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A STUDY OF COAL AVAILABILITY IN THE WAYNESBURG 7.5-MINUTE QUADRANGLE, GREENE AND WASHINGTON COUNTIES, PENNSYLVANIA

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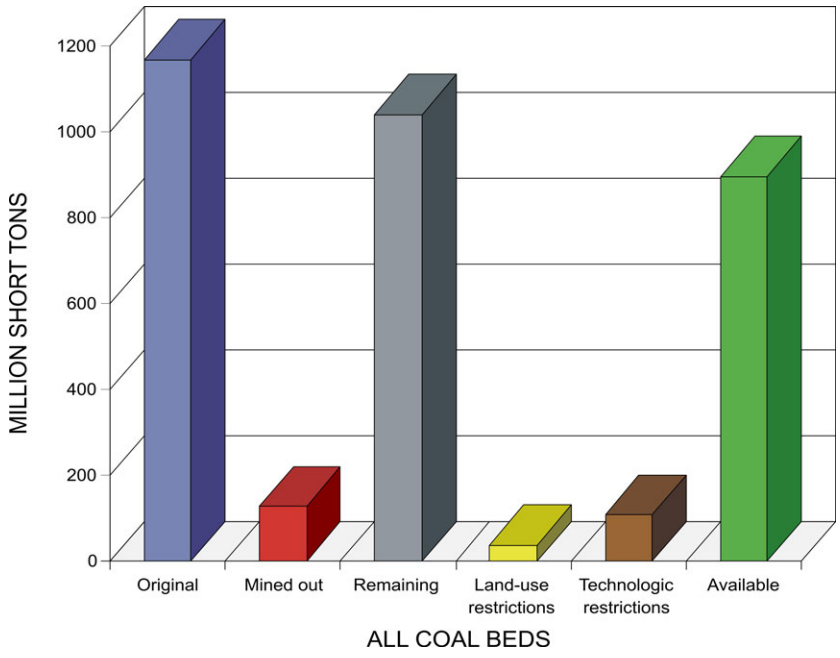

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by Viktoras W. Skema, James R. Shaulis, Rose-Anna Behr, Leonard J. Lentz, and John C. Neubaum
Pennsylvania Geological Survey

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ABSTRACT

The Waynesburg 7.5-minute quadrangle in Greene and Washington Counties is one of six quadrangles being studied in the Main Bituminous Coal Field of western Pennsylvania to help demonstrate how much coal, on average, remains available for extraction within a mature mining district. Pennsylvanian to Permian-age rocks are exposed in the quadrangle. Coals included in the study are: the Waynesburg and Waynesburg A coals of the Waynesburg Formation that outcrop in the southeast corner of the quadrangle; the Sewickley coal of the Monongahela Group; the Pittsburgh coal, which has been extensively deep mined; the Lower Bakerstown coal of the Conemaugh Group; and the Upper Freeport coal of the Allegheny Formation. The results of the study indicate that of the approximately 1,169 million short tons of bituminous coal originally present, 127 million short tons have been mined out. An additional 145 million short tons of coal can be excluded due to resource restrictions, such as land-use and technological factors, leaving about 897 million short tons, or 77 percent, of the original amount of coal available for mining. This report does not take into account economic or environmental limiting factors.

INTRODUCTION

This report is a continuation of a cooperative effort between the Pennsylvania Bureau of Topographic and Geologic Survey and the Coal Resources Branch of the U.S. Geological Survey to quantify coal resources available for mining using not only conventional methods but also by looking at the additional effect of land-use and technological restrictions to mining. This study focuses on six quadrangles of the Main Bituminous Coal Field in southwestern Pennsylvania carefully selected to be representative of the mined coals present in different parts of the geologic section and also of the different land-use patterns present in the region (Figure 1). Neighboring coal states in the Central and Northern Appalachians have conducted similar studies.

Coal exploration drill-hole descriptions and maps delineating mined-out areas were collected for the study. This information was incorporated into a computer stratigraphic database. Mining restriction categories used for the study were based upon the mining regulations of the Commonwealth of Pennsylvania but do not take into account environmental or economic factors. The data were retrieved for inclusion into a modified version of an ArcInfo AML designed by the Montana Bureau of Mines and Geology and the Illinois State Geological Surveys to emulate the geographic analysis program created by the U.S. Geological Survey using GRASS (Geographical Resources Analysis Support System) to calculate available coal based upon various coal and overburden thickness categories.

The study area incorporates coal stratigraphic data from nine quadrangles—the Waynesburg 7.5-minute quadrangle, and approximately three miles into the eight adjacent quadrangles—in an effort to minimize quadrangle "edge effects" when creating isopach maps of coal bed thickness and deriving coal bed structure maps. Resources are calculated, however, only for the Waynesburg 7.5-minute quadrangle.

Overall, the goals of this Coal Availability Study include:

1. Determine the original, mined-out, and remaining coal for 7.5-minute quadrangle-sized study areas that are representative of the bituminous coal measures of Pennsylvania and for which data exist.
2. Determine the amount of coal available for mining in these study areas by also considering the effect that land-use and technological restrictions have on that remaining resource base.
3. Establish a methodology and a means of comparison of future 7.5-minute quadrangle studies in other parts of the bituminous coal field in Pennsylvania.

This report presents the results of the Waynesburg study, providing estimates of the original, mined-out, remaining, restricted, and available resources.

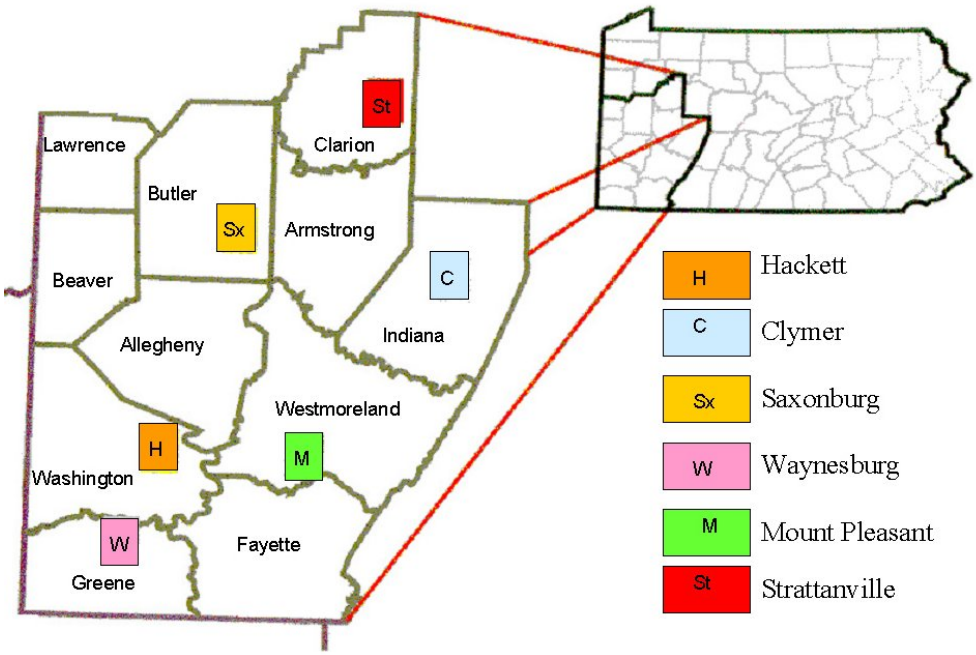

Figure 1. Location map of the Waynesburg 7.5-minute quadrangle and other Coal Availability Studies in Pennsylvania.

LOCATION

The Waynesburg 7.5-minute quadrangle is located in southwestern Pennsylvania, in north-central Greene County and southern Washington County, and includes Waynesburg, the county seat and largest city in the county (Figure 1). Drainage flows generally eastward through the study area, ultimately reaching the Monongahela River. The South Fork of Tenmile Creek and three of its tributaries, Browns Creek, Ruff Creek, and Smith Creek, are the major channels for this drainage (Figure 2).

Major highways are the limited-access Interstate 79, running generally north-south through the eastern part of the quadrangle bypassing the town of Waynesburg just to its east, and US Route 19, which roughly parallels Interstate 79 but goes through Waynesburg. State routes in the quadrangle are PA Route 21, running east west through the town of Waynesburg, and PA Routes 18, 218, and 221. Some county and township roads, mostly built low in the creek valleys, transect the study area as well.

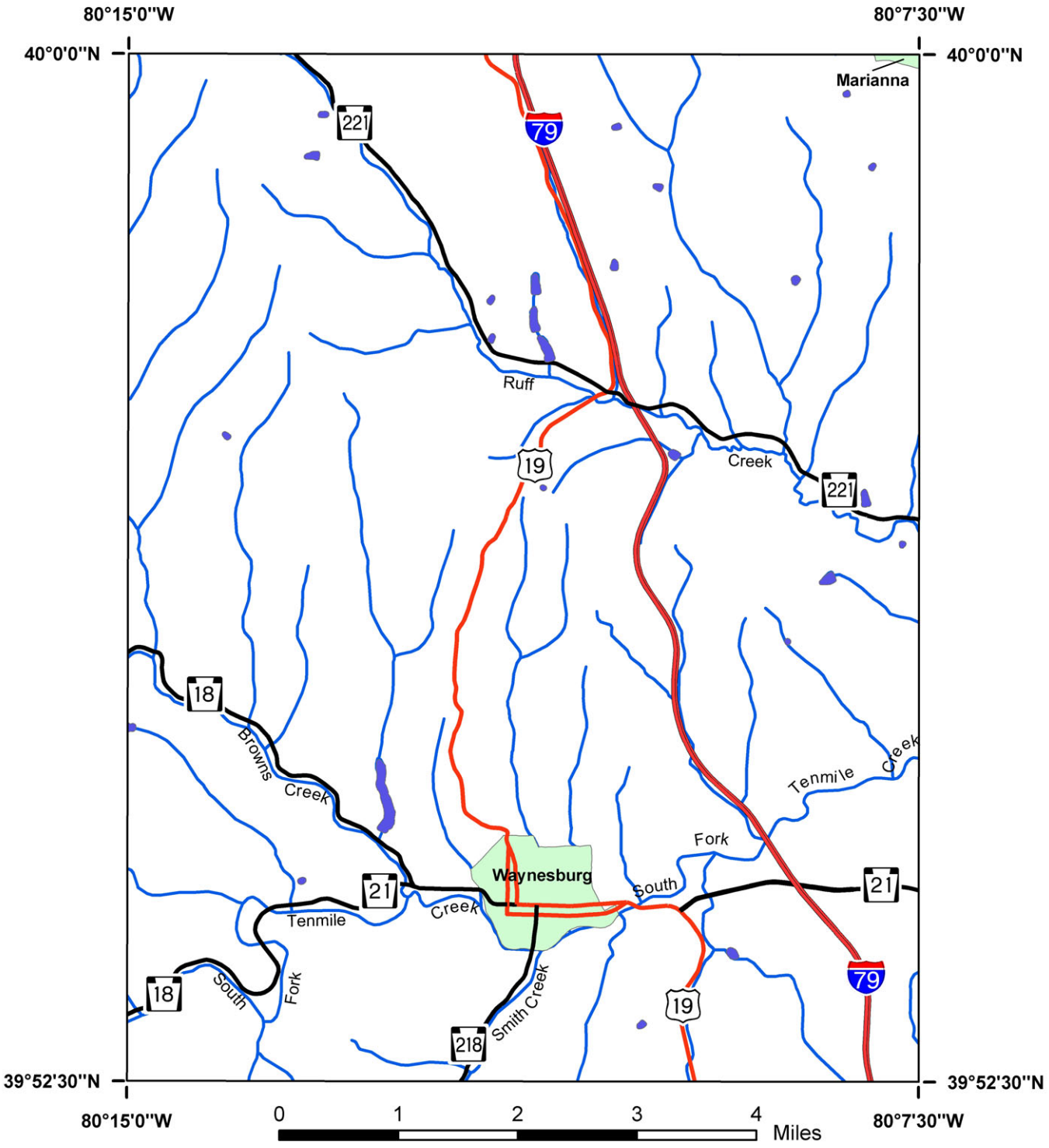

Figure 2. Location of selected roads, streams, and towns in the Waynesburg quadrangle.

GEOLOGY

PHYSIOGRAPHY

The Waynesburg quadrangle lies within the Waynesburg Hills section of the Appalachian Plateaus physiographic province (Sevon, 2000). This section is very hilly, highly dissected, with narrow hilltops and steep-sloped narrow valleys. There is very little flat topography in the quadrangle other than flood plains formed in some of the larger drainages. Average relief is around 300 feet. Greatest relief on any one hillside is 450 feet. This hill is located just east of US Route 19 at the southern edge of the quadrangle. Maximum topographic relief in the study area is 620 feet.

STRATIGRAPHY AND DEPOSITIONAL SETTING

The study includes rocks of the Permian Dunkard Group, and the Pennsylvanian Monongahela through the Allegheny Formations (Figure 3). They consist typically of shale, sandstone, limestone, and coal (Pennsylvania Geological Survey Map 11, 1992). Sedimentary facies change both laterally and vertically within each stratigraphic unit.

Stratigraphically, the lowest coal being considered in this study is the Upper Freeport coal that lies at the very top of the Allegheny Formation. The rocks surrounding the Upper Freeport coal reflect an alluvial plain setting with peat swamps being developed on broad interfluves between flowing streams occasionally punctuated by overbank deposits. During this time, a wet tropical climate favoring plant growth was prevalent. Because of this, even in this moderately high-energy setting, many swamps had enough time to accumulate substantial amounts of peat, sufficient to develop coal of a minable thickness.

Above the Allegheny Formation, the next coal considered in the study is the Lower Bakerstown coal in the Glenshaw Formation. The Glenshaw Formation lies within the lower half of the Conemaugh Group that is characterized by shifting shallow marine, and coastal or delta plain environments. Four major widespread marine events characterize the Glenshaw Formation (Skema, Dodge, and Shaulis, 1991). The Lower Bakerstown coal is associated with one of these events and displays a consistent thickness across the entire study area reflecting a widespread uniform depositional setting. The upper half of the Conemaugh Group, the Casselman Formation, lacks minable coals in this area and is characterized by lenticular and locally thick sandstones.

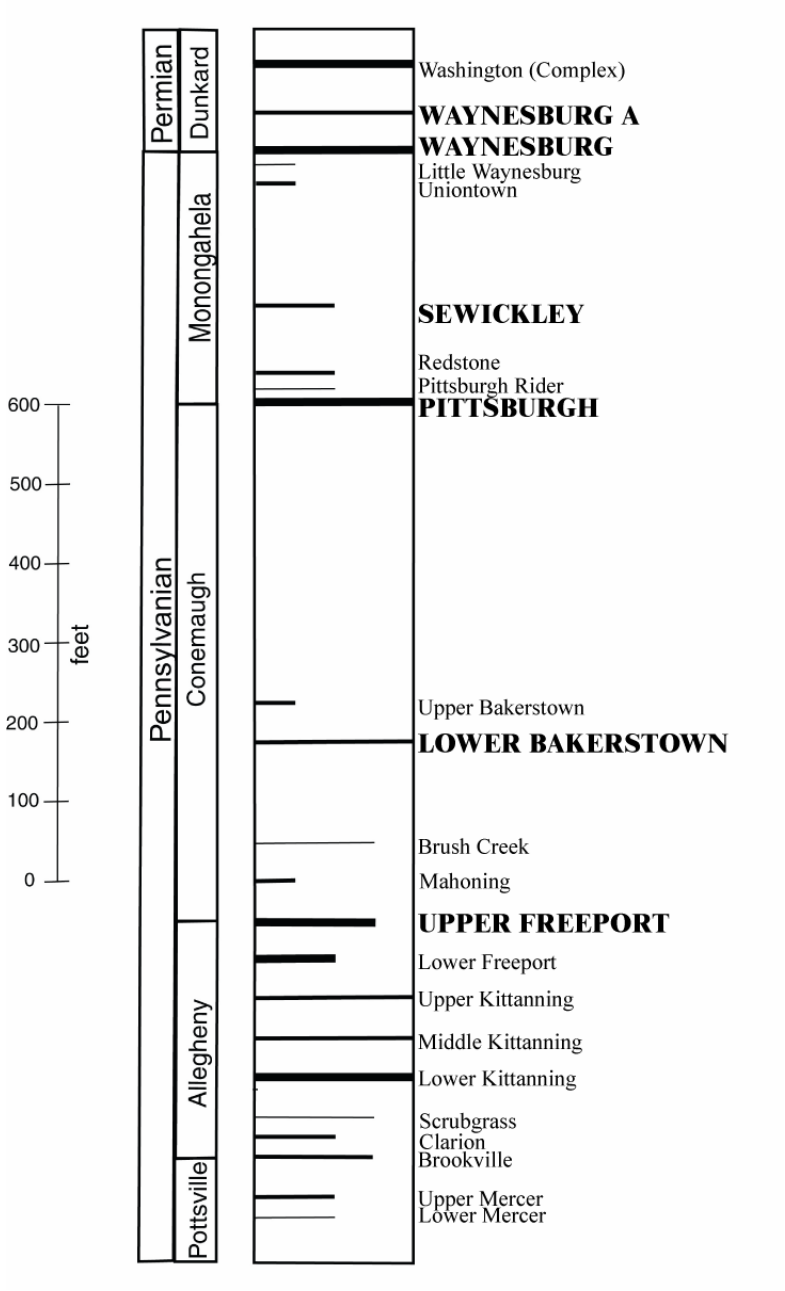

Figure 3. Generalized columnar section of coals of the Main Bituminous coal field of western Pennsylvania, highlighting the investigated coals (bold, uppercase) of the Waynesburg quadrangle.

Stratigraphically above the Lower Bakerstown coal are the Pittsburgh and Sewickley coal seams that lie in the Pittsburgh Formation, in the lower half of the Monongahela Group. Generally the rocks of this group reflect a change from a wet tropical to semi-arid climate of lower energy. However, in the basal half of this group, some occasional wet periods, resembling a moist savanna climate allowed large quantities of peat to accumulate in low-gradient, poorly-drained, coastal plain swamps (Fedorko, 1999). Some thick coals like the Pittsburgh and Sewickley, and several thick limestone beds like the Benwood and the Fishpot, testify to this depositional setting.

Moving stratigraphically higher, still a further reduction in energy is reflected in the Permian Dunkard Group rocks. They are characterized by low-energy lacustrine - deltaic deposits consisting of calcareous clays, silts, limestones, and commonly thin, but occasionally thicker coals such as the Waynesburg coal. Sandstones that are present are lenticular in nature and may be locally thick. Over ninety-five percent of the rocks exposed at the surface in the Waynesburg quadrangle lie within the Waynesburg, Washington, and Greene Formations of the Dunkard Group (Berg and Dodge, 1981).

