the Upper Clarion Coal Unavailable Due to Land-Use Restrictions*

[Land-use restrictions apply only where overburden thickness is from 0 to 200 feet (subject to surface mining). The remaining coal resources are subdivided into categories of reliability of estimate (measured, indicated, inferred, and hypothetical) and coal thickness (14–28 inches and >28 inches). Numbers may not total exactly because of independent rounding. Quantities are in short tons.]

LAND-USE RESTRICTIONS	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
	MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Airports	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cemeteries	0	15,399	15,399	39,347	15,580	54,927	16,045	0	16,045	0	0	0	55,392	30,979	86,371
Historic sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	510,289	615,157	1,125,447	2,807,663	2,321,596	5,129,259	800,901	585,120	1,386,021	0	0	0	4,118,853	3,521,873	7,640,726
Lakes	5,020	17,855	22,875	126,308	46,363	172,671	26,166	15,306	41,472	0	0	0	157,494	79,524	237,018
Oil and gas wells	11,748	15,959	27,707	65,096	42,675	107,770	34,212	5,977	40,189	0	0	0	111,056	64,610	175,665
Pipelines	30,799	0	30,799	14,740	0	14,740	11,382	0	11,382	0	0	0	56,921	0	56,921
PNDI sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power lines	52,601	13,833	66,434	256,999	73,183	330,182	11,492	0	11,492	0	0	0	321,092	87,016	408,108
Public buildings	0	381	381	150,200	106,969	257,169	0	0	0	0	0	0	150,200	107,350	257,550
Public lands	49,183	13,445	62,628	200,884	3,645	204,529	567,215	0	567,215	0	0	0	817,282	17,090	834,372
Railroads	14,599	13,003	27,602	121,380	198,035	319,415	56,550	0	56,550	0	0	0	192,529	211,038	403,567
Roads	230,564	270,439	501,003	1,047,482	1,348,988	2,396,470	572,820	156,234	729,054	0	0	0	1,850,866	1,775,661	3,626,527
Streams	39,040	63,514	102,554	386,219	359,411	745,631	117,392	21,076	138,468	0	0	0	542,651	444,001	986,652
Towns	0	0	0	459,353	63,457	522,810	942,211	0	942,211	0	0	0	1,401,564	63,457	1,465,022
Wetlands	19,965	0	19,965	43,633	445,554	489,186	7,324	2,815	10,138	0	0	0	70,922	448,368	519,290
Total	963,808	1,038,985	2,002,793	5,719,304	5,025,455	10,744,759	3,163,710	786,527	3,950,237	0	0	0	9,846,822	6,850,967	16,697,789

Table B–9. *Estimated Remaining Coal Resources of the Upper Clarion Coal Unavailable Due to Technologic Restrictions*

[Technologic restrictions apply only where overburden thickness is >200 feet (subject to underground mining). The remaining coal resources are subdivided into categories of overburden thickness (200–1000 feet and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). Quantities are in short tons.]

Overburden	TECHNOLOGIC RESTRICTIONS	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
		MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
		14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
200–1000 feet	Bed too thin to mine	28,798	—	28,798	131,787	—	131,787	7,881	—	7,881	0	—	0	168,466	—	168,466
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	4,019	4,019	0	0	0	0	0	0	0	0	0	0	4,019	4,019
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	28,798	4,019	32,817	131,787	0	131,787	7,881	0	7,881	0	0	0	168,466	4,019	172,485
>1000 feet	Bed too thin to mine	0	—	0	0	—	0	0	—	0	0	—	0	0	—	0
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	Bed too thin to mine	28,798	—	28,798	131,787	—	131,787	7,881	—	7,881	0	—	0	168,466	—	168,466
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	4,019	4,019	0	0	0	0	0	0	0	0	0	0	4,019	4,019
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	28,798	4,019	32,817	131,787	0	131,787	7,881	0	7,881	0	0	0	168,466	4,019	172,485

Table B–10. *Estimated Coal Resources of the Lower Kittanning Leader Coal*

[Estimated coal resources are subdivided into categories of overburden thickness (0–200 feet, 200–1000 feet, and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). Numbers may not total exactly because of independent rounding. Quantities are in short tons.]

		Overburden intervals (feet)	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
			MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
			14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Original		0–200	504,019	1,157,760	1,661,779	2,915,325	3,787,546	6,702,871	4,327,787	402,003	4,729,790	0	0	0	7,747,131	5,347,309	13,094,440
		200–1000	0	0	0	0	0	0	1,945	0	1,945	0	0	0	1,945	0	1,945
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	504,019	1,157,760	1,661,779	2,915,325	3,787,546	6,702,871	4,329,732	402,003	4,731,735	0	0	0	7,749,076	5,347,309	13,096,385
Mined Out	Surface	0–200	62,647	133,722	196,369	46,043	2,322	48,365	0	0	0	0	0	0	108,690	136,044	244,734
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	62,647	133,722	196,369	46,043	2,322	48,365	0	0	0	0	0	0	108,690	136,044	244,734
	Deep	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0–200	62,647	133,722	196,369	46,043	2,322	48,365	0	0	0	0	0	0	108,690	136,044	244,734
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	62,647	133,722	196,369	46,043	2,322	48,365	0	0	0	0	0	0	108,690	136,044	244,734
Remaining		0–200	441,372	1,024,038	1,465,410	2,869,282	3,785,224	6,654,506	4,327,787	402,003	4,729,790	0	0	0	7,638,441	5,211,265	12,849,706
		200–1000	0	0	0	0	0	0	1,945	0	1,945	0	0	0	1,945	0	1,945
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	441,372	1,024,038	1,465,410	2,869,282	3,785,224	6,654,506	4,329,732	402,003	4,731,735	0	0	0	7,640,386	5,211,265	12,851,651

Table B–10. *(Continued)*

		Overburden intervals (feet)	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
			MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
			14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Remaining		0–200	441,372	1,024,038	1,465,410	2,869,282	3,785,224	6,654,506	4,327,787	402,003	4,729,790	0	0	0	7,638,441	5,211,265	12,849,706
		200–1000	0	0	0	0	0	0	1,945	0	1,945	0	0	0	1,945	0	1,945
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	441,372	1,024,038	1,465,410	2,869,282	3,785,224	6,654,506	4,329,732	402,003	4,731,735	0	0	0	7,640,386	5,211,265	12,851,651
Restrictions	Land Use	0–200	140,440	386,713	527,153	901,416	1,293,770	2,195,186	1,677,806	54,658	1,732,464	0	0	0	2,719,662	1,735,141	4,454,803
		200–1000	Land-use restrictions do not apply for overburden thicknesses >200 feet														
		>1000															
		TOTAL	140,440	386,713	527,153	901,416	1,293,770	2,195,186	1,677,806	54,658	1,732,464	0	0	0	2,719,662	1,735,141	4,454,803
	Technologic	0–200	Technologic restrictions do not apply for overburden thicknesses ≤200 feet														
		200–1000	0	0	0	0	0	0	1,945	0	1,945	0	0	0	1,945	0	1,945
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	0	0	0	0	0	1,945	0	1,945	0	0	0	1,945	0	1,945
	Total	0–200	140,440	386,713	527,153	901,416	1,293,770	2,195,186	1,677,806	54,658	1,732,464	0	0	0	2,719,662	1,735,141	4,454,803
		200–1000	0	0	0	0	0	0	1,945	0	1,945	0	0	0	1,945	0	1,945
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	140,440	386,713	527,153	901,416	1,293,770	2,195,186	1,679,751	54,658	1,734,409	0	0	0	2,721,607	1,735,141	4,456,748
Available		0–200	300,932	637,325	938,257	1,967,866	2,491,454	4,459,320	2,649,981	347,345	2,997,326	0	0	0	4,918,779	3,476,124	8,394,903
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	300,932	637,325	938,257	1,967,866	2,491,454	4,459,320	2,649,981	347,345	2,997,326	0	0	0	4,918,779	3,476,124	8,394,903

Table B–11. *Estimated Remaining Coal Resources of the Lower Kittanning Leader Coal Unavailable Due to Land-Use Restrictions*

[Land-use restrictions apply only where overburden thickness is from 0 to 200 feet (subject to surface mining). The remaining coal resources are subdivided into categories of reliability of estimate (measured, indicated, inferred, and hypothetical) and coal thickness (14–28 inches and >28 inches). Numbers may not total exactly because of independent rounding. Quantities are in short tons.]

LAND-USE RESTRICTIONS	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
	MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Airports	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cemeteries	0	0	0	0	11,226	11,226	0	0	0	0	0	0	0	11,226	11,226
Historic sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	123,921	293,044	416,965	505,757	823,857	1,329,614	806,559	33,396	839,955	0	0	0	1,436,238	1,150,296	2,586,533
Lakes	0	1,744	1,744	35,727	7,334	43,060	6,143	0	6,143	0	0	0	41,870	9,077	50,948
Oil and gas wells	415	6,436	6,851	15,190	5,892	21,082	17,793	0	17,793	0	0	0	33,398	12,328	45,725
Pipelines	0	0	0	0	0	0	5,855	0	5,855	0	0	0	5,855	0	5,855
PNDI sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power lines	0	15,693	15,693	31,801	81,523	113,324	0	3,375	3,375	0	0	0	31,801	100,590	132,391
Public buildings	0	0	0	0	118,622	118,622	9,542	802	10,344	0	0	0	9,542	119,424	128,966
Public lands	0	0	0	0	0	0	1,136	0	1,136	0	0	0	1,136	0	1,136
Railroads	4,109	1,239	5,348	12,461	0	12,461	55,143	0	55,143	0	0	0	71,713	1,239	72,952
Roads	11,973	65,468	77,442	234,040	224,365	458,405	327,277	17,086	344,363	0	0	0	573,291	306,920	880,210
Streams	0	0	0	24,022	20,951	44,973	26,226	0	26,226	0	0	0	50,248	20,951	71,199
Towns	0	0	0	1,999	0	1,999	417,992	0	417,992	0	0	0	419,990	0	419,990
Wetlands	21	3,090	3,111	40,419	0	40,419	4,140	0	4,140	0	0	0	44,580	3,090	47,670
Total	140,440	386,713	527,153	901,416	1,293,770	2,195,186	1,677,806	54,658	1,732,464	0	0	0	2,719,662	1,735,141	4,454,803

Table B–12. *Estimated Remaining Coal Resources of the Lower Kittanning Leader Coal Unavailable Due to Technologic Restrictions*

[Technologic restrictions apply only where overburden thickness is >200 feet (subject to underground mining). The remaining coal resources are subdivided into categories of overburden thickness (200–1000 feet and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). Quantities are in short tons.]