STRUCTURE

Although the strata in the Appalachian Plateaus physiographic province are relatively flat-lying, there are a number of asymmetrical, gently to moderately folded rock layers forming anticlines and synclines which developed in the late Pennsylvanian to early Permian Alleghenian Orogeny (Berg, Edmunds, Geyer, and others, 1980). The Waynesburg quadrangle contains three northeast to southwest trending folds- the Waynesburg syncline and the Bellevernon and Amity anticlines (Dodge and Glover, 1984 and Figure 4). The steepest dip of the beds in any of these structures is on the northwestern flank of the Bellevernon anticline where the dip rate is approximately 100 feet per mile. In the northwestern third of the study area along either side of the Amity anticline the rate of dip drops to 20 feet or less per mile. The rate of plunge for all the axes is commonly zero to 20 feet per mile to the southwest, with local variations as shown on Figure 4. The greatest amplitude of folding is about 340 feet, and occurs between the Waynes-

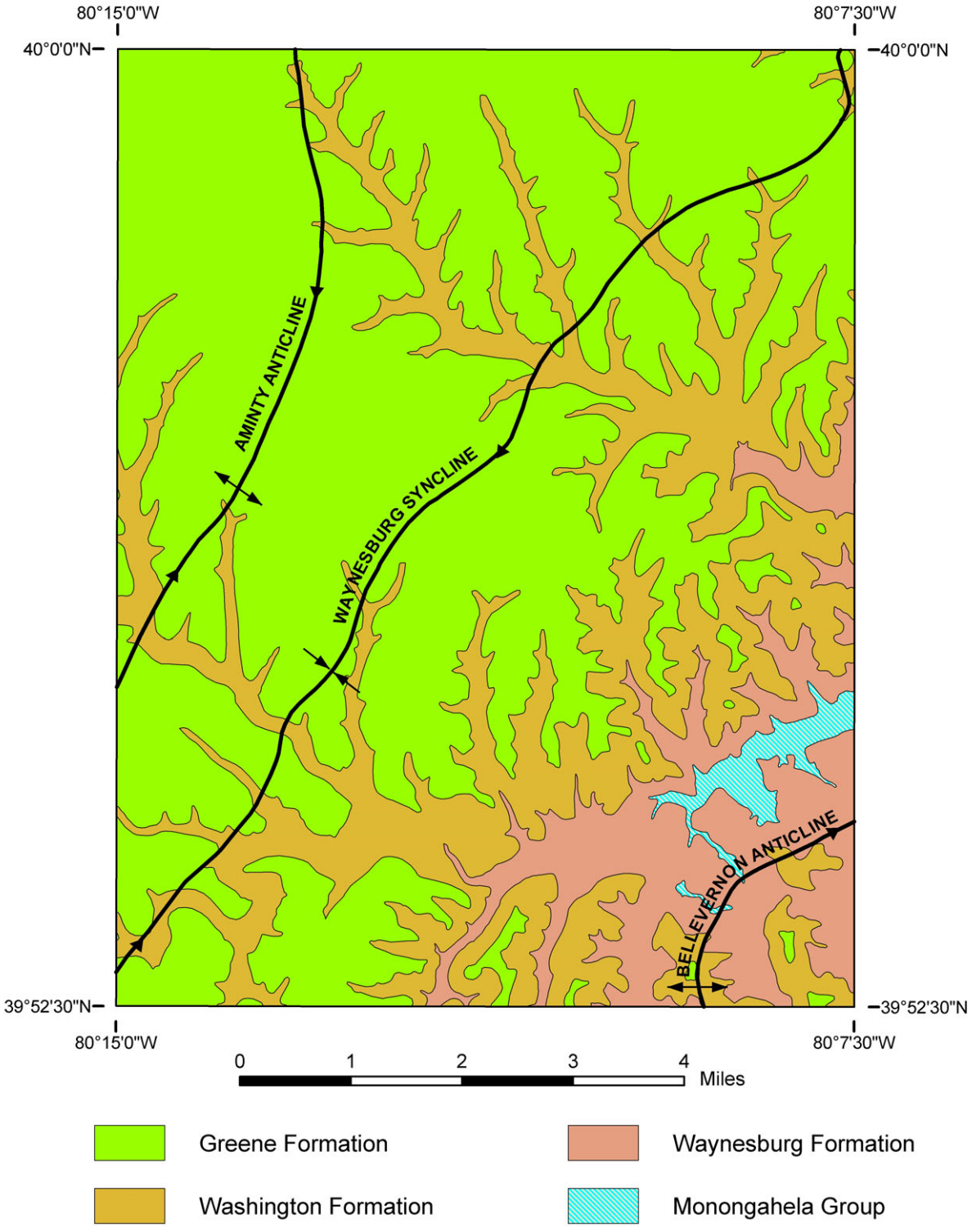

Figure 4. Simplified geologic map of the Waynesburg quadrangle (after Roen, 1970).

burg syncline and the Bellevernon anticline, where the base of the Pittsburgh coal rises from 300 feet above sea level to a maximum 640 feet above sea level in a southeasterly direction. In the northwestern portion of the quadrangle between the Waynesburg syncline and the Amity anticline the amplitude lessens to only about 100 feet. The structure appears to have very little relationship to the drainage patterns in the area except that the major drainages tend to flow normal to the structure, perhaps following fracture or joint patterns developed during the Alleghanian folding.

COAL DESCRIPTIONS

The coal seams mined in the study area, shown in uppercase on Figure 3, represent only a fraction of all the potentially minable coals known to occur in the Pennsylvanian and Permian rocks of western Pennsylvania. The Upper Freeport, Lower Bakerstown, Pittsburgh, Sewickley, Waynesburg, and Waynesburg A coal beds were considered in this study because of their thickness (i.e. greater than 14 inches thick when less than 200 feet from surface, and greater than 28 inches when more than 200 feet) and aerial extent. These criteria excluded marginal coals like the Washington coal bed complex in the Dunkard Group which outcrops in the southeast corner of the quadrangle, the Mahoning and other Conemaugh Group coals, and the Redstone in the Monongahela Group from the study because they are absent, thin (usually less than 14 inches thick), or where thicker, their occurrence is very local. Some of the Allegheny and Pottsville Formation coals may have economic importance, however too little data were available on these deeper coals to ascertain this with any reasonable degree of confidence.

The coals in the Waynesburg quadrangle are classified as high-volatile bituminous coals (Pennsylvania Geological Survey Map 11, 1992). The Pittsburgh coal and, to a very limited degree, the Waynesburg coal are the only coals that have been mined in the quadrangle. The Pittsburgh coal has traditionally been viewed as the premier resource regionally for supplying steam power, coke, and home heating. It is presently the only coal being mined in the quadrangle and is now used exclusively as fuel for generating electricity. The Waynesburg coal was mined locally in a few country banks in the mid to late 1800s and early in the 1900s near Waynesburg and used locally for domestic heating (Stevenson, 1876 and Stone, 1932).

Upper Freeport Coal

The eastern third of the Waynesburg quadrangle is underlain by thick Upper Freeport coal (Figure 5). This coal is the western portion of a large, thick oval, dome-shaped pod that is approximately 9 miles wide by 12 miles long and is entirely in the subsurface in northeastern Greene County (Skema, Sholes, and Edmunds, 1982). It has a definite limit to the west where it is bounded by a several-mile wide, north-south trending belt containing primarily sandstone and sandy shale, which is situated along the entire length of the central portion of the Waynesburg quadrangle. The coal thins rapidly and splits as it approaches this no-coal area.

Much of the Upper Freeport is greater than 60 inches thick. Maximum thickness exceeds 100 inches in two separate peaks to the east of the study area, and also an area north of the study area near Marianna and the North Fork of Tenmile Creek. The portion of the pod that is within the Waynesburg quadrangle is mostly greater than 28 inches thick and has a maximum thickness of 77 inches. The coal is frequently bony with partings of thin carbonaceous clay shale lenses in the top twelve inches (Brian Shaffer, personal communication, 2007). The coal is situated relatively deep in the Waynesburg quadrangle, 1,000 feet or more below the surface nearly everywhere. Nonetheless, despite its depth, its thickness and quality characteristics give it great potential for future mining.

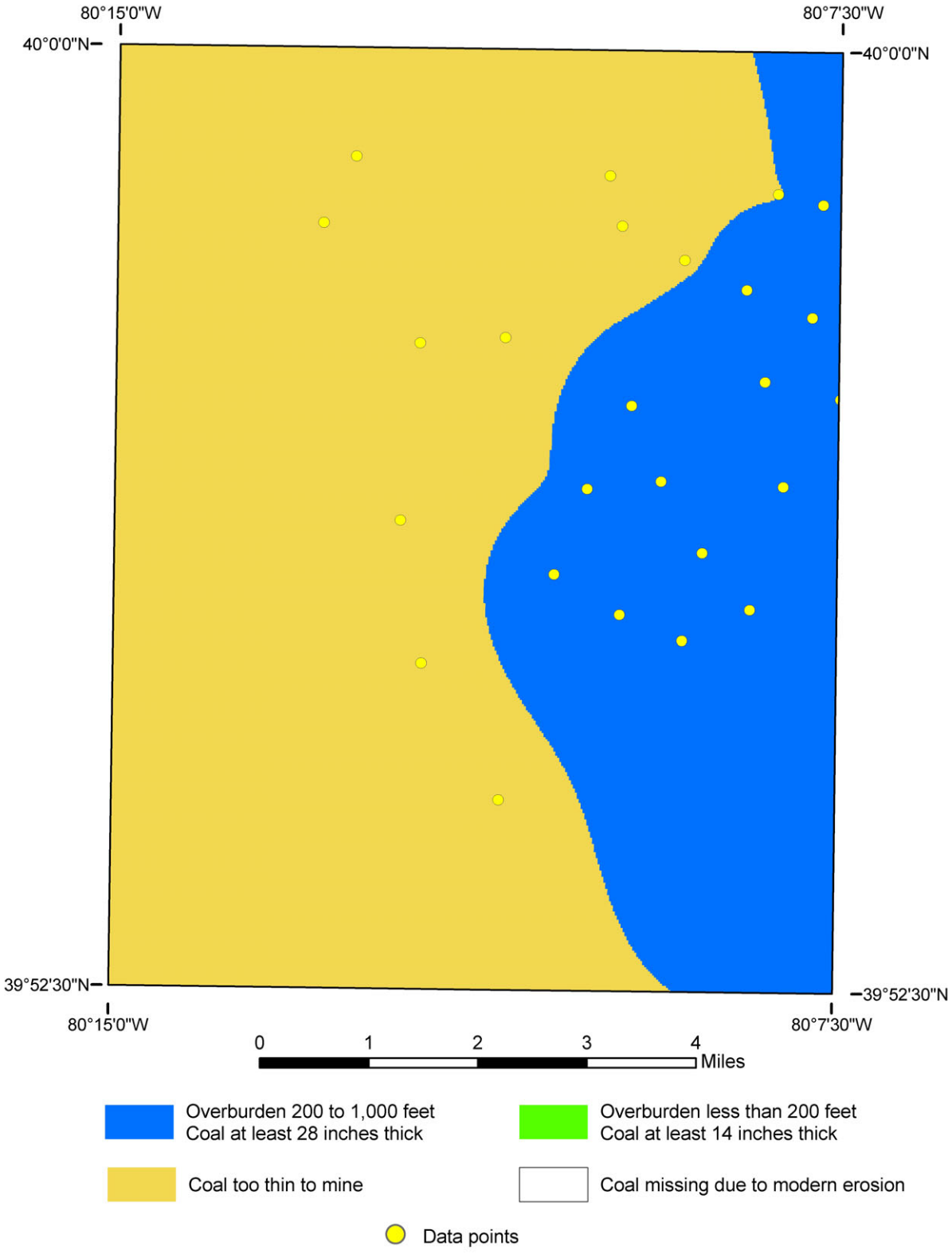

Figure 5. Amount of overburden, coal thickness, and data point locations for the Upper Freeport coal.

Lower Bakerstown Coal

The Lower Bakerstown coal is continuously present throughout the Waynesburg quadrangle and is persistently about three feet thick (28 – 45 inches) (Figure 6). It is in the Glenshaw Formation of the Conemaugh Group and is approximately 180 feet above the Upper Freeport coal. Like the Upper Freeport coal it is relatively deep and does not outcrop anywhere in the quadrangle or the region. It is overlain by dark shale and a thin limestone containing marine invertebrate fossils. The Lower Bakerstown coal's uniform thickness is typical of other Glenshaw Formation coals and coals lower in the stratigraphic section overlain by marine zones. These coals are believed to have originated in peat swamps that formed on a coastal plain bordering an advancing sea. Peat accumulation was uniformly terminated as the encroaching seawater drowned long stretches of swamp forests paralleling the retreating shoreline. The peat was covered with typically fine-grained near shore and bay mud. This process produced characteristically continuous coals having a relatively uniform thickness and a planar top surface. High sulfur content is another characteristic of coals formed in this depositional environment, which also tend to contain high levels of pyrite. The depth, marginally acceptable thickness for deep mining, and high sulfur content (from pyrite) give the Lower Bakerstown very low mining potential for the foreseeable future.

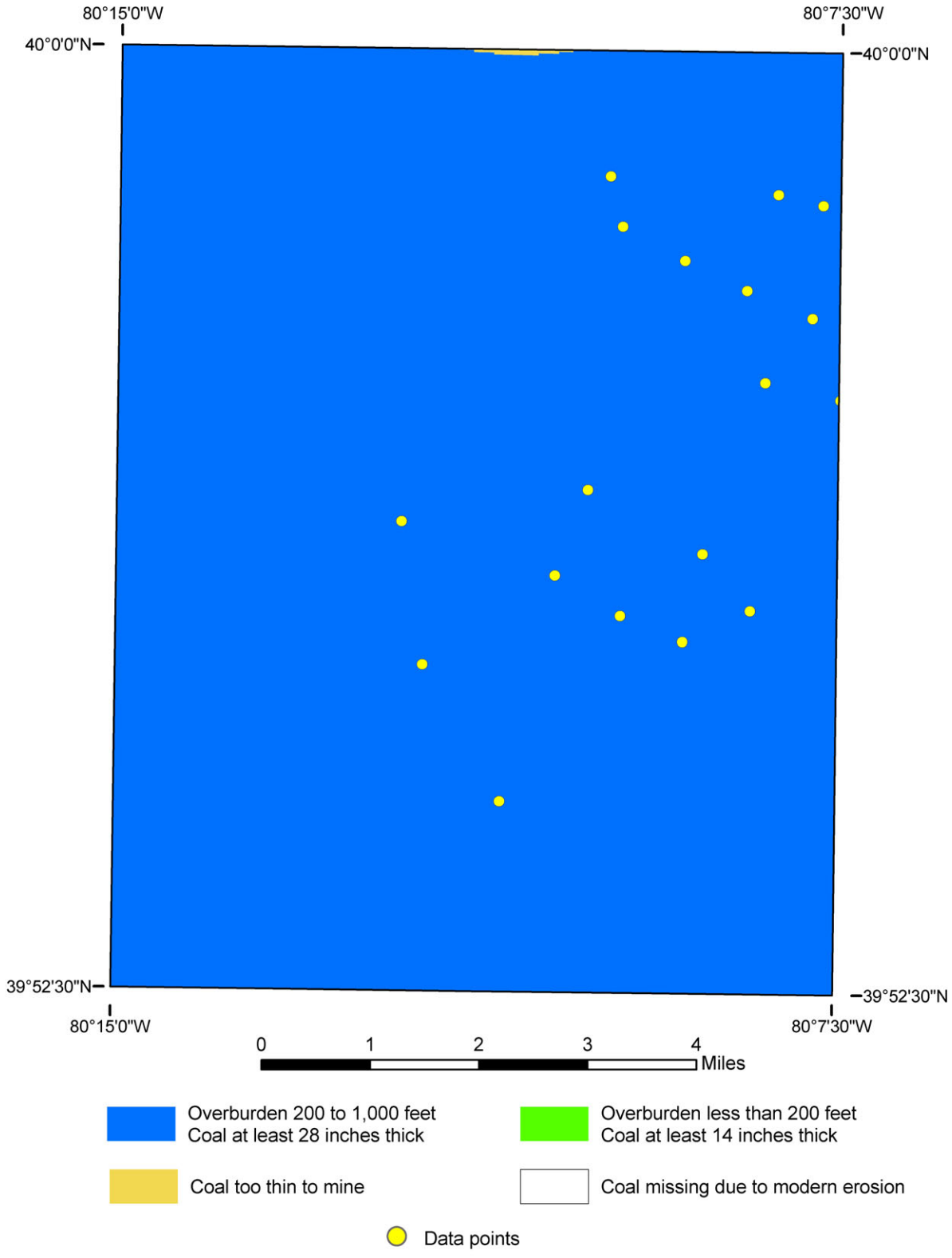

Figure 6. Amount of overburden, coal thickness, and data point locations for the Lower Bakerstown coal.

Pittsburgh Coal

Typically, the Pittsburgh coal bed comprises two major benches: a lower "main" coal and a "roof" coal. The two are separated by a nonbedded, slickensided fireclay commonly called "draw slate." The "roof" coal is often ignored during mining because it usually consists of multiple thin coals of poor quality separated by shale and claystone partings, which are often as thick as the coals. Where the thick Pittsburgh sandstone is present the roof coals are often absent, through erosion or non-deposition. The mined "main" bed is typically 63-86 inches thick in the Waynesburg quadrangle and contains several thin partings (quarter inch thick or less). One persistent parting, called the "bearing-in bench" typically occurs in the middle of the main bed and consists of ¼" to 1 ¾" grey to black shale or bone. The main bed locally attains a maximum thickness of 111 inches along the eastern border of the quadrangle just north of the South Fork of Tenmile Creek. Several narrow, linear, north-south oriented zones of thin coal have been identified in drilling and encountered in past mining. These are apparently associated with small stream channels flowing during the later stages of peat accumulation of the "main" seam, or after, at the time the draw slate was deposited. The channels caused considerable disruption in the peat but only within a small area in close proximity to these narrow channels. Coal is usually thin in these areas. Doubling of coal has been observed in recent exploration drilling along one of these channels (personal communication Shaffer, 2002). It appears that this was caused by slumping. These north-south channels were precursors to a large river system that produced sandstone deposits exceeding 60 feet thickness in places above the Pittsburgh "roof" coals (Roen and Kreimeyer, 1973). The Pittsburgh coal underlies the entire quadrangle (Figure 7). Cover ranges from approximately 300 feet in the southeastern corner of the quadrangle under the South Fork of Tenmile Creek to approximately 1,150 feet under the highest hilltops northwest of Waynesburg where the coal is at its structurally lowest point along the axis of the Waynesburg Syncline.

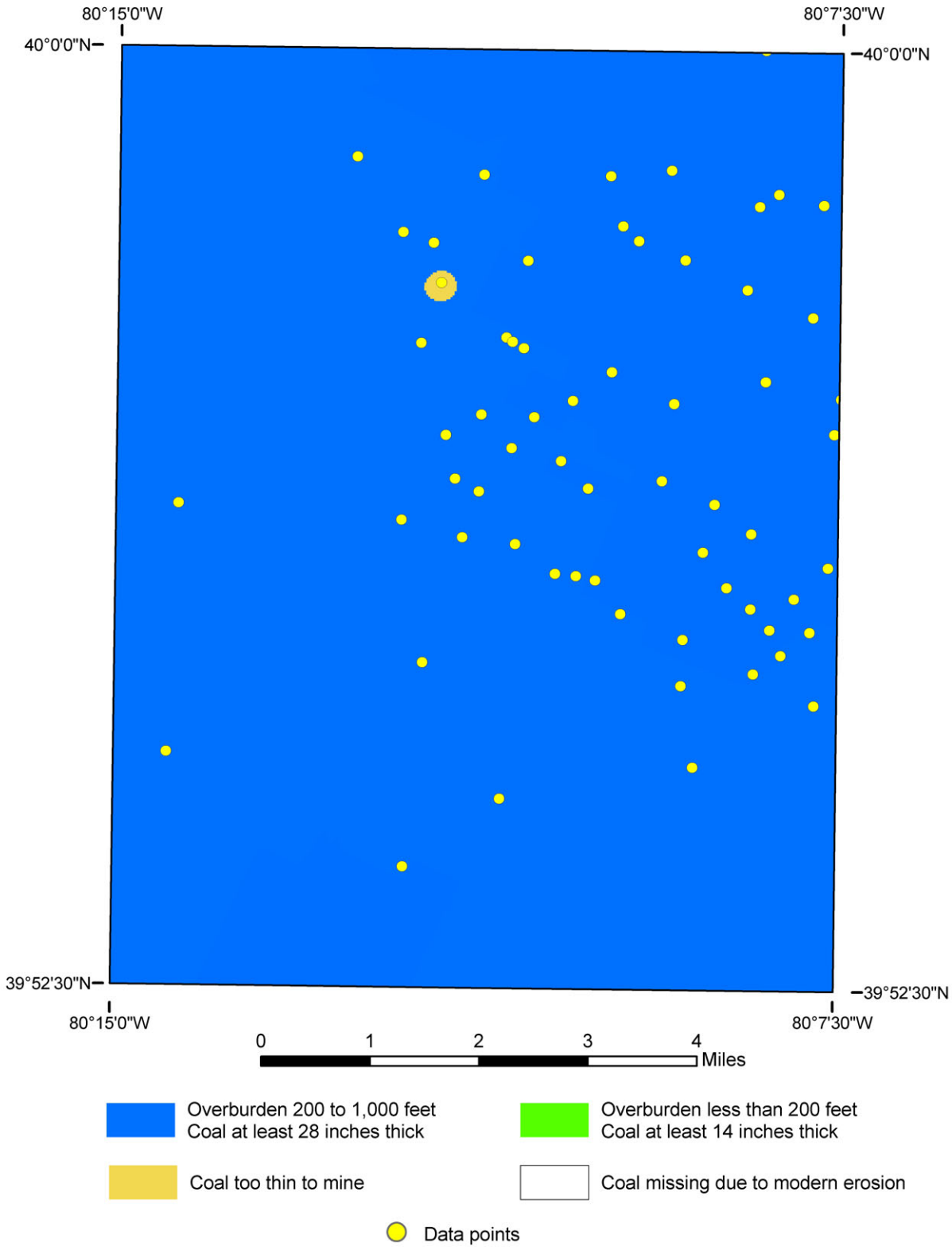

Figure 7. Amount of overburden, coal thickness, and data point locations for the Pittsburgh coal.

Sewickley Coal

The Sewickley coal is a relatively thick coal throughout the southern two thirds of Greene County. The coal thins and is split by clastics to the north, east, and west. It is very thin or missing throughout Washington County to the north (Figure 8). The transition zone between the thick Sewickley to the south and the no coal area to the north passes through the Waynesburg quadrangle. Coal is spotty and thin in the northern third of the quadrangle (18 inches of less) and has minable thickness in most of the remainder of the quadrangle to the south (28 to 60 inches thick, with an average of 36-42 inches). A roughly linear belt of thin coal cuts through the well-developed coal from the southeast corner of the quadrangle to the thin coal area in the north central part. This was possibly caused by a meandering stream system active during or shortly after peat development and could well have created a discontinuity dividing the thick coal into two separate pods. Additional drilling data are needed to determine the full extent of this thin coal zone. The Sewickley is split in places into two coals separated by as much as 18 feet of shale. The lower split is usually much thinner than the other and was not considered in this resource study. The Sewickley coal is slightly shallower than 200 feet underground in the southeast corner of the quadrangle and greater than 1000 feet underground in the northwest. It does not outcrop in the Waynesburg quadrangle.

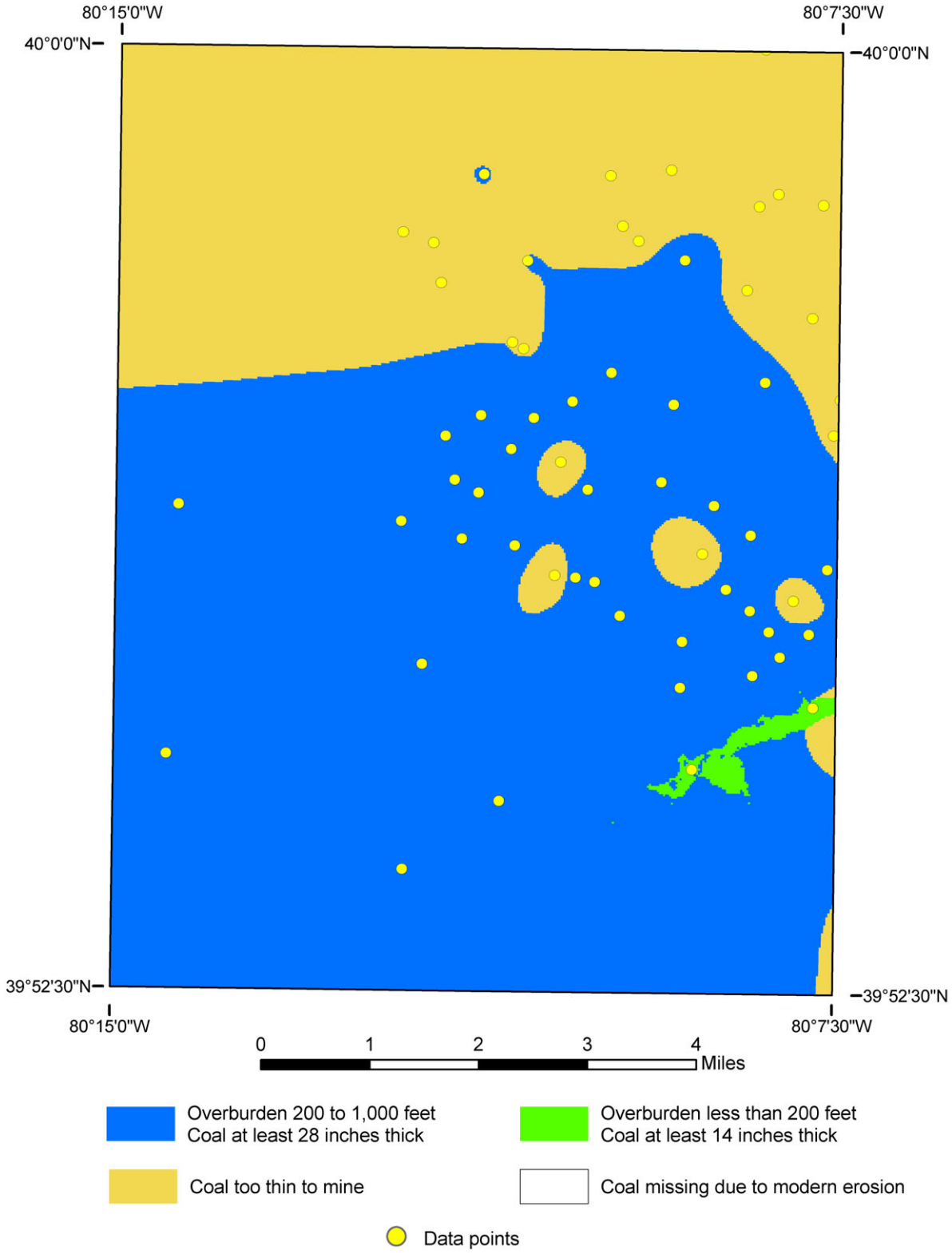

Figure 8. Amount of overburden, coal thickness, and data point locations for the Sewickley coal.

Waynesburg Coal

The Waynesburg coal bed outcrops only in the South Fork of Tenmile Creek downstream from Waynesburg and the deeper parts of its tributaries valleys in the southeastern part of the quadrangle (Figure 9). The Waynesburg coal is about 50-60 inches thick (excluding partings) over the majority of the quadrangle, with two good benches of coal typically separated by a 1-2 foot thick claystone parting. Thickness ranges from about 74 inches (excluding the thick middle parting) at some localities to less than 6 inches in a few isolated spots. Each bench contains numerous thin shale and fusain partings, and often contains pyrite. Depth of cover ranges from 0 feet (at outcrop) to more than 900 feet in the deepest part of the Waynesburg Syncline northwest of Waynesburg. Several data points indicate small areas of thin coal. One set of these has a definite north-south alignment bisecting the quadrangle in its center. Another small area of thin coal in the northeast corner of the quadrangle and is aligned with a zone of thin coal encountered in the drill hole at the center of the eastern edge of the quadrangle. These narrow, linear zones of thin coal probably were the result of channel down-cutting from streams flowing through the area subsequent to peat development, and also possibly attributable to contemporaneous stream channels flowing through the swamp disrupting peat development. Interestingly, the effects of fluvial systems following about the same path through the quadrangle can be found in the Upper Freeport, Pittsburgh, Sewickley, and Waynesburg coals. This suggests entrenchment of a major drainage system over a remarkably long period of time, and if true raises the question of what could be controlling the river systems position so effectively.

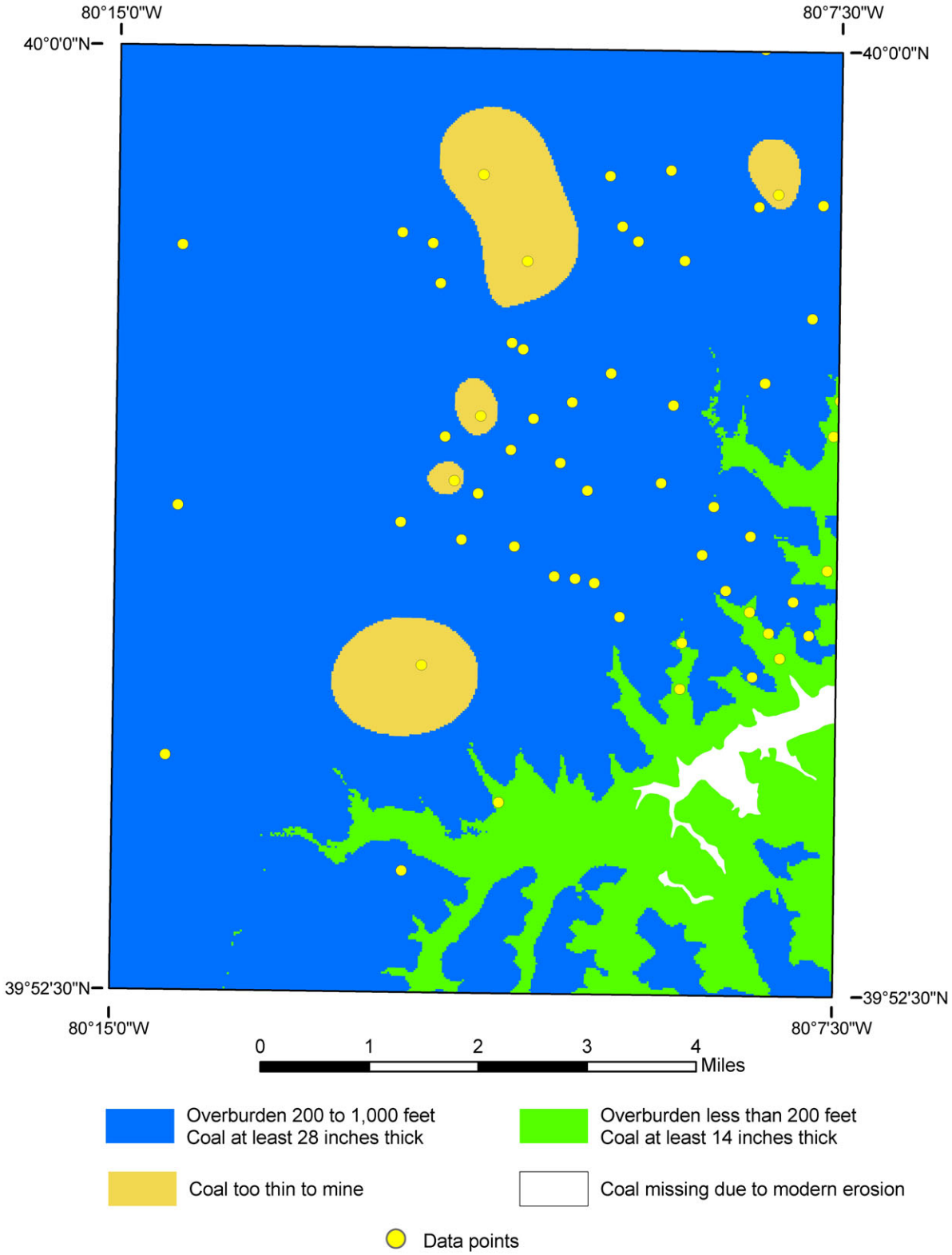

Figure 9. Amount of overburden, coal thickness, and data point locations for the Waynesburg coal.

Waynesburg A Coal

The Waynesburg A coal bed is stratigraphically positioned 50 to 70 feet above the Waynesburg coal bed, and ranges in thickness from 0 inches to more than 30 inches in a few isolated spots in the northeastern to central portion of the Waynesburg quadrangle (Figure 10). Thickness can vary greatly over short distances, perhaps due to sandstone channel scours or to increasing water depths, which restricted peat development in the swamp. The Waynesburg A coal usually has a number of thin shale partings throughout. It outcrops only in the valleys in the southeastern corner of the quadrangle. Depth of cover ranges from 0 feet (at outcrop) to more than 850 feet under the highest hilltops northwest of Waynesburg.

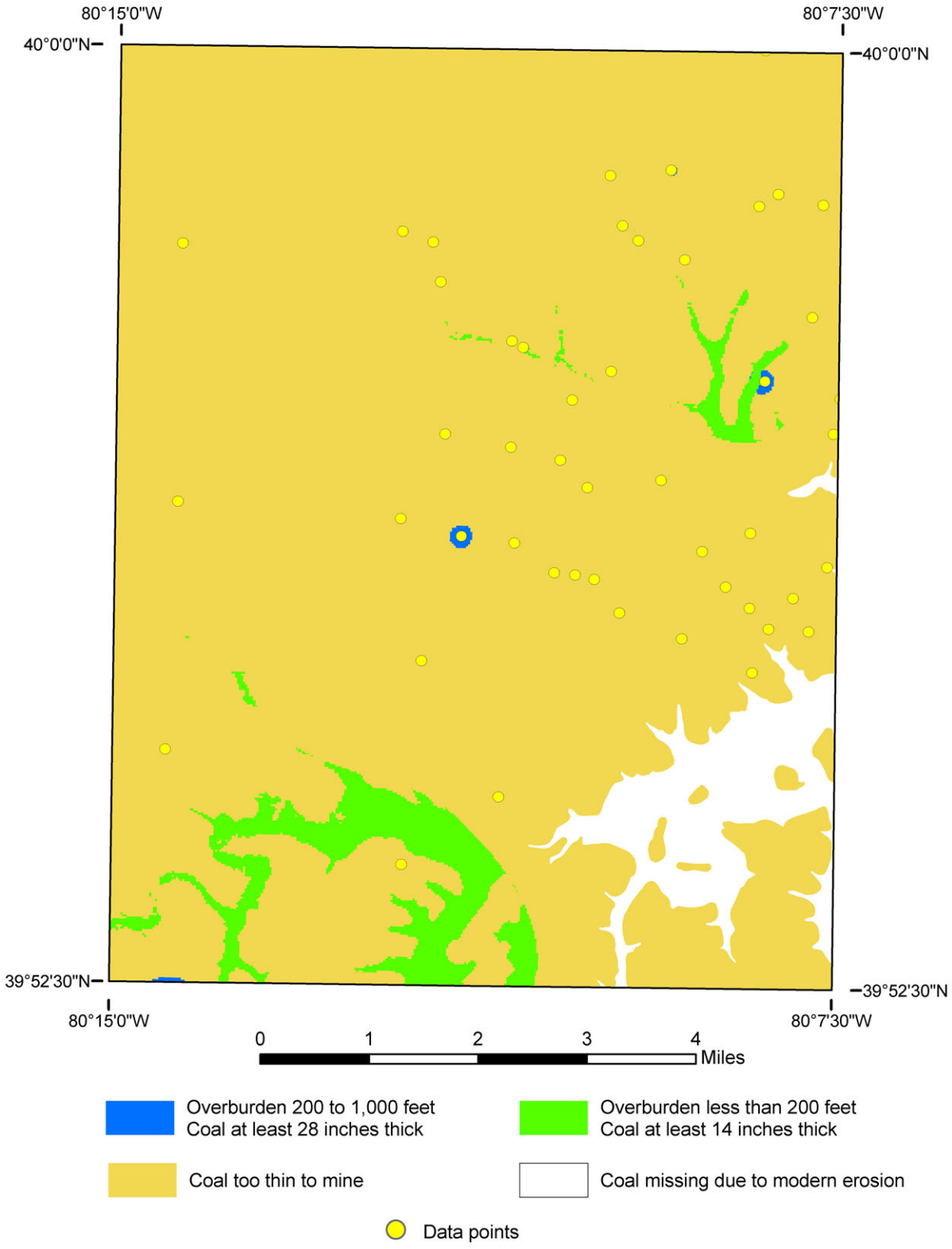

Figure 10. Amount of overburden, coal thickness, and data point locations for the Waynesburg A.

DATA COMPILATION

Mining information and coal crop lines were compiled from work maps created by Dodge and Glover (1984). These work maps were further updated by collecting recent mining information for the Waynesburg quadrangle from RAG Resources, LP (now Foundation Coal Company), which operates the Emerald and Cumberland mines in the Pittsburgh coal. Mined tonnage values and extent of mining information used for this report include data only up to 1993 so that the various coal availability reports would have a uniform cut-off date. Coal stratigraphic and thickness data were obtained from drill hole records in the Pennsylvania Geological Survey's open file Stratigraphic Data Files. Land-use practices and technological restrictions to mining were determined from state and local regulations.

COAL RESOURCES

Resources are calculated in short tons for the purpose of this study, using a basic conversion factor of one acre per foot of coal equals 1,800 short tons of coal. By convention, short ton is the standard means to denote a 2,000 pound ton in tonnage estimates. Other terminology for tons (e.g. long ton, metric ton) as a measurement exist, but these are not normally used in resource studies. Their value is usually greater than a 2,000 pound ton (e.g. 2,200 pounds for long ton).