Overburden	TECHNOLOGIC RESTRICTIONS	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
		MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
		14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
200–1000 feet	Bed too thin to mine	0	—	0	0	—	0	1,945	—	1,945	0	—	0	1,945	—	1,945
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	1,945	0	1,945	0	0	0	1,945	0	1,945
>1000 feet	Bed too thin to mine	0	—	0	0	—	0	0	—	0	0	—	0	0	—	0
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	Bed too thin to mine	0	—	0	0	—	0	1,945	—	1,945	0	—	0	1,945	—	1,945
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	1,945	0	1,945	0	0	0	1,945	0	1,945

Table B–13. *Estimated Coal Resources of the Lower Kittanning Coal*

[Estimated coal resources are subdivided into categories of overburden thickness (0–200 feet, 200–1000 feet, and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). Numbers may not total exactly because of independent rounding. Quantities are in short tons.]

		Overburden intervals (feet)	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
			MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
			14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Original		0–200	3,894,891	5,668,571	9,563,462	5,734,179	9,238,086	14,972,265	809,420	1,050,140	1,859,560	0	0	0	10,438,490	15,956,797	26,395,287
		200–1000	0	8,124	8,124	0	0	0	0	0	0	0	0	0	0	8,124	8,124
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	3,894,891	5,676,695	9,571,586	5,734,179	9,238,086	14,972,265	809,420	1,050,140	1,859,560	0	0	0	10,438,490	15,964,921	26,403,411
Mined Out	Surface	0–200	992,825	2,085,522	3,078,347	1,556,909	4,076,681	5,633,590	113,953	215,993	329,946	0	0	0	2,663,687	6,378,196	9,041,883
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	992,825	2,085,522	3,078,347	1,556,909	4,076,681	5,633,590	113,953	215,993	329,946	0	0	0	2,663,687	6,378,196	9,041,883
	Deep	0–200	375,051	784,780	1,159,831	547,678	538,321	1,085,999	11,092	1,545	12,637	0	0	0	933,821	1,324,646	2,258,467
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	375,051	784,780	1,159,831	547,678	538,321	1,085,999	11,092	1,545	12,637	0	0	0	933,821	1,324,646	2,258,467
	Total	0–200	1,367,876	2,870,302	4,238,178	2,104,587	4,615,002	6,719,589	125,045	217,538	342,583	0	0	0	3,597,508	7,702,842	11,300,350
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	1,367,876	2,870,302	4,238,178	2,104,587	4,615,002	6,719,589	125,045	217,538	342,583	0	0	0	3,597,508	7,702,842	11,300,350
Remaining		0–200	2,527,015	2,798,269	5,325,284	3,629,592	4,623,084	8,252,676	684,375	832,602	1,516,977	0	0	0	6,840,982	8,253,955	15,094,937
		200–1000	0	8,124	8,124	0	0	0	0	0	0	0	0	0	0	8,124	8,124
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	2,527,015	2,806,393	5,333,408	3,629,592	4,623,084	8,252,676	684,375	832,602	1,516,977	0	0	0	6,840,982	8,262,079	15,103,061

Table B–13. *(Continued)*

		Overburden intervals (feet)	DATA RELIABILITIES AND COAL-THICKNESS CLASSES															
			MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
			14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Remaining		0–200	2,527,015	2,798,269	5,325,284	3,629,592	4,623,084	8,252,676	684,375	832,602	1,516,977	0	0	0	6,840,982	8,253,955	15,094,937
		200–1000	0	8,124	8,124	0	0	0	0	0	0	0	0	0	0	8,124	8,124
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	2,527,015	2,806,393	5,333,408	3,629,592	4,623,084	8,252,676	684,375	832,602	1,516,977	0	0	0	6,840,982	8,262,079	15,103,061
Restrictions	Land Use	0–200	328,475	902,523	1,230,998	857,786	2,180,796	3,038,582	197,871	348,141	546,012	0	0	0	1,384,132	3,431,460	4,815,592
		200–1000	Land-use restrictions do not apply for overburden thicknesses >200 feet														
		>1000															
		TOTAL	328,475	902,523	1,230,998	857,786	2,180,796	3,038,582	197,871	348,141	546,012	0	0	0	1,384,132	3,431,460	4,815,592
	Technologic	0–200	Technologic restrictions do not apply for overburden thicknesses ≤200 feet														
		200–1000	0	1,286	1,286	0	0	0	0	0	0	0	0	0	0	1,286	1,286
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	1,286	1,286	0	0	0	0	0	0	0	0	0	0	1,286	1,286
	Total	0–200	328,475	902,523	1,230,998	857,786	2,180,796	3,038,582	197,871	348,141	546,012	0	0	0	1,384,132	3,431,460	4,815,592
		200–1000	0	1,286	1,286	0	0	0	0	0	0	0	0	0	0	1,286	1,286
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	328,475	903,809	1,232,284	857,786	2,180,796	3,038,582	197,871	348,141	546,012	0	0	0	1,384,132	3,432,746	4,816,878
Available		0–200	2,198,540	1,895,746	4,094,286	2,771,806	2,442,288	5,214,094	486,504	484,461	970,965	0	0	0	5,456,850	4,822,495	10,279,345
		200–1000	0	6,838	6,838	0	0	0	0	0	0	0	0	0	0	6,838	6,838
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	2,198,540	1,902,584	4,101,124	2,771,806	2,442,288	5,214,094	486,504	484,461	970,965	0	0	0	5,456,850	4,829,333	10,286,183

Table B–14. *Estimated Remaining Coal Resources of the Lower Kittanning Coal*

[Land-use restrictions apply only where overburden thickness is from 0 to 200 feet (subject to surface mining). The remaining coal resources are subdivided into categories of reliability of estimate (measured, indicated, inferred, and hypothetical) and coal thickness (14–28 inches and >28 inches). Numbers may not total exactly because of independent rounding. Quantities are in short tons.]