The relative volumes of the original coal resources for the six coal seams studied in the Waynesburg quadrangle, as determined by using an ArcInfo AML resources program (designed to emulate the geographic analysis program created by the U.S. Geological Survey using GRASS - Geographical Resources Analysis Support System), are depicted in Figure 11. The grand total original coal tonnage for the six beds is estimated to be 1,169 million short tons (Figure 12). About 127 million short tons, or 11 percent of the original amount, have since been mined-out or lost-in-mining, leaving remaining resources of approximately 1,042 million short tons or 89 percent of the original. About 962 million short tons, or 92 percent of that remaining coal, are from coal greater than 28 inches thick. Additional resources possibly exist in the deep Allegheny and Pottsville Formation coals, but the data needed to define their lateral extent and thickness are unavailable in this area, making a resource estimate for these seams impossible.

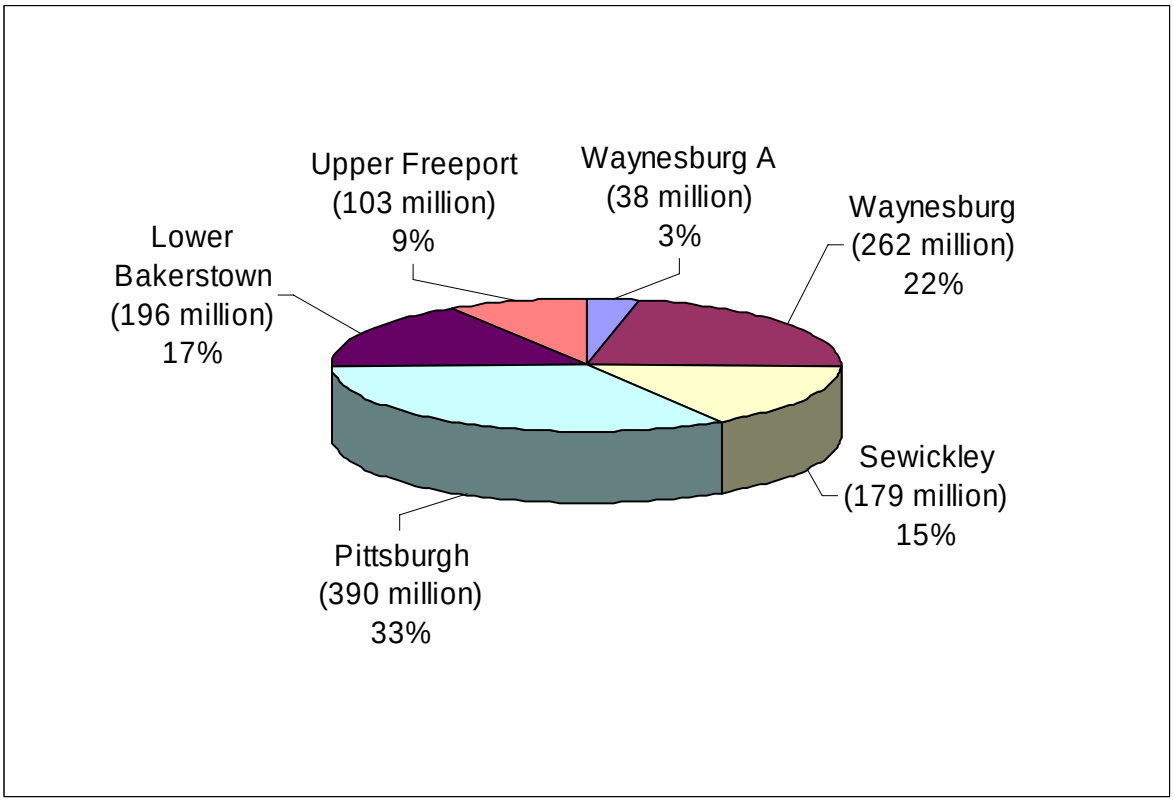

Figure 11. Summary of total original coal resources by coal bed for the Waynesburg quadrangle.

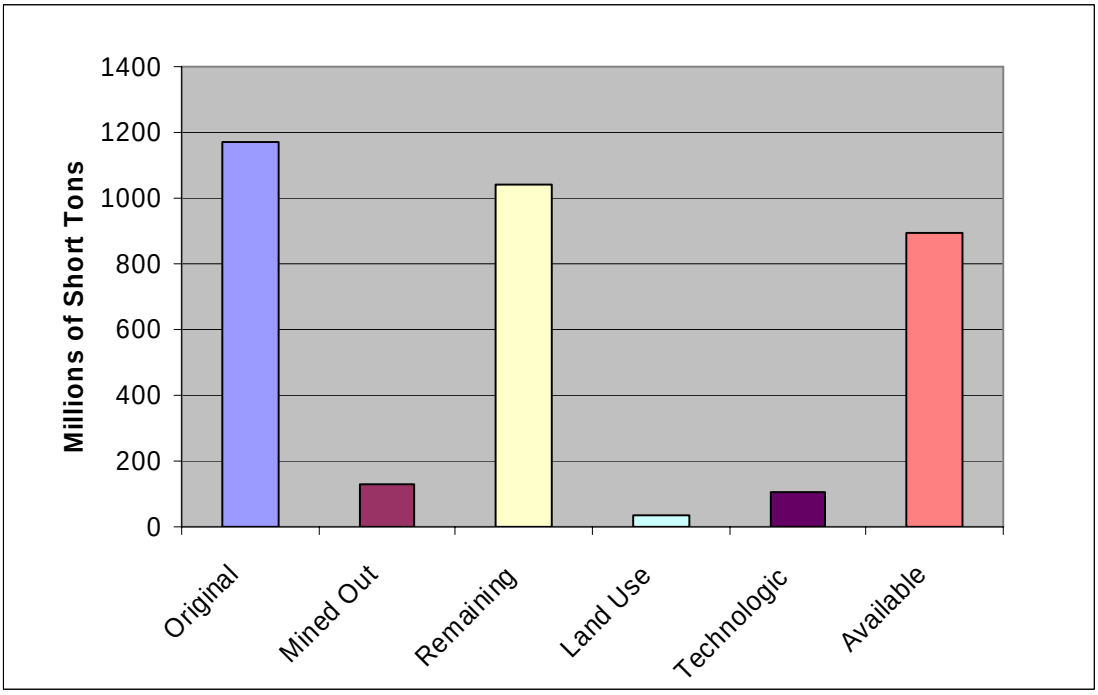

Figure 12. Cumulative tonnages for all coal-resource categories for the Waynesburg quadrangle.

Fifteen land-use and five technological restrictions to mining were identified for the Waynesburg quadrangle. Land-use restrictions include airports, cemeteries, historical sites, houses, public buildings, towns, roads, railroads, pipelines, oil and gas wells, lakes, streams and wetlands, public lands, and Pennsylvania Natural Diversity Index (PNDI) sites. Though PNDI sites were considered exclusions, they would need to be addressed in a case by case basis when it actually comes to mining. If no federally protected species exist at that site, and the species of special concern within that region will not be affected, the Department of Environmental Protection may permit mining. For additional information on land-use and technologic restrictions refer to Lentz and Neubaum (2005). Figure 13 is a composite map illustrating the distribution of the land-use restrictions in the quadrangle. Table A-1 lists the gross amount of coal restricted to mining by coal bed for both land-use and technological restriction types. Land-use and technological restrictions, which impact upon both the surface and deep mining of coal, account for an additional resource likely lost to mining of about 145 million short tons (12% of original total), thus leaving nearly 897 million short tons, or 86 percent of the remaining amount available for future mining (Figure 12), and approximately 77 percent of the original coal resource. Nearly all of this available coal, approximately 896 million short tons is greater than 28 inches thick. Original, mined-out, remaining, restricted, and available tonnage totals for the individual coals have been summarized below, and in Appendix A where they have been rendered into charts. Complete resource tabulations for each bed are given in Appendix B.

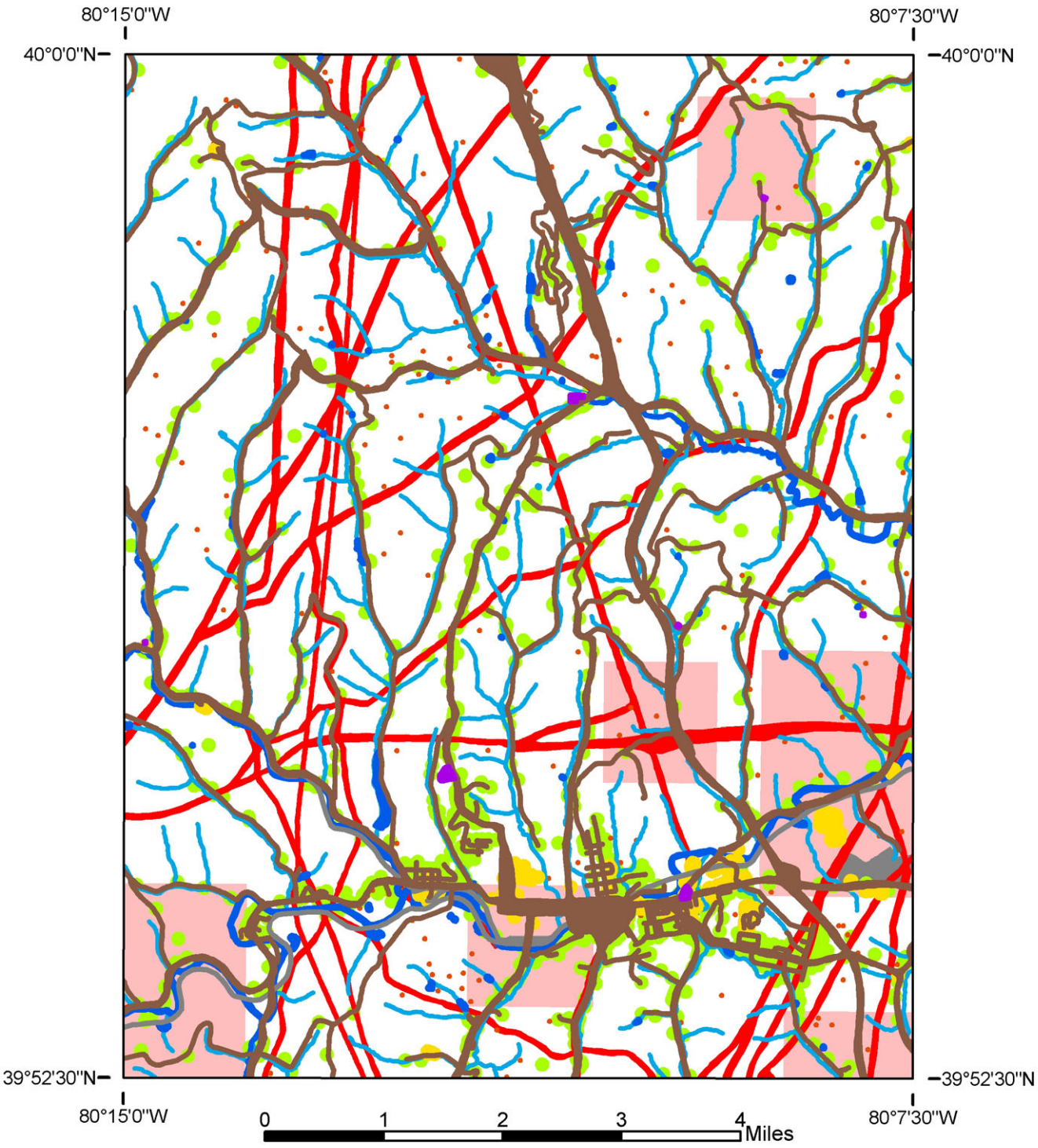

Figure 13. Spatial arrangement of land-use restrictions for the Waynesburg quadrangle. Some of the restrictions are roads (brown), railroads and the airport (gray), power lines and pipelines (red), bodies of water (blue), oil and gas wells (tan dots), towns (dark-yellow areas), houses (green), and PNDI sites (pink).

UPPER FREEPORT COAL

The Upper Freeport coal horizon is deeper than 1,000 feet nearly everywhere in the Waynesburg quadrangle and has never been mined (Figure 14). Though the coal is too deep for surface mining, it has very good potential for deep mining. It is estimated that there is a total of approximately 103 million short tons of original Upper Freeport coal greater than 28 inches thick present in the Waynesburg quadrangle, or 9 percent of total original resources for all coals in this study combined (all the known coal initially present in the quadrangle that are greater than 28 inches thick and considered to be minable by past and current technologies of coal extraction, see Figure 11). None of the possible fifteen land-use restrictions identified in the Waynesburg quadrangle are a factor in future mining of the Upper Freeport coal. Four out of the five technological restrictions impact future deep mining and remove approximately 13 million short tons from potential mining (Figure 15). The impact of these restrictions on the resource is portrayed by the graph in Figures 16 and is tabulated as gross tonnages in Table A-1. This leaves nearly 91 million short tons of Upper Freeport coal available for future deep mining all in the eastern third of the quadrangle (Figure 17), representing slightly less than 88 percent of the total original tonnage for this bed (Appendix A). A large portion of the available Upper Freeport coal in the quadrangle is greater than 60 inches thick. The Upper Freeport coal here in the Waynesburg quadrangle is part of a large pod of coal underlying several quadrangles. The resource estimate of available coal for the entire Upper Freeport coal pod is more than double the above value when the remainder of the pod is considered in the adjacent Mather quadrangle to the east and the Ellsworth quadrangle to the northeast. Some possible local mining restrictions were not addressed in this study, including the potential for water or methane gas inflow from overlaying abandoned Pittsburgh coal mines.

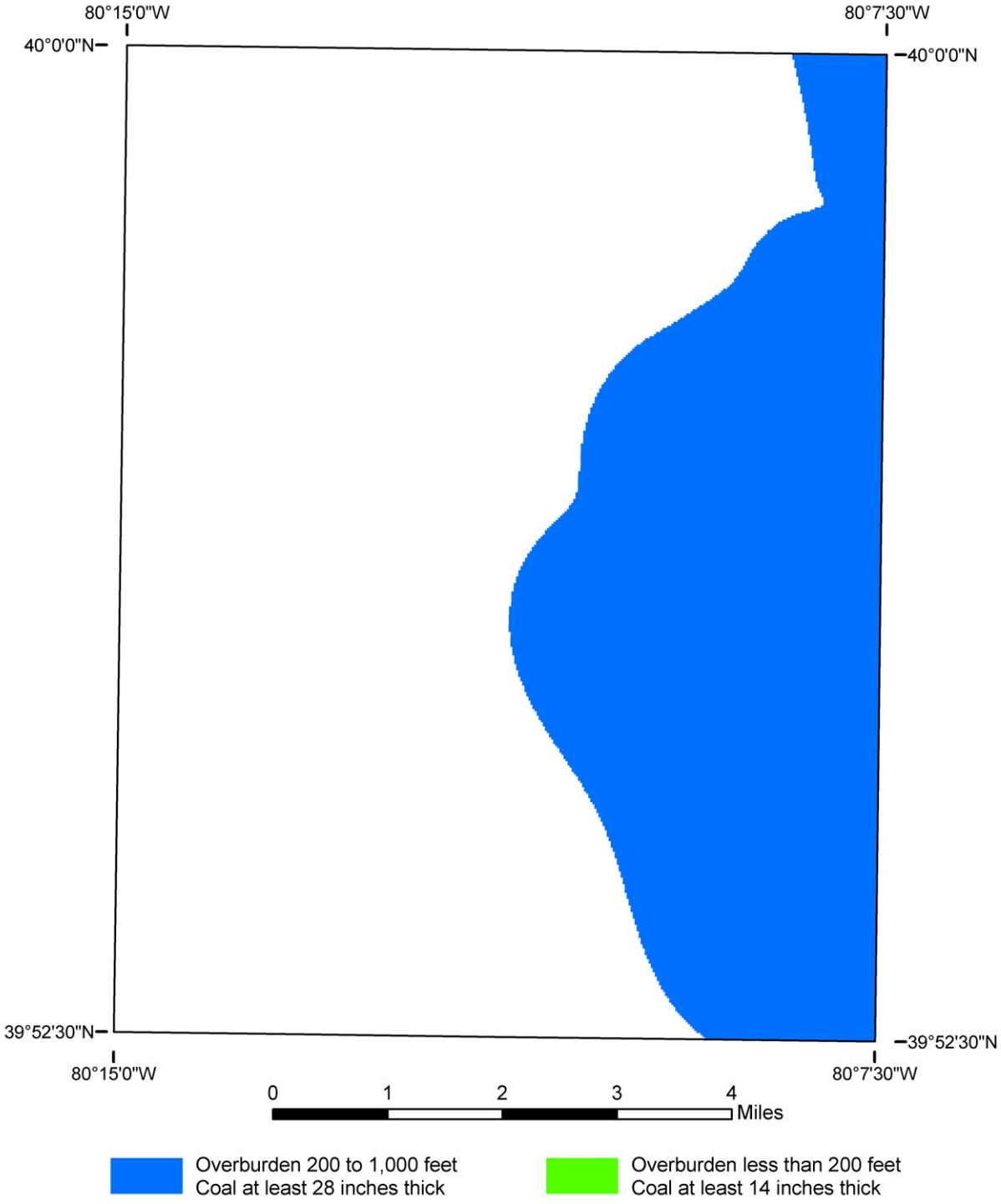

Figure 14. Distribution of remaining resources for the Upper Freeport coal.

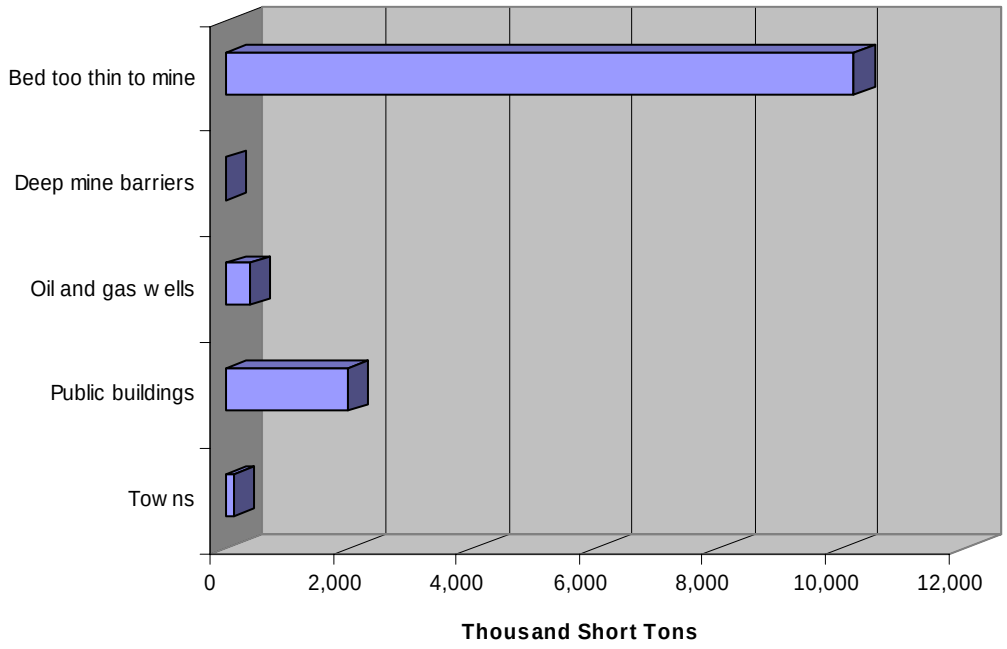

Figure 15. Impact of individual technological restrictions on the Upper Freeport coal. There are no land-use restrictions on this coal.