LAND-USE RESTRICTIONS	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
	MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Airports	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cemeteries	0	10,248	10,248	0	6,118	6,118	0	0	0	0	0	0	0	16,366	16,366
Historic sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	158,514	440,835	599,350	341,544	1,145,596	1,487,140	45,127	167,889	213,015	0	0	0	545,185	1,754,320	2,299,504
Lakes	12,777	6,021	18,798	15,527	13,859	29,385	0	3,496	3,496	0	0	0	28,304	23,375	51,679
Oil and gas wells	18,653	14,502	33,155	9,034	7,105	16,138	10,176	7,143	17,319	0	0	0	37,863	28,749	66,612
Pipelines	0	0	0	21,450	0	21,450	19,728	1,345	21,073	0	0	0	41,177	1,345	42,522
PNDI sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power lines	44,368	68,371	112,739	58,282	52,575	110,857	0	0	0	0	0	0	102,651	120,946	223,597
Public buildings	0	24,558	24,558	39,119	5,083	44,202	0	443	443	0	0	0	39,119	30,084	69,202
Public lands	0	0	0	0	0	0	72,364	0	72,364	0	0	0	72,364	0	72,364
Railroads	0	10,868	10,868	18,623	14,609	33,232	3,392	3,201	6,593	0	0	0	22,015	28,677	50,692
Roads	84,054	308,858	392,912	146,467	437,031	583,497	11,145	97,731	108,876	0	0	0	241,666	843,619	1,085,285
Streams	7,904	18,262	26,166	26,879	1,477	28,356	0	0	0	0	0	0	34,783	19,738	54,522
Towns	392	0	392	177,872	475,990	653,862	35,940	66,896	102,836	0	0	0	214,204	542,886	757,090
Wetlands	1,812	0	1,812	2,990	21,356	24,346	0	0	0	0	0	0	4,803	21,356	26,158
Total	328,475	902,523	1,230,998	857,786	2,180,796	3,038,582	197,871	348,141	546,012	0	0	0	1,384,132	3,431,460	4,815,592

Table B–15. *Estimated Remaining Coal Resources of the Lower Kittanning Coal Unavailable Due to Technologic Restrictions*

[Technologic restrictions apply only where overburden thickness is >200 feet (subject to underground mining). The remaining coal resources are subdivided into categories of overburden thickness (200–1000 feet and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). Quantities are in short tons.]

Overburden	TECHNOLOGIC RESTRICTIONS	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
		MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
		14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
200–1000 feet	Bed too thin to mine	0	—	0	0	—	0	0	—	0	0	—	0	0	—	0
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	1,286	1,286	0	0	0	0	0	0	0	0	0	0	1,286	1,286
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	1,286	1,286	0	0	0	0	0	0	0	0	0	0	1,286	1,286
>1000 feet	Bed too thin to mine	0	—	0	0	—	0	0	—	0	0	—	0	0	—	0
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	Bed too thin to mine	0	—	0	0	—	0	0	—	0	0	—	0	0	—	0
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	1,286	1,286	0	0	0	0	0	0	0	0	0	0	1,286	1,286
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	1,286	1,286	0	0	0	0	0	0	0	0	0	0	1,286	1,286

Table B–16. *Estimated Coal Resources of the Middle Kittanning Coal*

[Estimated coal resources are subdivided into categories of overburden thickness (0–200 feet, 200–1000 feet, and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). Numbers may not total exactly because of independent rounding. Quantities are in short tons.]

		Overburden intervals (feet)	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
			MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
			14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Original		0–200	1,813,331	642,516	2,455,847	2,072,800	56,310	2,129,110	411,598	0	411,598	0	0	0	4,297,729	698,826	4,996,555
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	1,813,331	642,516	2,455,847	2,072,800	56,310	2,129,110	411,598	0	411,598	0	0	0	4,297,729	698,826	4,996,555
Mined Out	Surface	0–200	587,755	175,998	763,753	919,751	24,884	944,635	112,743	0	112,743	0	0	0	1,620,249	200,882	1,821,131
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	587,755	175,998	763,753	919,751	24,884	944,635	112,743	0	112,743	0	0	0	1,620,249	200,882	1,821,131
	Deep	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0–200	587,755	175,998	763,753	919,751	24,884	944,635	112,743	0	112,743	0	0	0	1,620,249	200,882	1,821,131
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	587,755	175,998	763,753	919,751	24,884	944,635	112,743	0	112,743	0	0	0	1,620,249	200,882	1,821,131
Remaining		0–200	1,225,576	466,518	1,692,094	1,153,049	31,426	1,184,475	298,855	0	298,855	0	0	0	2,677,480	497,944	3,175,424
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	1,225,576	466,518	1,692,094	1,153,049	31,426	1,184,475	298,855	0	298,855	0	0	0	2,677,480	497,944	3,175,424

Table B–16. *(Continued)*

		Overburden intervals (feet)	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
			MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
			14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Remaining		0–200	1,225,576	466,518	1,692,094	1,153,049	31,426	1,184,475	298,855	0	298,855	0	0	0	2,677,480	497,944	3,175,424
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	1,225,576	466,518	1,692,094	1,153,049	31,426	1,184,475	298,855	0	298,855	0	0	0	2,677,480	497,944	3,175,424
Restrictions	Land Use	0–200	151,562	43,074	194,636	131,944	26,542	158,486	60,180	0	60,180	0	0	0	343,686	69,616	413,302
		200–1000	Land-use restrictions do not apply for overburden thicknesses >200 feet														
		>1000															
		TOTAL	151,562	43,074	194,636	131,944	26,542	158,486	60,180	0	60,180	0	0	0	343,686	69,616	413,302
	Technologic	0–200	Technologic restrictions do not apply for overburden thicknesses ≤200 feet														
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0–200	151,562	43,074	194,636	131,944	26,542	158,486	60,180	0	60,180	0	0	0	343,686	69,616	413,302
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	151,562	43,074	194,636	131,944	26,542	158,486	60,180	0	60,180	0	0	0	343,686	69,616	413,302
Available		0–200	1,074,014	423,444	1,497,458	1,021,105	4,884	1,025,989	238,675	0	238,675	0	0	0	2,333,794	428,328	2,762,122
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	1,074,014	423,444	1,497,458	1,021,105	4,884	1,025,989	238,675	0	238,675	0	0	0	2,333,794	428,328	2,762,122

Table B–17. *Estimated Remaining Coal Resources of the Middle Kittanning Coal Unavailable Due to Land-Use Restrictions*

[Land-use restrictions apply only where overburden thickness is from 0 to 200 feet (subject to surface mining). The remaining coal resources are subdivided into categories of reliability of estimate (measured, indicated, inferred, and hypothetical) and coal thickness (14–28 inches and >28 inches). Numbers may not total exactly because of independent rounding. Quantities are in short tons.]

LAND-USE RESTRICTIONS	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
	MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Airports	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Historic sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	64,140	29,860	94,000	80,045	21,813	101,858	44,287	0	44,287	0	0	0	188,471	51,673	240,144
Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and gas wells	5,450	8,960	14,410	545	0	545	6,177	0	6,177	0	0	0	12,172	8,960	21,132
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PNDI sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power lines	18,151	0	18,151	22,237	0	22,237	0	0	0	0	0	0	40,388	0	40,388
Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public lands	2,611	0	2,611	0	0	0	0	0	0	0	0	0	2,611	0	2,611
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	56,769	4,254	61,023	27,654	4,729	32,383	7,173	0	7,173	0	0	0	91,596	8,983	100,579
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Towns	0	0	0	1,463	0	1,463	2,543	0	2,543	0	0	0	4,006	0	4,006
Wetlands	4,442	0	4,442	0	0	0	0	0	0	0	0	0	4,442	0	4,442
Total	151,562	43,074	194,636	131,944	26,542	158,486	60,180	0	60,180	0	0	0	343,686	69,616	413,302

Table B–18. *Estimated Remaining Coal Resources of the Middle Kittanning Coal Unavailable Due to Technologic Restrictions*

[Technologic restrictions apply only where overburden thickness is >200 feet (subject to underground mining). The remaining coal resources are subdivided into categories of overburden thickness (200–1000 feet and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). Quantities are in short tons.]

Overburden	TECHNOLOGIC RESTRICTIONS	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
		MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
		14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
200–1000 feet	Bed too thin to mine	0	—	0	0	—	0	0	—	0	0	—	0	0	—	0
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1000 feet	Bed too thin to mine	0	—	0	0	—	0	0	—	0	0	—	0	0	—	0
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	Bed too thin to mine	0	—	0	0	—	0	0	—	0	0	—	0	0	—	0
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B–19. *Estimated Coal Resources of the Upper Kittanning Coal*

[Estimated coal resources are subdivided into categories of overburden thickness (0–200 feet, 200–1000 feet, and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). Numbers may not total exactly because of independent rounding. Quantities are in short tons.]

		Overburden intervals (feet)	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
			MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
			14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Original		0–200	80,065	0	80,065	59,881	0	59,881	32,614	0	32,614	0	0	0	172,560	0	172,560
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	80,065	0	80,065	59,881	0	59,881	32,614	0	32,614	0	0	0	172,560	0	172,560
Mined Out	Surface	0–200	15,367	0	15,367	0	0	0	0	0	0	0	0	0	15,367	0	15,367
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	15,367	0	15,367	0	0	0	0	0	0	0	0	0	15,367	0	15,367
	Deep	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0–200	15,367	0	15,367	0	0	0	0	0	0	0	0	0	15,367	0	15,367
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	15,367	0	15,367	0	0	0	0	0	0	0	0	0	15,367	0	15,367
Remaining		0–200	64,698	0	64,698	59,881	0	59,881	32,614	0	32,614	0	0	0	157,193	0	157,193
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	64,698	0	64,698	59,881	0	59,881	32,614	0	32,614	0	0	0	157,193	0	157,193