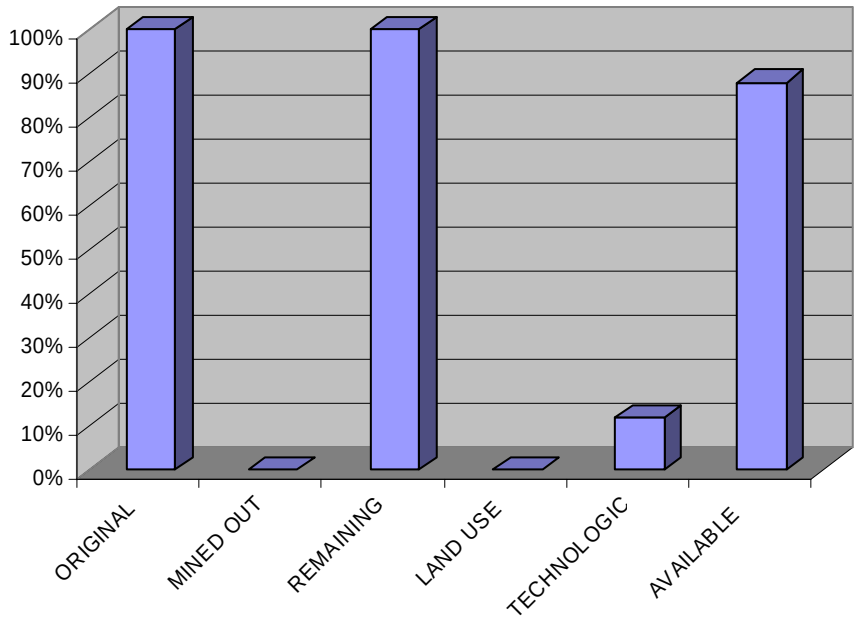

Figure 16. Original, mined-out, remaining, restricted, and available coal resources for the Upper Freeport coal in the Waynesburg quadrangle.

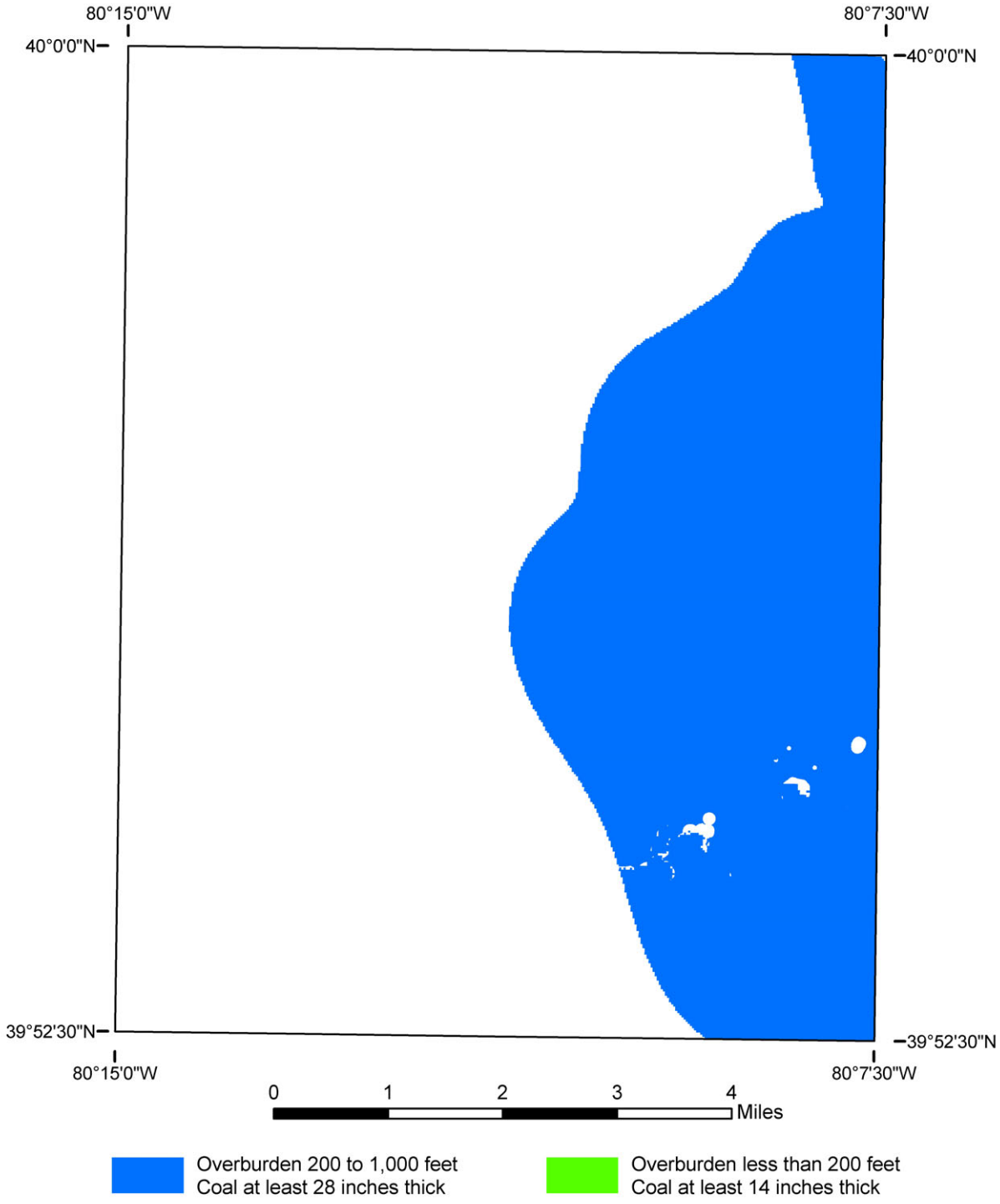

Figure 17. Distribution of available resources for the Upper Freeport coal.

LOWER BAKERSTOWN COAL

The Lower Bakerstown coal is deep underground throughout the Waynesburg quadrangle and has never been mined. All of the approximately 196 million short tons of original Lower Bakerstown coal remain in the ground (Figure 18). This represents 17 percent of the total original resources for all minable coals in the quadrangle. Since all of the Lower Bakerstown coal is deeper than 200 feet below surface and therefore not considered surface minable, no land-use restrictions apply. Four of the possible five technological restrictions identified in the quadrangle impact deep mining of the Lower Bakerstown coal and remove approximately an additional 6 million short tons from potential mining or about 3 percent of the remaining coal (Figure19). The impact of these restrictions on the resource is portrayed by the graph in Figure 20, and is tabulated as gross tonnages in Table A-1.

This leaves nearly 190 million short tons of Lower Bakerstown coal available for future deep mining (Figure 21), representing nearly 97 percent of the original tonnage for this bed (Appendix A). All of the Lower Bakerstown coal in the quadrangle, except an insignificant sliver along the northern border of the quadrangle, ranges from 28 to 45 inches thick. More than half ranges from 36 to 45 inches thick. Even though the Lower Bakerstown coal technically meets the criteria for deep-minable coal, its depth and position between two more economically viable seams probably give it only a low potential for deep mining. Its also has a high sulfur content. Some local mining restrictions were not addressed in this study, including the potential for water or methane gas inflow from overlaying abandoned Pittsburgh coal mines.

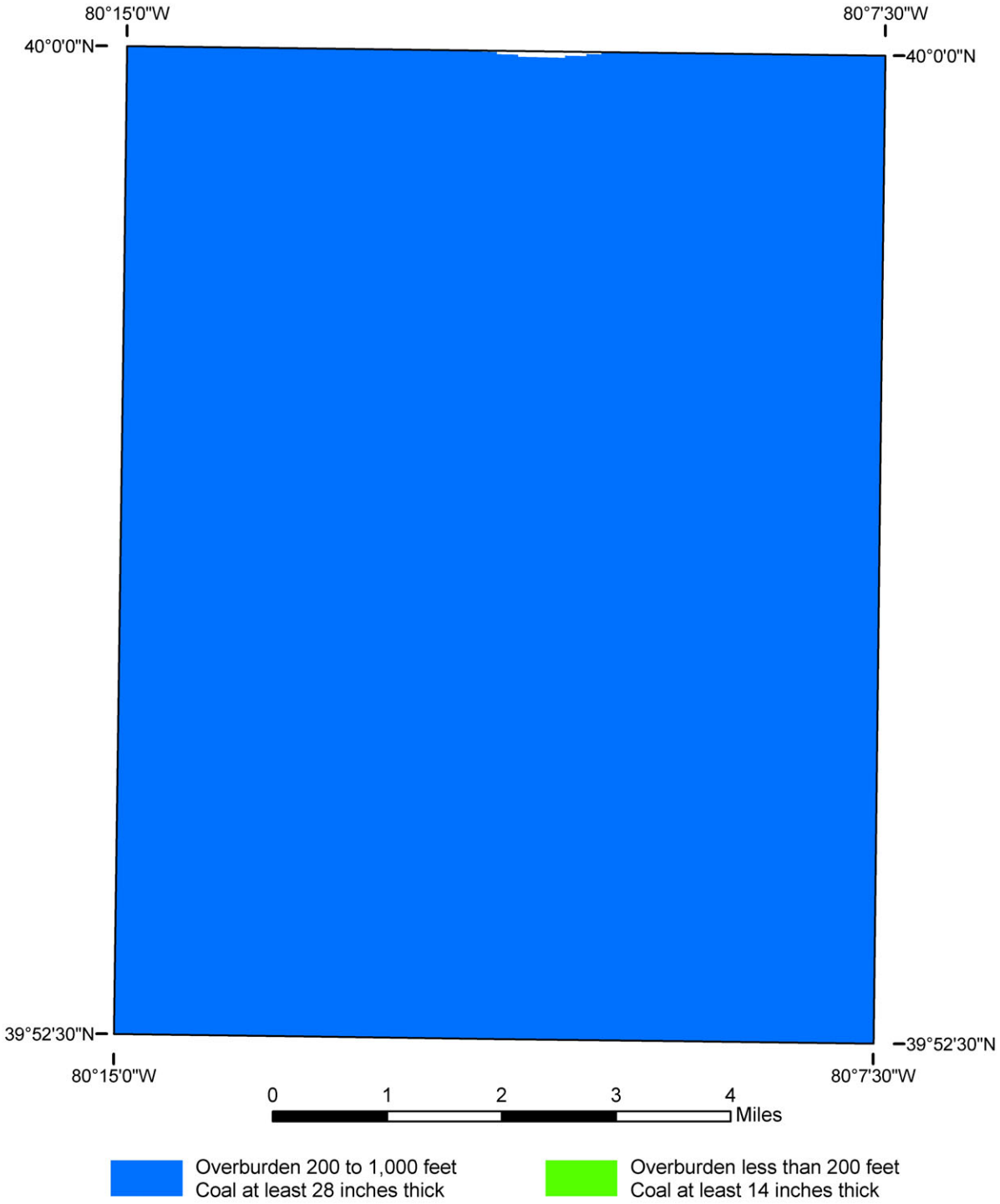

Figure 18. Distribution of remaining resources for the Lower Bakerstown coal.

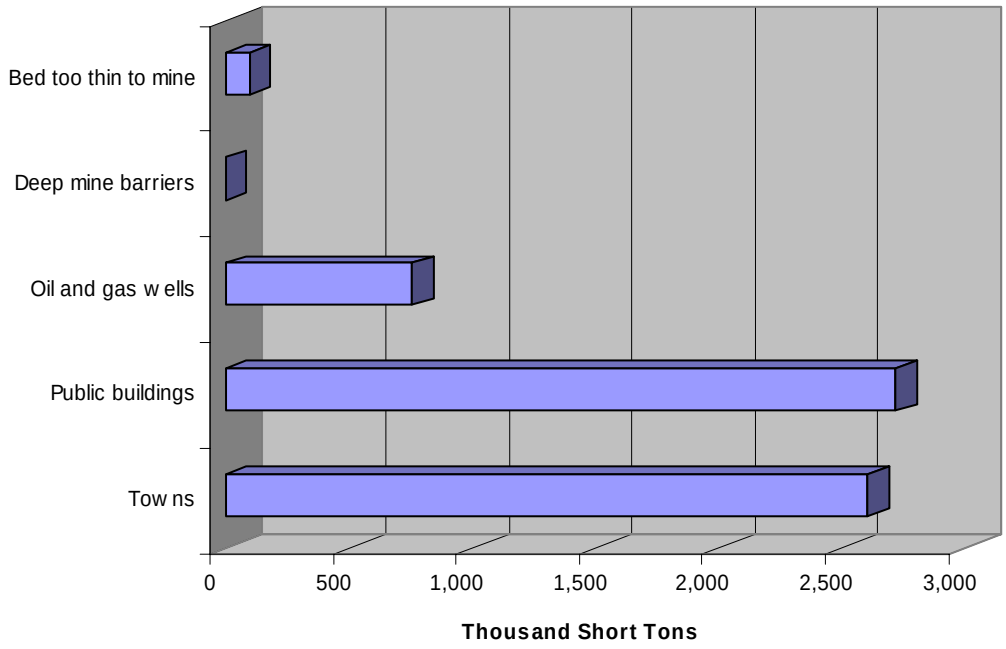

Figure 19. Impact of individual technological restrictions on the Lower Bakerstown coal. There are no land-use restrictions on this coal.

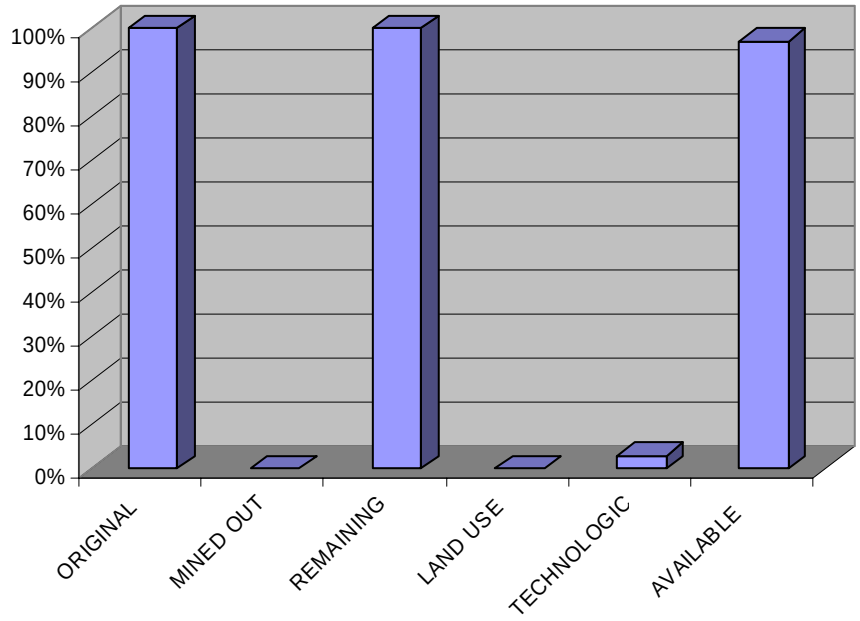

Figure 20. Original, mined-out, remaining, restricted, and available coal resources of the Lower Bakerstown coal.

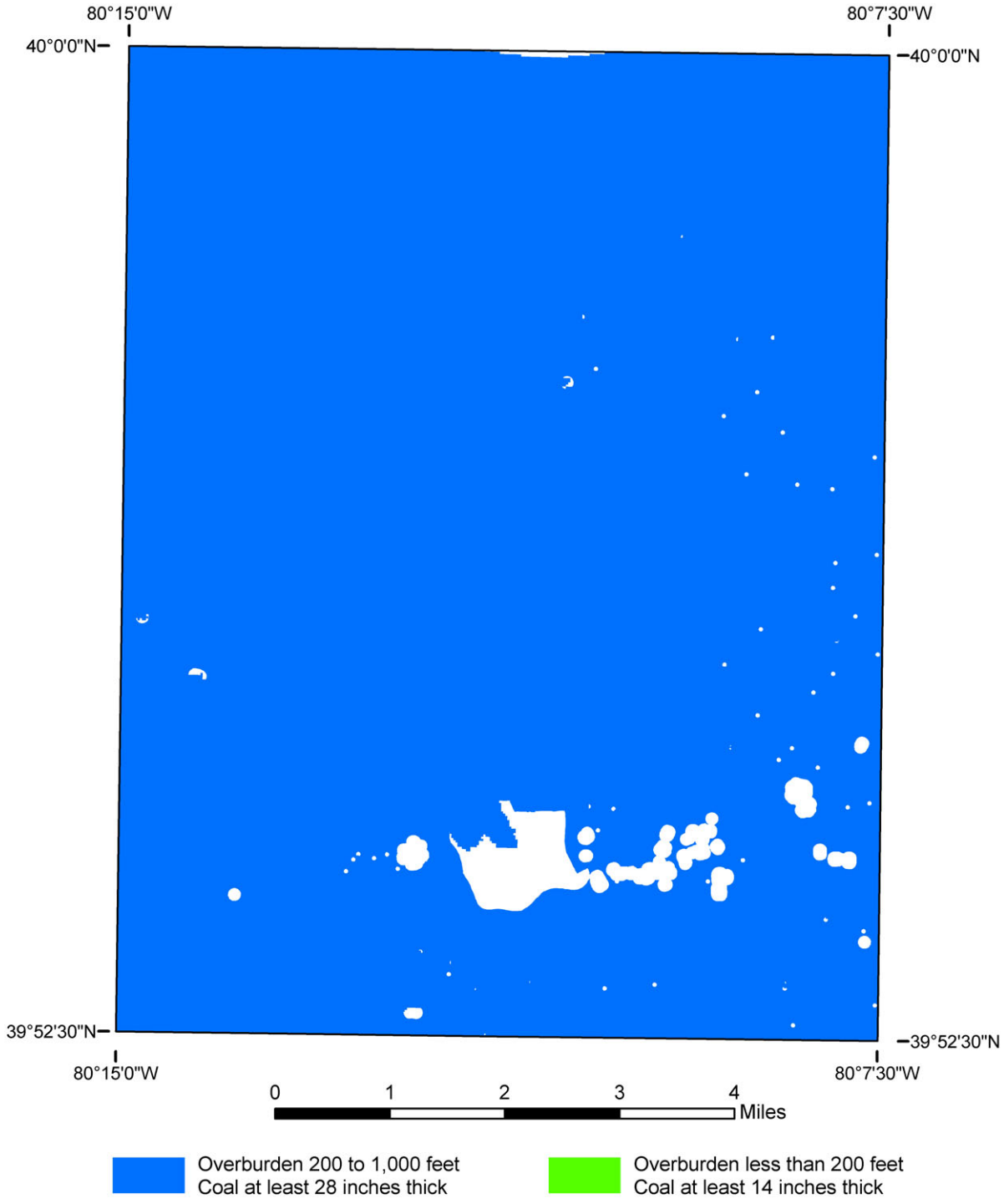

Figure 21. Distribution of available resources for the Lower Bakerstown coal.