Table B–19. *(Continued)*

		Overburden intervals (feet)	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
			MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
			14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Remaining		0–200	64,698	0	64,698	59,881	0	59,881	32,614	0	32,614	0	0	0	157,193	0	157,193
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	64,698	0	64,698	59,881	0	59,881	32,614	0	32,614	0	0	0	157,193	0	157,193
Restrictions	Land Use	0–200	1,062	0	1,062	2,597	0	2,597	493	0	493	0	0	0	4,152	0	4,152
		200–1000	Land-use restrictions do not apply for overburden thicknesses >200 feet														
		>1000															
		TOTAL	1,062	0	1,062	2,597	0	2,597	493	0	493	0	0	0	4,152	0	4,152
	Technologic	0–200	Technologic restrictions do not apply for overburden thicknesses ≤200 feet														
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0–200	1,062	0	1,062	2,597	0	2,597	493	0	493	0	0	0	4,152	0	4,152
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	1,062	0	1,062	2,597	0	2,597	493	0	493	0	0	0	4,152	0	4,152
Available		0–200	63,636	0	63,636	57,284	0	57,284	32,121	0	32,121	0	0	0	153,041	0	153,041
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	63,636	0	63,636	57,284	0	57,284	32,121	0	32,121	0	0	0	153,041	0	153,041

Table B–20. *Estimated Remaining Coal Resources of the Upper Kittanning Coal Unavailable Due to Land-Use Restrictions*

[Land-use restrictions apply only where overburden thickness is from 0 to 200 feet (subject to surface mining). The remaining coal resources are subdivided into categories of reliability of estimate (measured, indicated, inferred, and hypothetical) and coal thickness (14–28 inches and >28 inches). Quantities are in short tons.]

LAND-USE RESTRICTIONS	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
	MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Airports	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Historic sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	0	0	0	0	0	0	493	0	493	0	0	0	493	0	493
Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and gas wells	1,062	0	1,062	0	0	0	0	0	0	0	0	0	1,062	0	1,062
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PNDI sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power lines	0	0	0	2,597	0	2,597	0	0	0	0	0	0	2,597	0	2,597
Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public lands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1,062	0	1,062	2,597	0	2,597	493	0	493	0	0	0	4,152	0	4,152

Table B–21. *Estimated Remaining Coal Resources of the Upper Kittanning Coal Unavailable Due to Technologic Restrictions*

[Technologic restrictions apply only where overburden thickness is >200 feet (subject to underground mining). The remaining coal resources are subdivided into categories of overburden thickness (200–1000 feet and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). Quantities are in short tons.]

Overburden	TECHNOLOGIC RESTRICTIONS	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
		MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
		14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
200–1000 feet	Bed too thin to mine	0	—	0	0	—	0	0	—	0	0	—	0	0	—	0
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1000 feet	Bed too thin to mine	0	—	0	0	—	0	0	—	0	0	—	0	0	—	0
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	Bed too thin to mine	0	—	0	0	—	0	0	—	0	0	—	0	0	—	0
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B–22. *Estimated Coal Resources of the Lower Freeport Coal*

[Estimated coal resources are subdivided into categories of overburden thickness (0–200 feet, 200–1000 feet, and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). Numbers may not total exactly because of independent rounding. Quantities are in short tons.]

		Overburden intervals (feet)	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
			MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
			14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Original		0–200	0	41,970	41,970	0	0	0	2,106	0	2,106	0	0	0	2,106	41,970	44,076
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	41,970	41,970	0	0	0	2,106	0	2,106	0	0	0	2,106	41,970	44,076
Mined Out	Surface	0–200	0	32,192	32,192	0	0	0	2,106	0	2,106	0	0	0	2,106	32,192	34,298
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	32,192	32,192	0	0	0	2,106	0	2,106	0	0	0	2,106	32,192	34,298
	Deep	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0–200	0	32,192	32,192	0	0	0	2,106	0	2,106	0	0	0	2,106	32,192	34,298
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	32,192	32,192	0	0	0	2,106	0	2,106	0	0	0	2,106	32,192	34,298
Remaining		0–200	0	9,778	9,778	0	0	0	0	0	0	0	0	0	0	9,778	9,778
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	9,778	9,778	0	0	0	0	0	0	0	0	0	0	9,778	9,778

Table B–22. *(Continued)*

		Overburden intervals (feet)	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
			MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
			14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–-28	>28	TOTAL
Remaining		0–200	0	9,778	9,778	0	0	0	0	0	0	0	0	0	0	9,778	9,778
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	9,778	9,778	0	0	0	0	0	0	0	0	0	0	9,778	9,778
Restrictions	Land Use	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200–1000	Land-use restrictions do not apply for overburden thicknesses >200 feet														
		>1000															
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Technologic	0–200	Technologic restrictions do not apply for overburden thicknesses ≤200 feet														
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Available		0–200	0	9,778	9,778	0	0	0	0	0	0	0	0	0	0	9,778	9,778
		200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	0	9,778	9,778	0	0	0	0	0	0	0	0	0	0	9,778	9,778

Table B–23. *Estimated Remaining Coal Resources of the Lower Freeport Coal Unavailable Due to Land-Use Restrictions*

[Land-use restrictions apply only where overburden thickness is from 0 to 200 feet (subject to surface mining). The remaining coal resources are subdivided into categories of reliability of estimate (measured, indicated, inferred, and hypothetical) and coal thickness (14–28 inches and >28 inches). Quantities are in short tons.]

LAND-USE RESTRICTIONS	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
	MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
Airports	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Historic sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PNDI sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power lines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public lands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B–24. *Estimated Remaining Coal Resources of the Lower Freeport Coal Unavailable Due to Technologic Restrictions*

[Technologic restrictions apply only where overburden thickness is >200 feet (subject to underground mining). The remaining coal resources are subdivided into categories of overburden thickness (200–1000 feet and >1000 feet), reliability of estimate (measured, indicated, inferred, and hypothetical), and coal thickness (14–28 inches and >28 inches). Quantities are in short tons.]

Overburden	TECHNOLOGIC RESTRICTIONS	DATA RELIABILITIES AND COAL-THICKNESS CLASSES														
		MEASURED			INDICATED			INFERRED			HYPOTHETICAL			TOTAL		
		14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL	14–28	>28	TOTAL
200–1000 feet	Bed too thin to mine	0	—	0	0	—	0	0	—	0	0	—	0	0	—	0
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1000 feet	Bed too thin to mine	0	—	0	0	—	0	0	—	0	0	—	0	0	—	0
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	Bed too thin to mine	0	—	0	0	—	0	0	—	0	0	—	0	0	—	0
	Deep-mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Public buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX C. USE OF ARCINFO MACRO LANGUAGE PROGRAMS TO PROCESS DATA TO CALCULATE COAL-RESOURCE ESTIMATES

by
Michael E. Moore

For the Coal Availability Studies in the Clymer, Mount Pleasant, Strattanville, and Waynesburg 7.5-minute quadrangles, western Pennsylvania (Figure 1), a series of programs, written in ArcInfo Macro Language (AML), were used to process the data in ArcInfo Workstation. Data for each project were prepared as a series of ArcInfo coverages or layers. ArcInfo coverages can be of three types—points, lines, and polygons. Points are locations defined by "X" and "Y" coordinates; lines are created by connecting a sequence of points; and polygons are created by connecting a series of lines. The AMLs require the following input coverages:

1. ArcInfo polygon coverages for each of 17 different types of restrictions. These coverages include both the restricted feature plus any associated buffer zone. For example, road restrictions include the right-of-way plus the area within 100 feet of the right-of-way.
2. ArcInfo point coverages for the data points to be used to describe each coal bed that is analyzed. These coverages can include points located in the quadrangle being studied, as well as points in any of the surrounding eight quadrangles. Including data points from outside of the study boundary minimizes the impact of edge effects during the gridding operations described below.
3. ArcInfo polygon coverages for the coal crop lines, surface-mined areas, underground-mined areas, and 200-foot buffer areas around the underground mines of each coal bed as appropriate. These coverages are used by the AMLs to define the extent of each coal bed within the quadrangle, as well as the extent and type of mining within each seam. Because the coverages for surface and underground mining are done independently of each other, it is not uncommon to find that areas have been subject to both types of mining—earlier underground mines are subsequently remined during surface operations. To ensure that the resources in these areas is not counted twice, the deep-mine-buffer coverage is used to define the extent of both the areas that had only deep mining as well as the areas of the buffers that fall within the current

definition of underground resources. That is, the buffer coverage defines polygons that represent areas where underground but no surface mining occurred; as well as 200-foot barrier areas around the underground-mine areas.

4. An ArcInfo polygon coverage defining the quadrangle boundary. This coverage is used to constrain the analysis to the area of the quadrangle.
5. The 30-meter Digital Elevation Models (DEMs) for the study quadrangle, as well as for the eight adjacent quadrangles. The AMLs combine all nine DEMs into a single mosaic that is used as the elevation model of the land surface.
6. Finally, the AMLs require a comma-delimited text file that lists the coal beds to be analyzed, a unique abbreviation for each coal, and an indication as to whether or not coverages are provided for the crop lines, surface mines, and underground mines for each coal.

The AMLs create a single combined coverage from all 17 of the individual restriction coverages. Because it is not uncommon for various restriction coverages to overlap, each polygon in the resulting combined coverage is defined by a different combination of restrictions from those of its immediate neighbors. A simple example of this overlap is illustrated in Figure 64, where road restrictions are shown in brown, stream restrictions in blue, and house restrictions in yellow. The figure shows many areas represented by various combinations of these three restriction coverages. The attribute table that results from the combination of these 17 restriction coverages includes a field for each of the 17 types of restrictions. Each of these 17 fields contains a value of "0" if the polygon is not restricted relative to that feature, whereas a value of "1" indicates that the polygon is restricted relative to the feature.

The coal crop-line, surface-mine, underground-mine, and underground-mine-barrier coverages for each coal bed are joined (combined) into a single coverage. Each polygon in that coverage is attributed as to the type of coal-bed feature it represents—no coal, remaining coal, surface mine, underground mine, or mine barrier.

Buffering the points in the data-point coverage for each coal creates resource-reliability polygons. Reliability is defined by the proximity of a location to a known measurement of the coal seam. Areas within 1/4 mile of a known measurement are designated as measured resources, those between 1/4 mile to 3/4 mile are designated as indicated, those between 3/4 mile