PITTSBURGH COAL

Historically, the Pittsburgh coal has been the most important coal bed in the entire region and has been so extensively mined over the last century and a half that it has garnered the reputation of being one of world's most valuable mined deposits. It is the only coal bed in the Waynesburg quadrangle that has been extensively mined (Figure 22). It is estimated that there were originally 390 million short tons of Pittsburgh coal in the quadrangle or 33 percent of total original resources for all minable coals in the quadrangle. The roof coals were not included in this study and calculations here are based solely on the main seam. The coal is more than 300 feet deep and does not outcrop anywhere in the quadrangle. Consequently the Pittsburgh coal has been exclusively mined underground, and nearly all of the mining in the Waynesburg area occurred in the later half of the 1900s, later than in the eastern portion of Greene County, where the coal is much closer to the surface. Only one active mine remains in the Waynesburg quadrangle, the Emerald Mine operated by Foundation Coal Company. It is using modern longwall mining equipment and has been producing coal at record-setting levels. A total of approximately 127 million short tons of Pittsburgh coal have been mined through the years in the quadrangle, leaving about 263 million short tons remaining in the ground (Figure 23). Five technological restrictions effect future mining, amounting to an estimated 16 million short tons of coal that cannot be mined, leaving about 247 million short tons or 63 percent of the original Pittsburgh coal resource available for underground mining (Figures 24 and 25 and Appendix A). Figure 26 indicates where the available Pittsburgh coal resources remain in the study quadrangle.

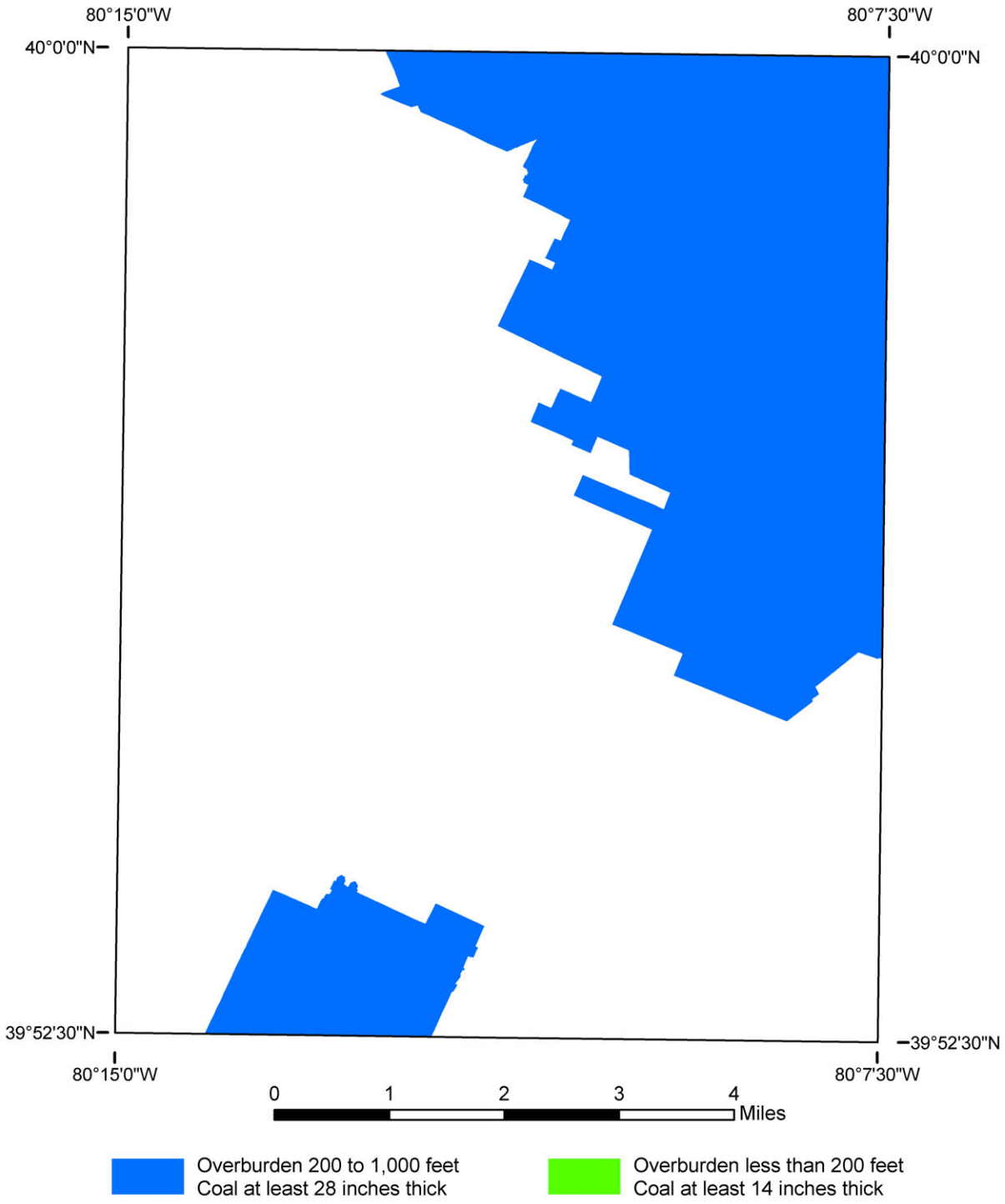

Figure 22. Pittsburgh coal underground-mined-out areas (blue).

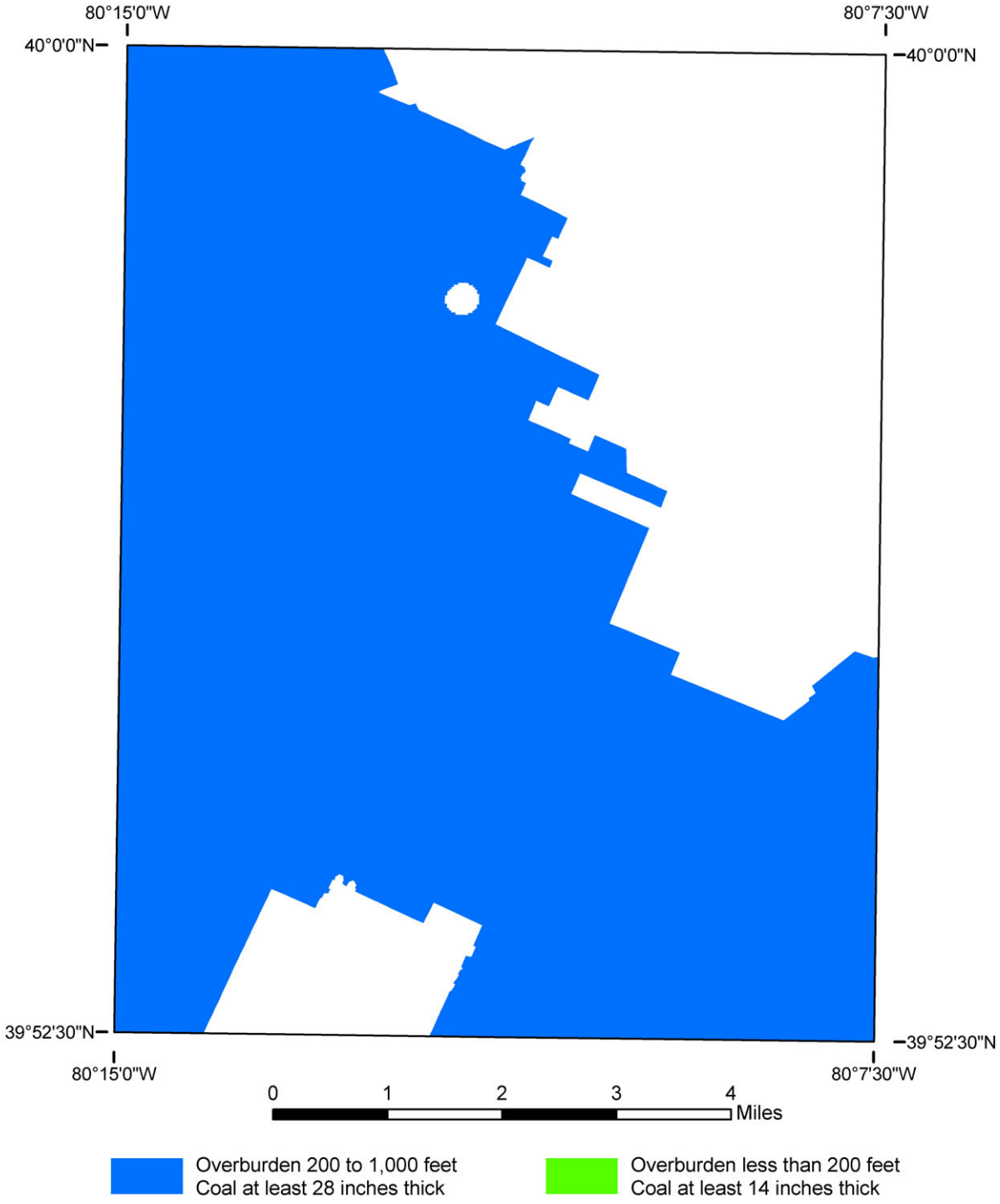

Figure 23. Distribution of remaining resources for the Pittsburgh coal.

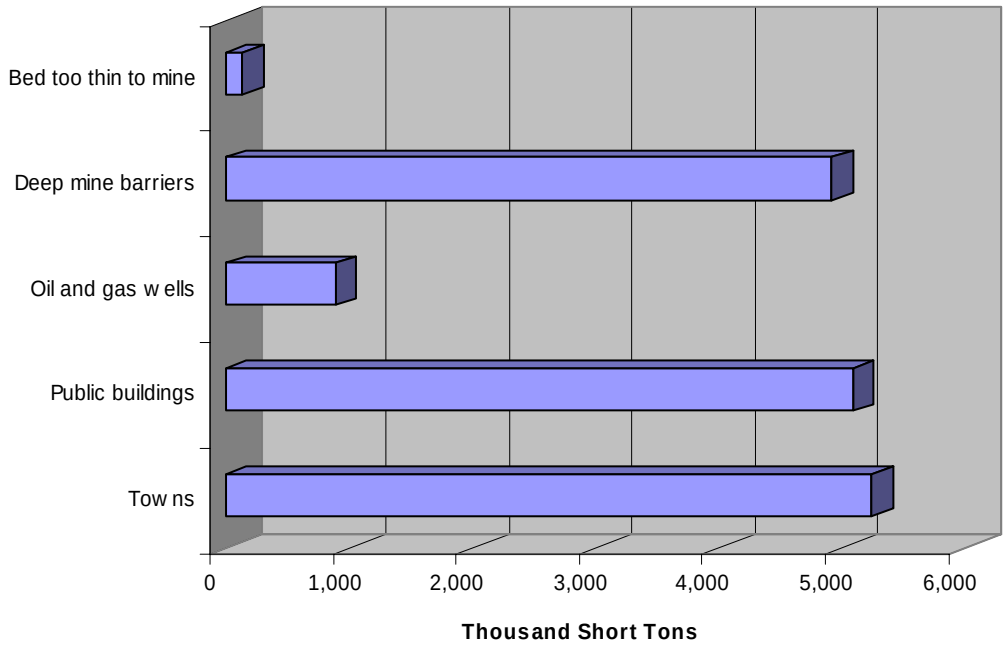

Figure 24. Impact of individual technological restrictions on the Pittsburgh coal. There are no land-use restrictions on this coal.

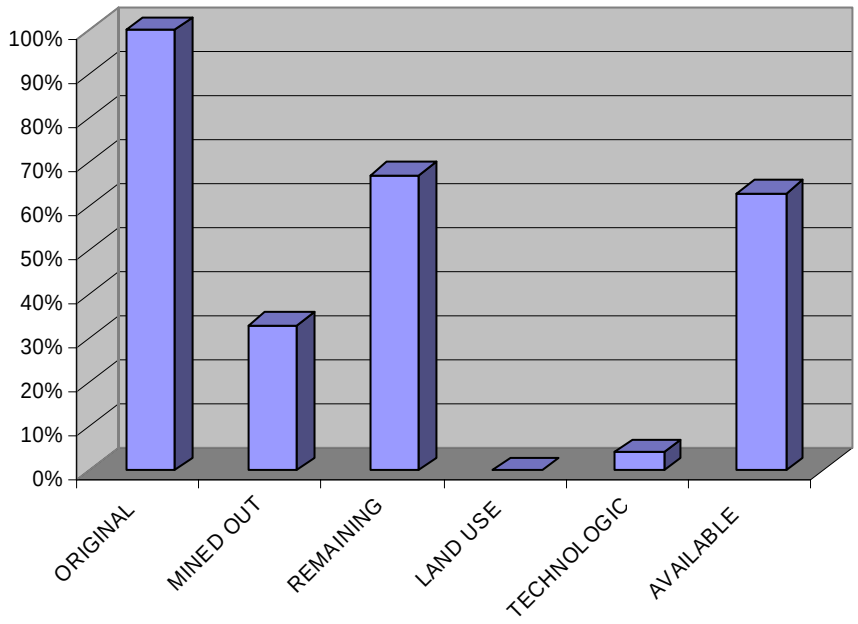

Figure 25. Original, mined-out, remaining, restricted and available coal resources for the Pittsburgh coal in the Waynesburg quadrangle.

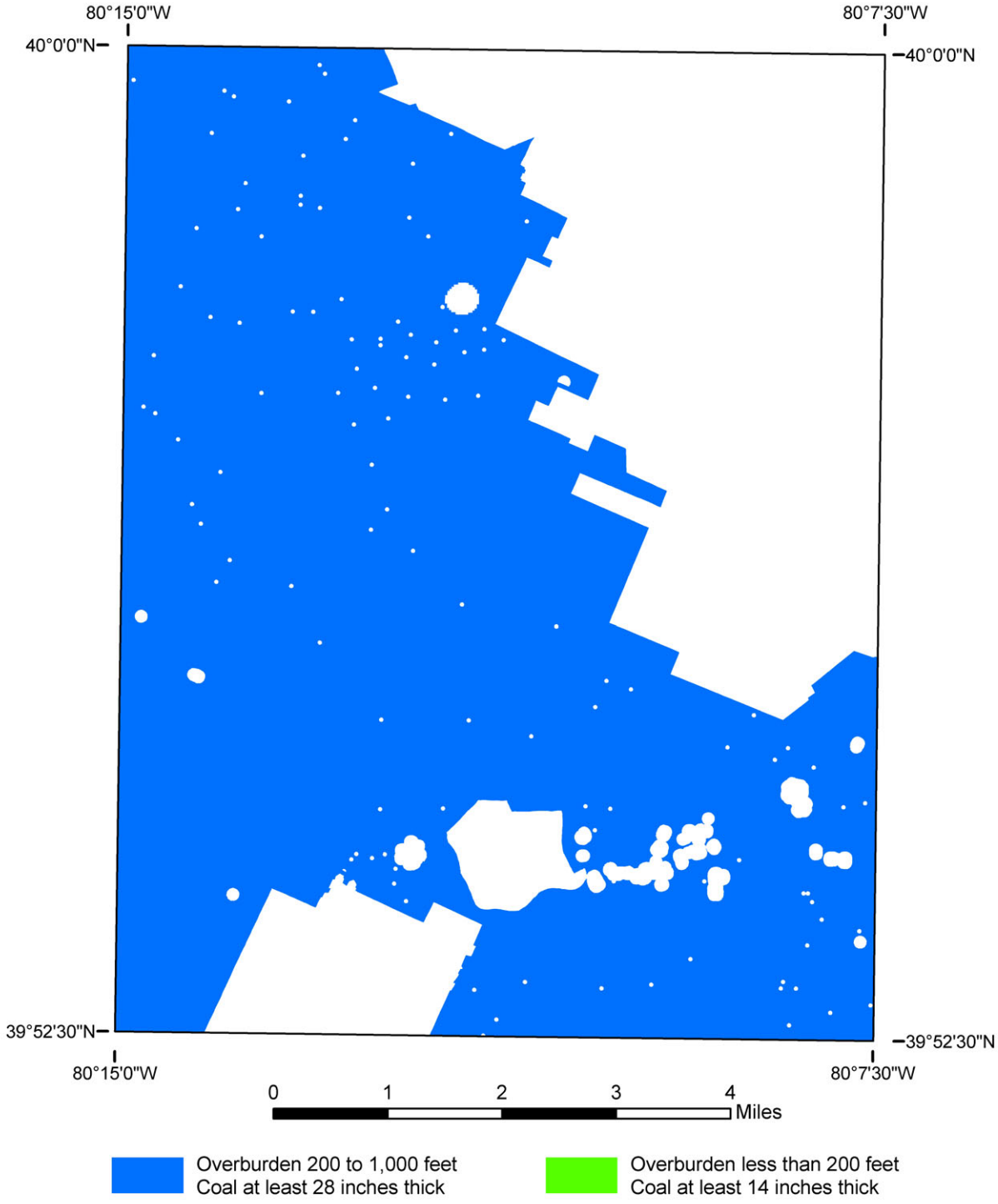

Figure 26. Distribution of available resources for the Pittsburgh coal.

SEWICKLEY COAL

The Sewickley coal is positioned approximately 120 feet above the Pittsburgh coal, and like the Pittsburgh coal, it also is entirely in the subsurface throughout the Waynesburg quadrangle and does not outcrop. It has never been mined. All of the approximately 179 million short tons of original Sewickley coal remain in the ground (Figure 27). This represents 15 percent of the total original resources for all minable coals in the quadrangle (Figure 11). Technically 0.75% of the coal is surface minable since it is less than 200 feet underground. This is under the South Fork of Tenmile Creek at the eastern edge of the quadrangle, and is an unlikely strip mine site. However, for this study, land-use restrictions for this small area are still considered. Ten of the fifteen land-use restrictions and four of the possible five technological restrictions identified in the quadrangle impact surface and deep mining of the Sewickley coal and remove approximately an additional 33 million short tons from potential mining or about 18 percent of the remaining coal (Figures 28 and 29). The impact of these restrictions on the resource is portrayed by the graph in Figures 30, and is tabulated as gross tonnages in Table A-1. This leaves slightly more than 146 million short tons of Sewickley coal available for future mining (Figure 31), representing nearly 82 percent of the original tonnage for this bed (Appendix A). These calculations are based solely on the upper split of the Sewickley, as the lower split is usually much thinner, and the partings too thick. Mined-out areas of the Pittsburgh coal bed, particularly where longwall methods were used, may have caused subsidence features and highly fractured coal, roof, and floor zones within the Sewickley coal bed, making it more difficult or impossible to mine. This study could not address these possible mining restrictions.

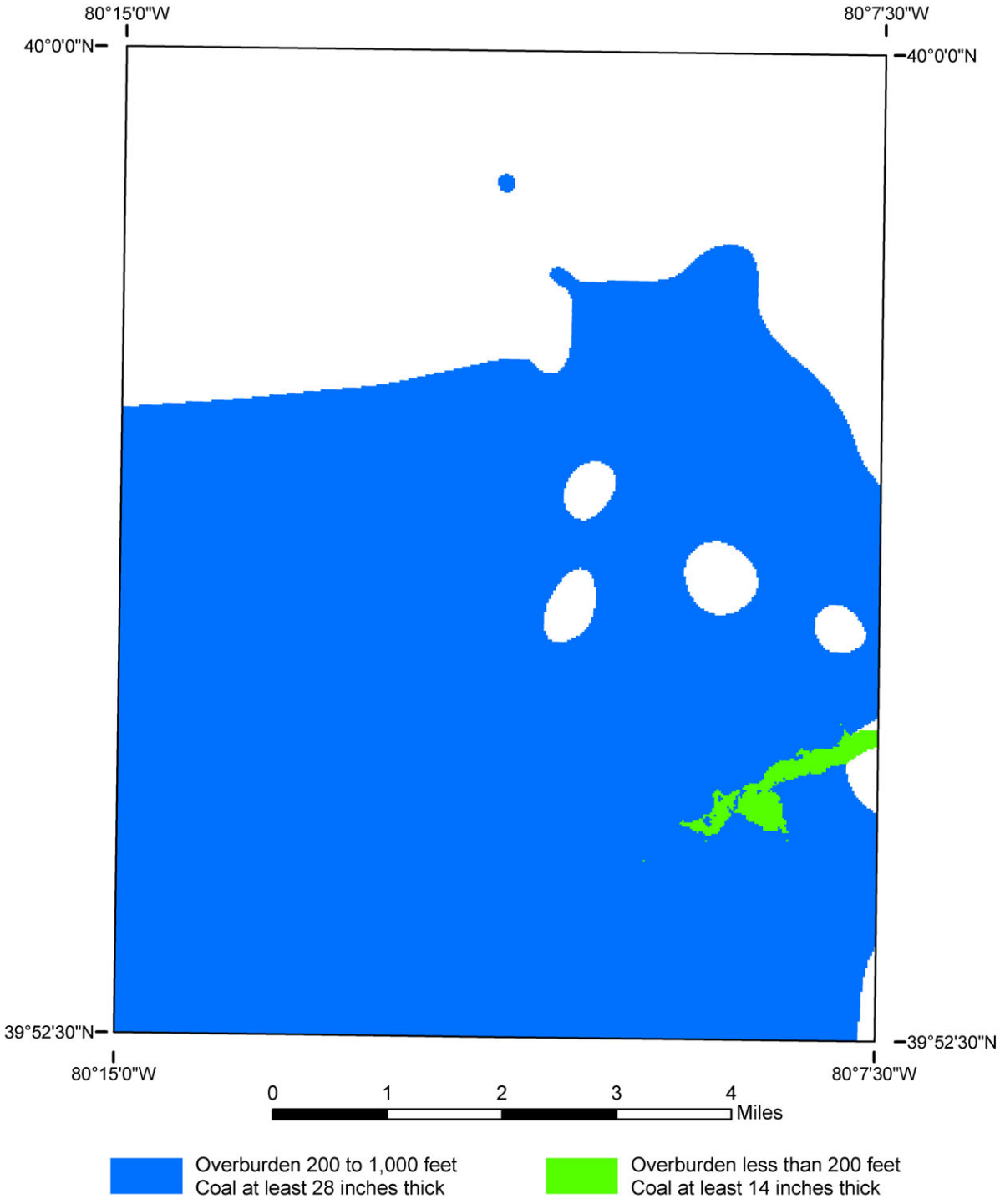

Figure 27. Distribution of remaining resources for the Sewickley coal.

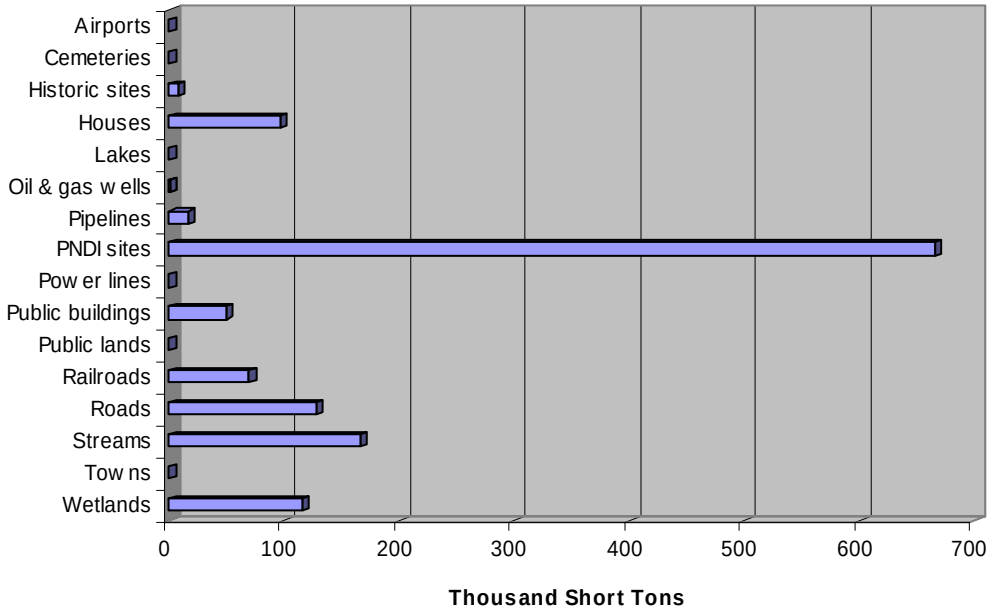

Figure 28. Impact of individual land-use restrictions on the Sewickley coal.

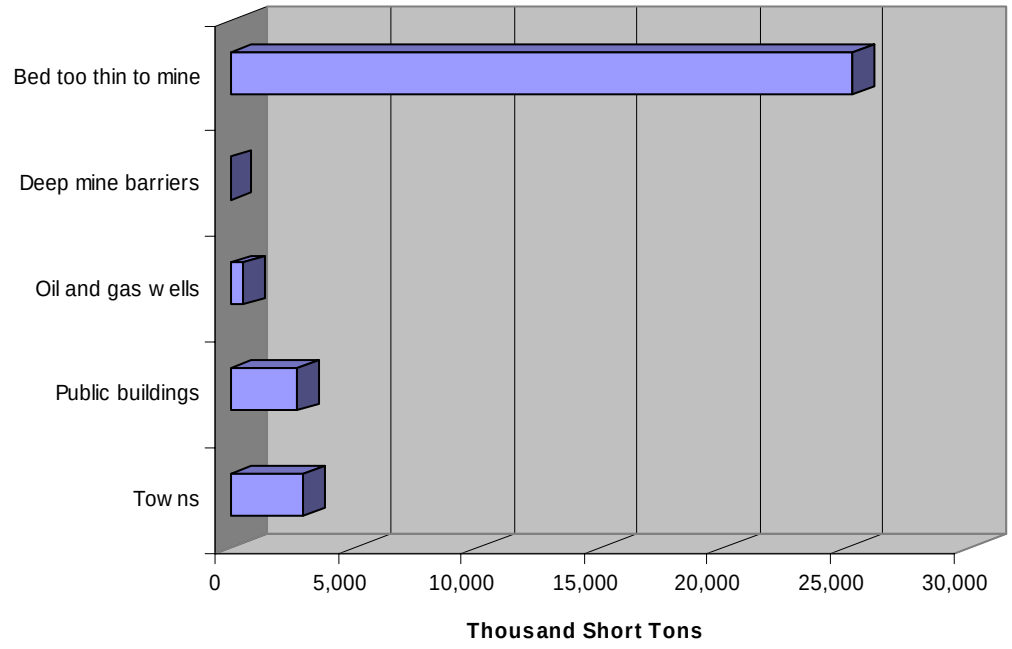

Figure 29. Impact of individual technological restrictions on the Sewickley coal.

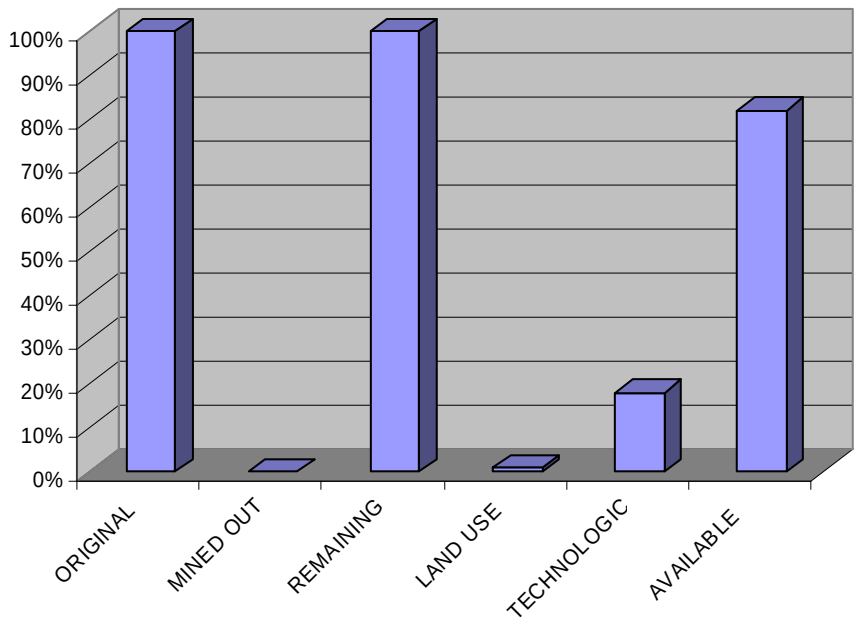

Figure 30. Original, mined-out, remaining, restricted and available coal resources for the Sewickley coal in the Waynesburg quadrangle.

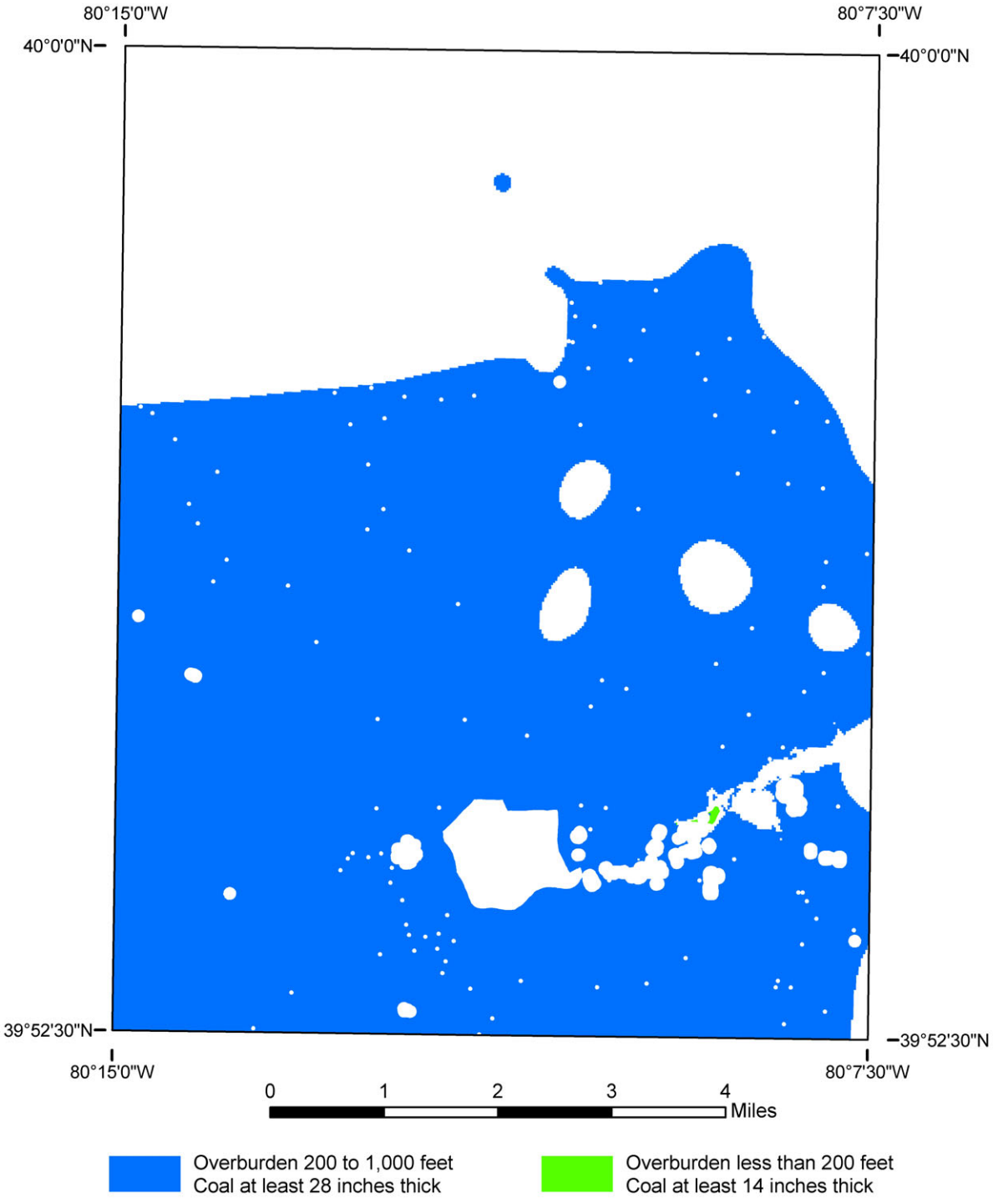

Figure 31. Distribution of available resources for the Sewickley coal.

WAYNESBURG COAL

Historically, the Waynesburg coal was the principal source of coal for home heating needs in the Waynesburg area through the second half of the nineteenth century and into the twentieth century. Small country banks mining the coal outcrops east of Waynesburg along the South Fork of Tenmile Creek and some of its tributaries were reported to be in operation prior to the 1870s (Stevenson, 1876) (Figure 32). These underground mines were small by modern standards and no maps exist recording their extent. It is impossible to estimate with any accuracy the amount of coal removed during this period, and it is assumed for the purpose of this study that the amount is insignificant.

No additional mining of Waynesburg coal has occurred in the quadrangle since the operation of these country banks and most all of the estimated 262 short tons of original Waynesburg coal, or 22 percent of the total original resources for all minable coals in the quadrangle remain in the ground (Figure 11 and 33).

Fourteen of the fifteen land-use and four of the five technological restrictions for the quadrangle impact the Waynesburg coal. Their gross tonnages are given in Table A-1. Figures 34 and 35 illustrate the amount of coal excluded due to the individual land-use and technological restrictions for this coal bed. These Waynesburg coal land-use and technological restrictions remove about 40 million short tons of coal from potential mining, leaving 222 million short tons or 85 percent of the original coal resource available for surface or underground mining (Figure 36 and Appendix A). Figure 37 indicates where the available Waynesburg coal resources remain in the study quadrangle. Mined-out areas of the Pittsburgh coal bed, particularly where longwall methods were used, may have caused subsidence features and highly fractured coal, roof, and floor zones within the Waynesburg coal bed, making it more difficult or impossible to deep mine. This study could not address these possible mining restrictions.

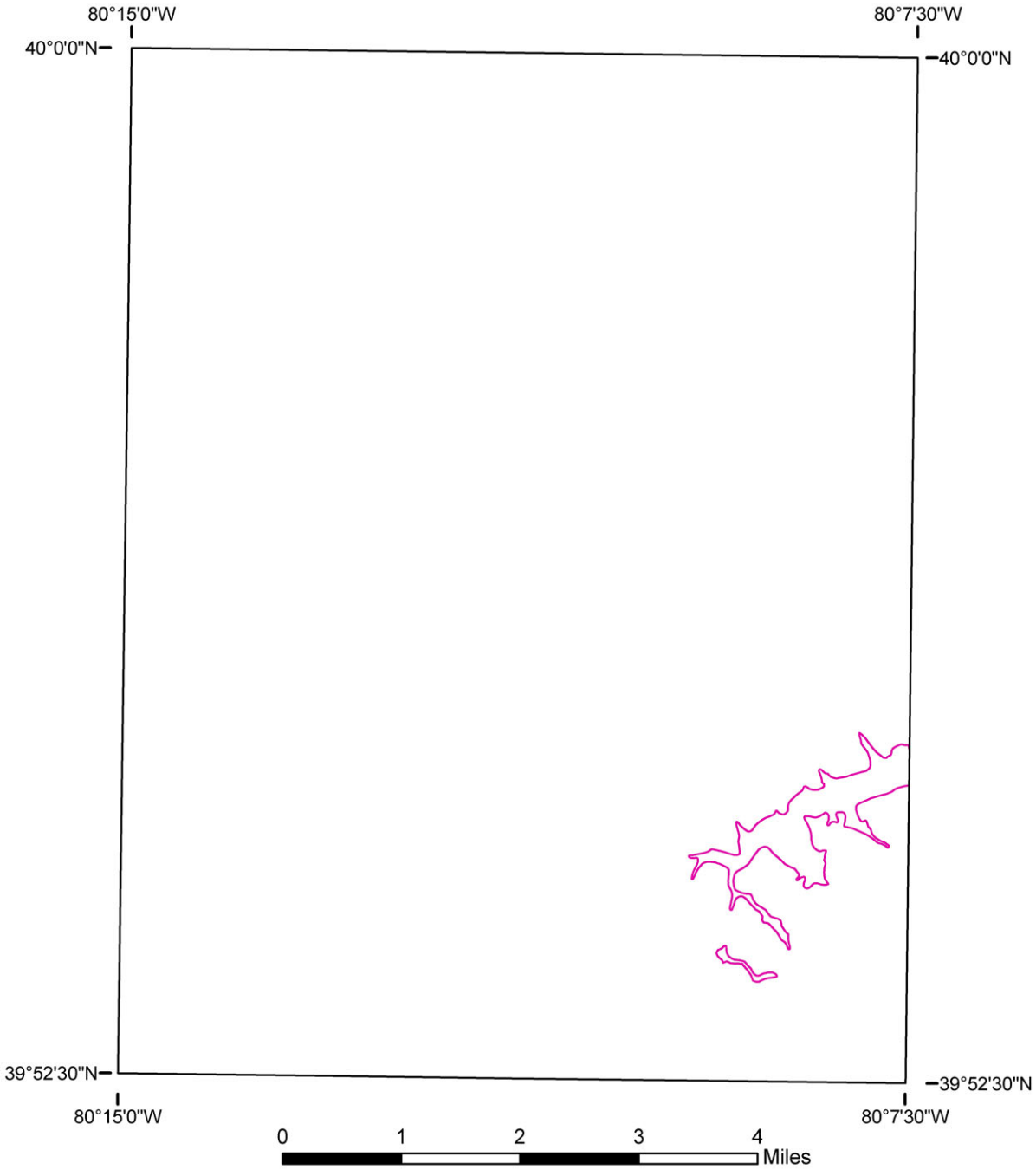

Figure 32. Waynesburg coal crop lines.