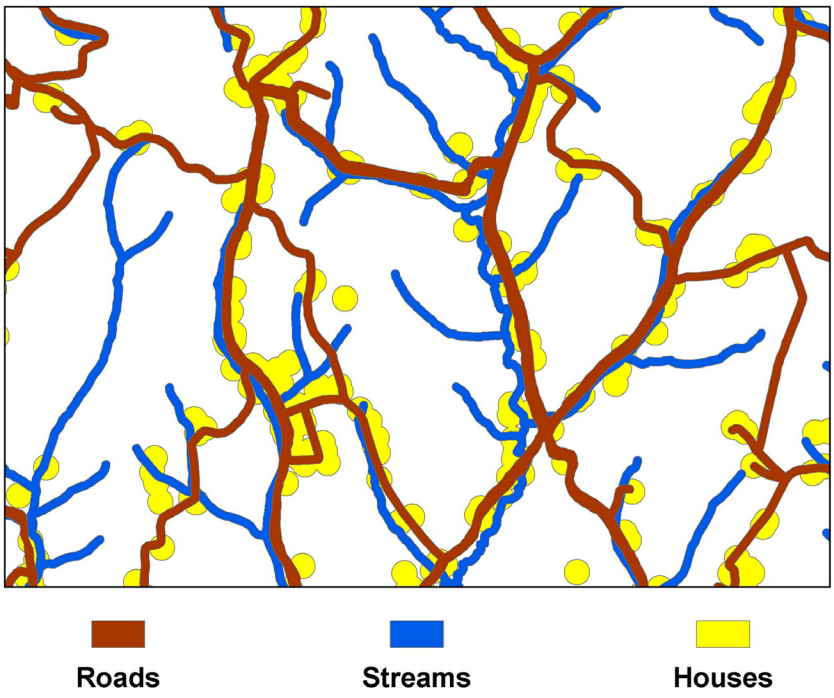


Figure 64. Example of overlapping restriction coverages.

and 3 miles are designated as inferred, and those greater than 3 miles are designated as hypothetical.

A combining (overlay) operation between the reliability coverage and the final coal-bed coverage is done to define the reliability of the resource estimate for each area where that coal seam exists in the quadrangle.

Next, the data-point files for each coal are used to create several grids for each bed. A grid is a network of square cells, 30 meters on a side, which fill the entire quadrangle. A cell size of 30 meters is used because that is the size of the cells (resolution) of the DEMs used to create the model of the land surface. Each cell in a grid is assigned a single value. The value for each cell is typically determined by some type of mathematical manipulation or estimation.

After using the DEMs to create a grid of the land-surface elevations, the AMLs import the coal-thickness data for the data points of each bed into an algorithm that creates a coal-thickness grid. Next, the AMLs multiply the thickness grid (composed of cells that are 30 meters by 30 meters in area) by a density factor to create a new grid of coal tonnages.

Even though the attribute table for the point coverage of each coal contains surveyed elevations of the land surface corresponding to the top of boreholes or stratigraphic sections, the values of the surface elevations usually vary significantly from those displayed on the surface grid generated from the DEMs. This is partly because each cell in the surface model averages the surface elevation over a square of land 30 meters (about 100 feet) on a side. Because so many calculations are based on the grid of the land surface, the AMLs reassign a surface elevation to each point in the coverage based on the elevation of the cell in which the data point falls. Whereas coal crop lines represent the intersection of coals with the land surface, the elevation of coals along their outcrop are the same as the land surface elevations at the same location points. For such coal points, the AMLs determine the surface elevation (coal elevation) at each vertex in the outcrop coverage. Data from both the point-data coverage and the outcrop elevations are then used to create the grid of the coal elevation. Each value in the coal-elevation grid is then subtracted from the value at the same point location in the surface-elevation grid. The result is a 30-meter grid of the depth of overburden. A polygon coverage is created from the depth of overburden grid. This polygon coverage is defined by grouping the grid cells into one of three overburden categories—0 to 200 feet; 200 to 1000 feet; and >1000 feet. This polygon coverage is joined with the coal seam polygon coverage. The resulting polygon coverage now has a depth of overburden attribute corresponding with one of the three aforementioned categories.

Next, the coal-height data from the point coverage for each bed are imported into the gridding algorithm to create a grid of coal thickness. Finally, a tonnage grid is created by multiplying each cell in the coal-height grid (each cell being 30 meters by 30 meters in area) by a density factor.

To prepare for the calculation and categorization of the resource, each of the final, assembled coal-bed coverages is joined to the final restriction coverage. The result is a polygon coverage that defines the category of the resources (remaining coal, surface mined, underground mined, mine barrier, no coal), as well as the restrictions present in each polygon and the reliability of the resource estimate.

The last step is to overlay the final polygon coverage for each coal bed on top of the tonnage grid for that bed and to sum the cells that underlie each polygon. This process is refined

enough that when polygons split an underlying cell of the tonnage grid, the proportional amount of tonnage from that cell is credited to each of the adjoining polygons.

The resulting polygon coverage now has, among other things, attributes that indicate which if any of the 17 possible restrictions apply, depth of overburden, reliability of the resource estimate, the estimated tonnage, and designation as to whether or not the polygon represents coal, coal mines, or coal barriers. The AMLs use this information to assign each polygon in the coverage to one of fifteen possible coal classifications (Table C–1). Resource summaries are prepared by importing the final attribute tables for all of the coals in the study area into an Access database. Database queries tally the original tonnages, the mined tonnages, and the

Table C–1. *Various Possible Coal Classifications Assigned to Each Record of the Final Attribute Table for Each Coal Bed*

Coal_Class	Class Description
0	No Coal
1	Underground minable, not restricted, measured
2	Underground minable, not restricted, indicated
3	Underground minable, not restricted, inferred
4	Underground minable, not restricted, hypothetical
5	Underground minable, restricted
6	Surface minable, not restricted, measured
7	Surface minable, not restricted, indicated
8	Surface minable, not restricted, inferred
9	Surface minable, not restricted, hypothetical
10	Surface minable, restricted
11	200-foot underground-mine buffer
12	Technically not minable
13	Underground mined
14	Surface mined

restricted tonnages for each restriction category. In situations where a record is impacted by more than one restriction (see Figure 64), the queries allocate a proportional amount of the tonnage to each restriction category (i.e., each category receives an equal amount of the total tonnage affected by the restrictions, using the ratio of 1/n, where n = the total number of overlapping restrictions).