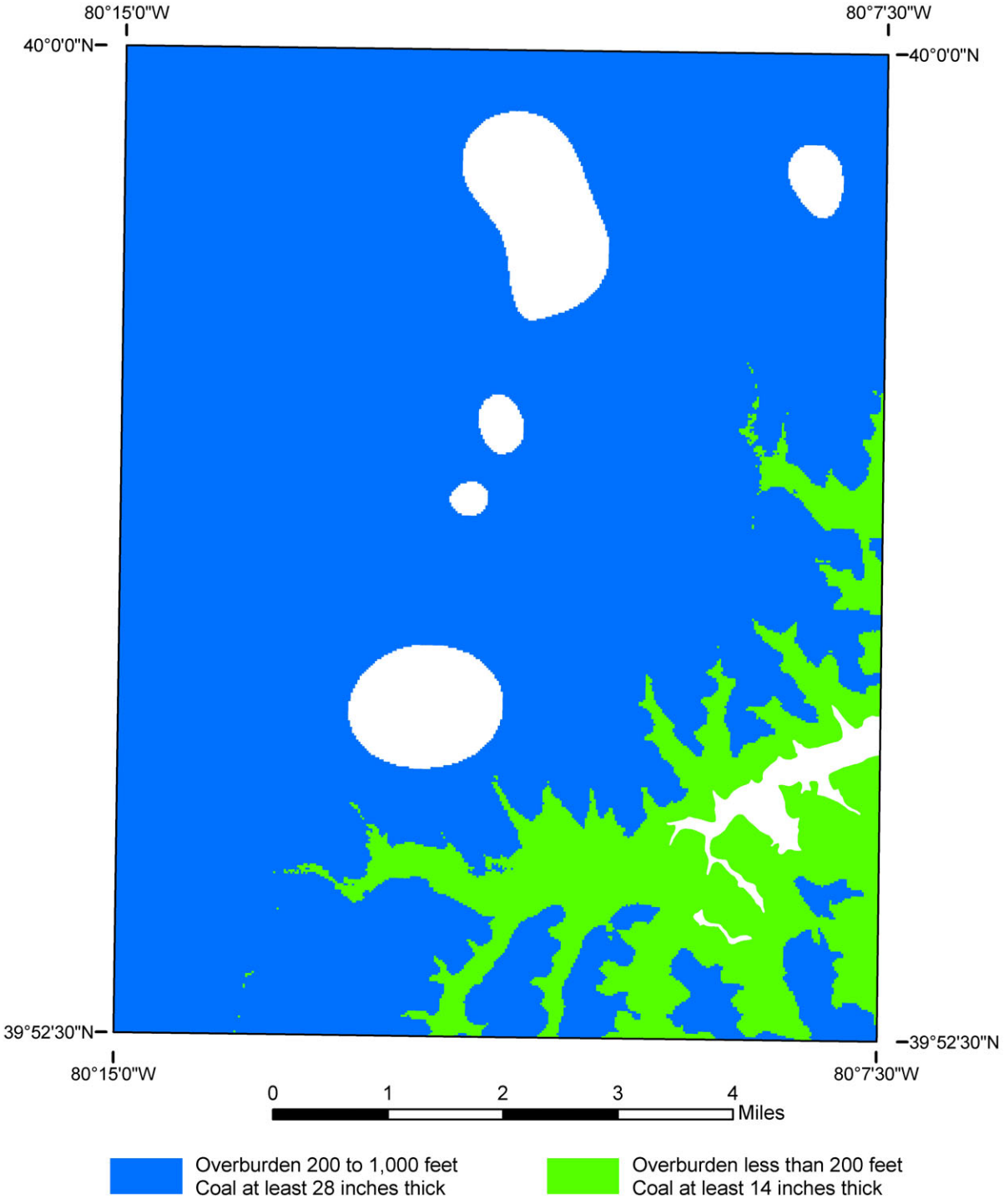

Figure 33. Distribution of remaining resources for the Waynesburg coal.

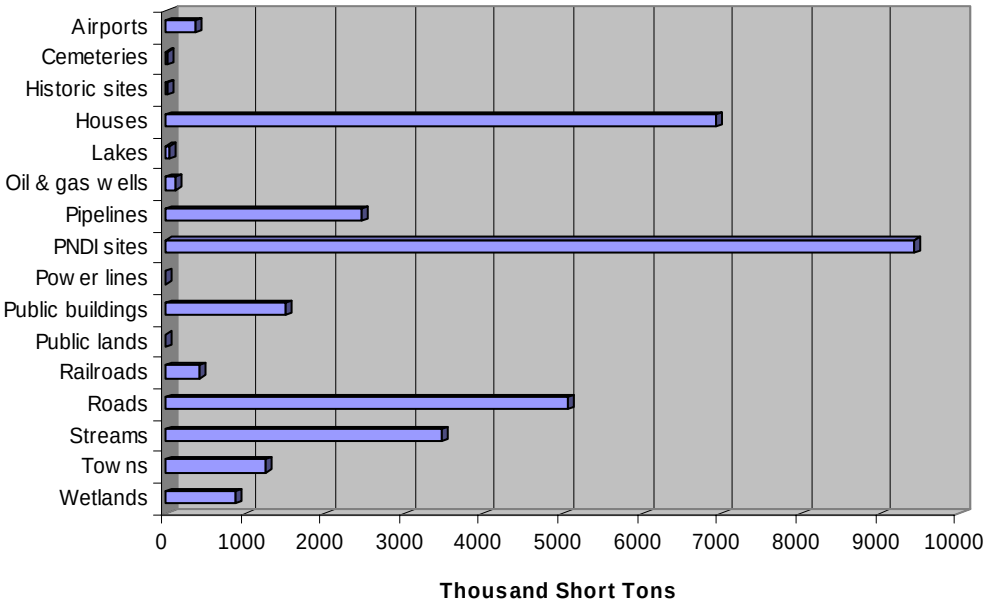

Figure 34. Impact of individual land-use restrictions on the Waynesburg coal.

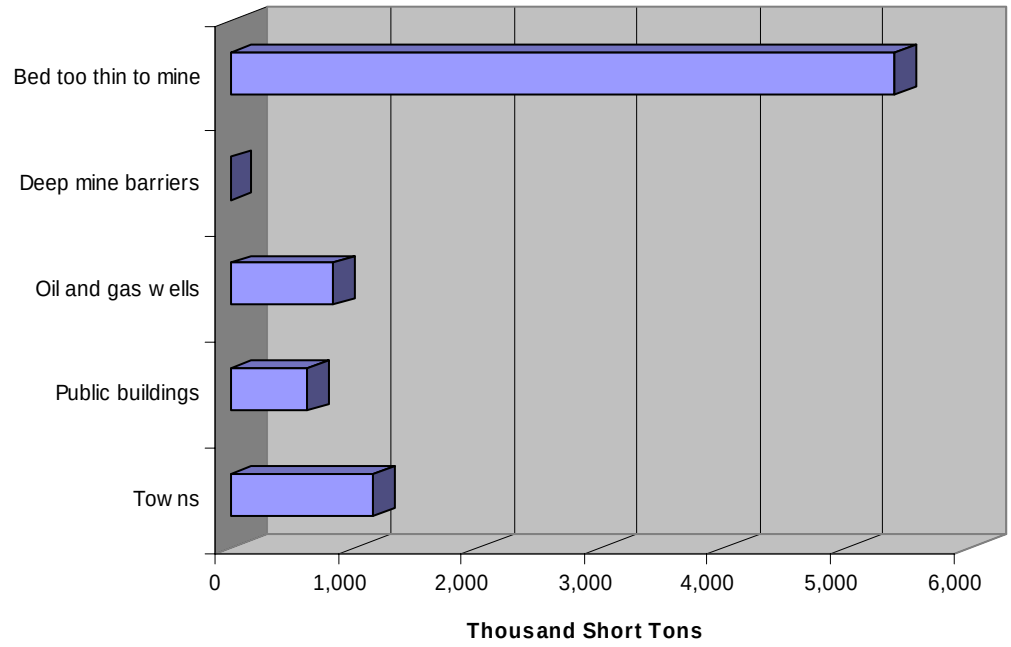

Figure 35. Impact of individual technological restrictions on the Waynesburg coal.

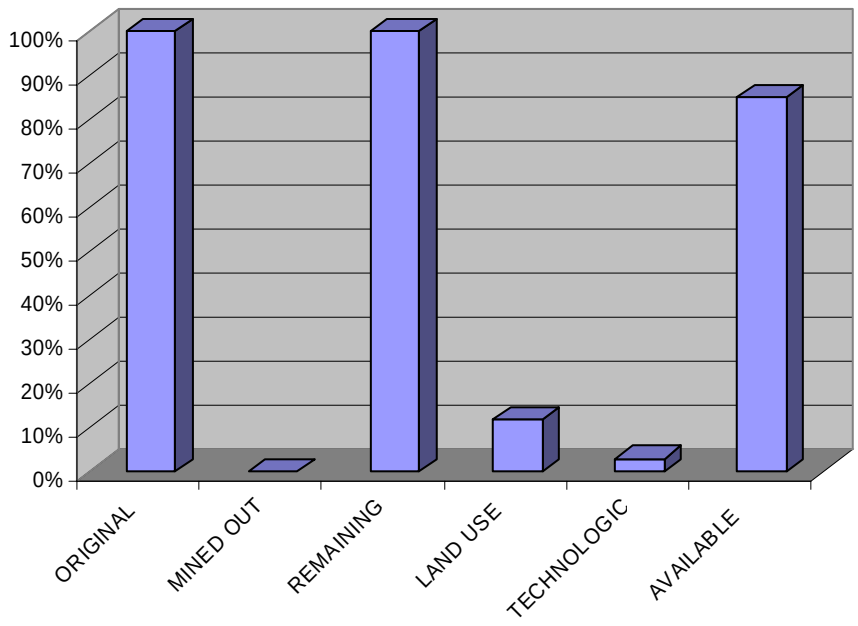

Figure 36. Original, mined-out, remaining, restricted, and available coal-resources for the Waynesburg coal in the Waynesburg quadrangle.

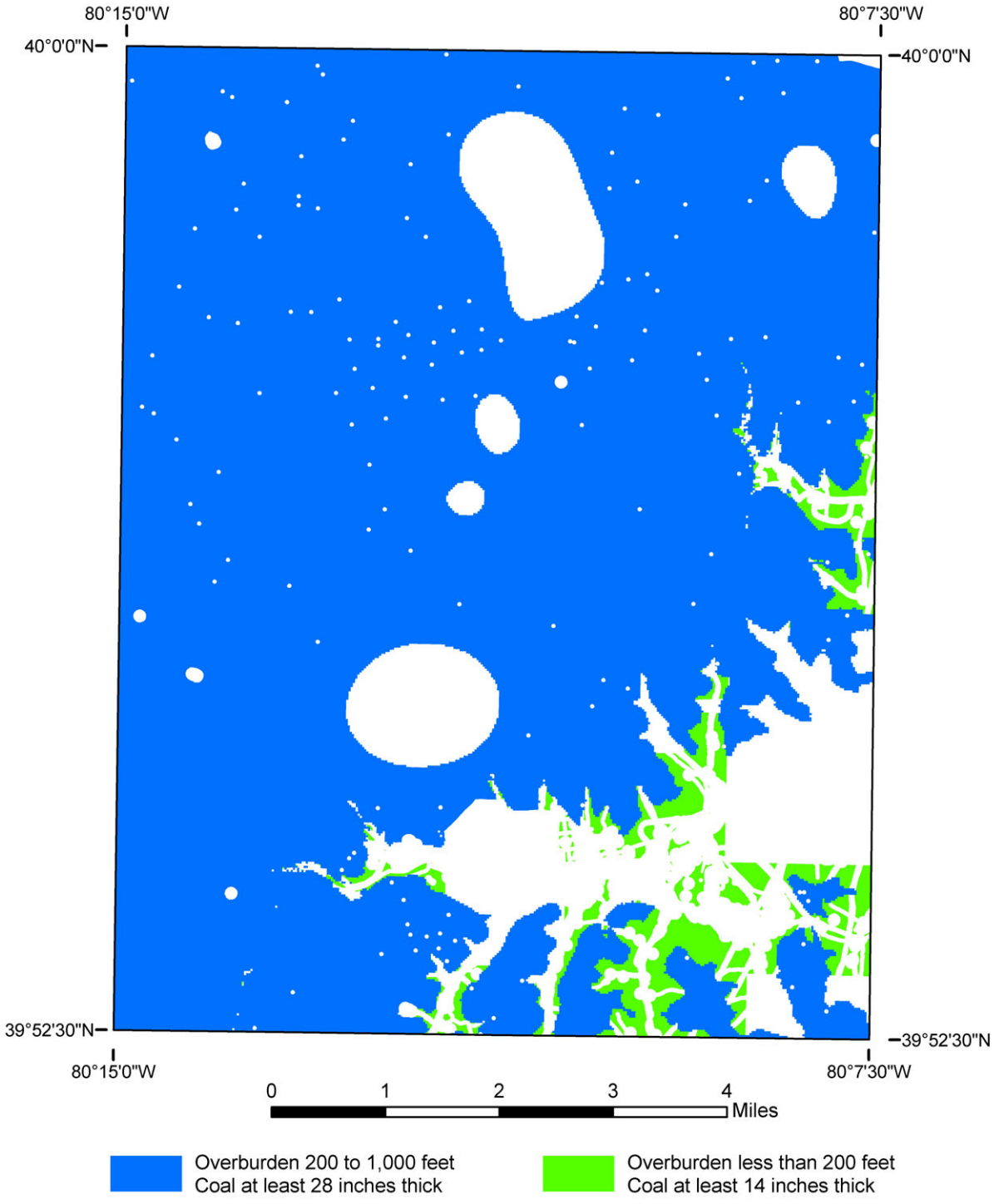

Figure 37. Distribution of available resources for the Waynesburg coal.

WAYNESBURG A COAL

The Waynesburg A coal is thin and discontinuous in the Waynesburg quadrangle. Maximum thickness is 30 inches and occurs in only a very few small, scattered areas. The Waynesburg A would normally not be considered a minable resource. It was included in this study only because of its stratigraphically close proximity to the Waynesburg. It can be as close as 50 feet above the Waynesburg coal. In surface mines a short distance north of the Waynesburg quadrangle in Washington County the Waynesburg A coal is often extracted with the underlying and widely mined Waynesburg coal.

In the Waynesburg quadrangle, the Waynesburg A coal bed accounted for approximately 38 million short tons of coal or 3 percent of the total original resources for all minable coals in the quadrangle (Figure 11). Since there has been no mining, all of the original coal remains in the ground (Figures 38 and 39).

Twelve of the fifteen land-use, and two out of the five technological restrictions for the quadrangle impact the Waynesburg A coal. Their gross tonnages are given in Table A-1. Figures 40 and 41 provide a graphical companion to this table. These Waynesburg land-use and technological restrictions remove about another 37 million short tons of coal from potential mining, leaving about 1 million short tons or 3 percent of the original Waynesburg A coal resource available for surface mining (Figure 42 and Appendix A). The calculated reserve estimates show that less than a quarter million short tons are available for deep mining. This is misleading in that the amount is so low and the geographic distribution is so spotty that actually there is no Waynesburg A coal available for deep mining. Realistically future mining potential is limited to the relatively small area of thin coal in the southeast corner of the quadrangle where the Waynesburg coal is shallow, and the Waynesburg A could be incidentally removed in conjunction with Waynesburg surface mining (Figure 37).

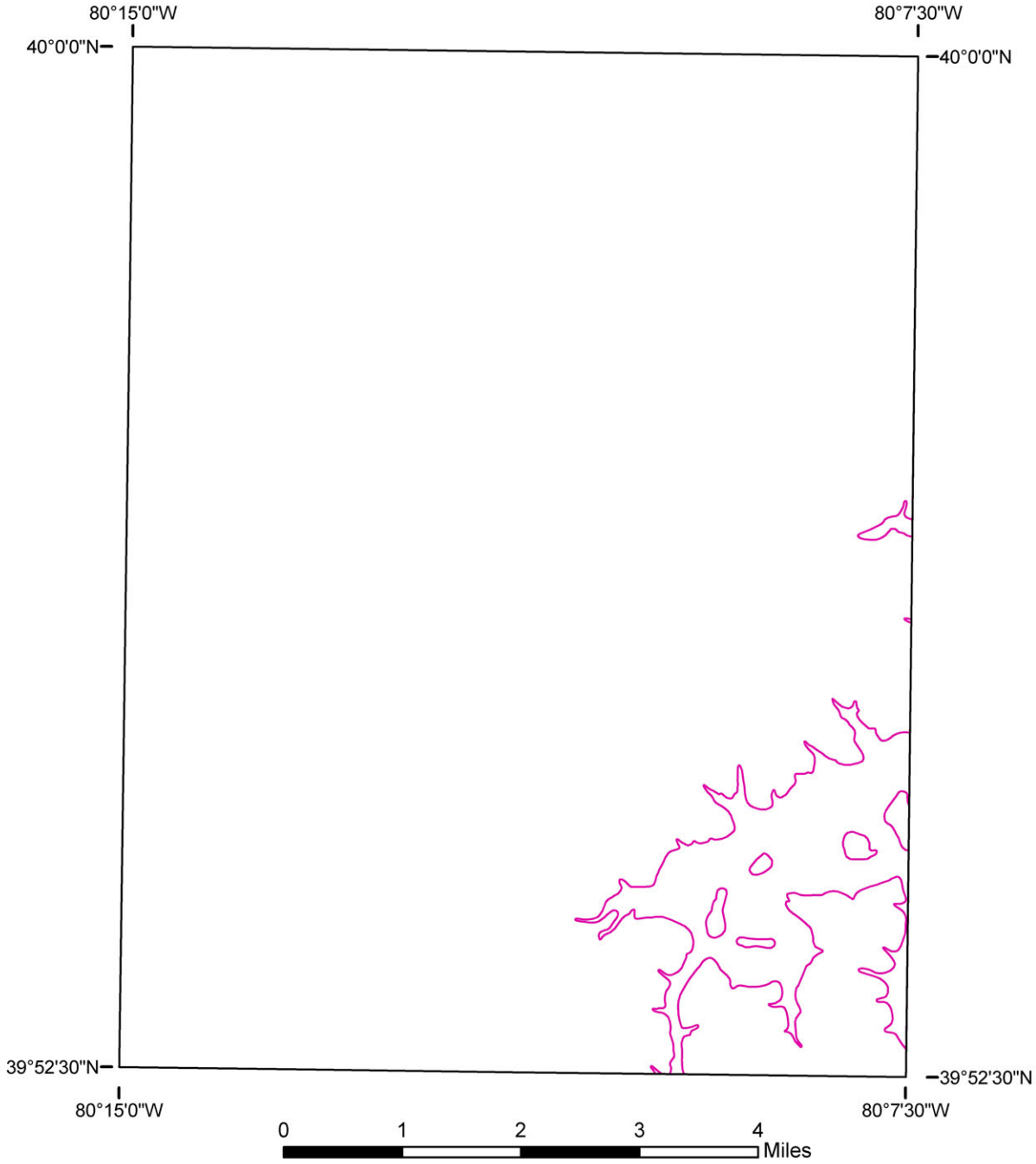

Figure 38. Waynesburg A coal crop lines.

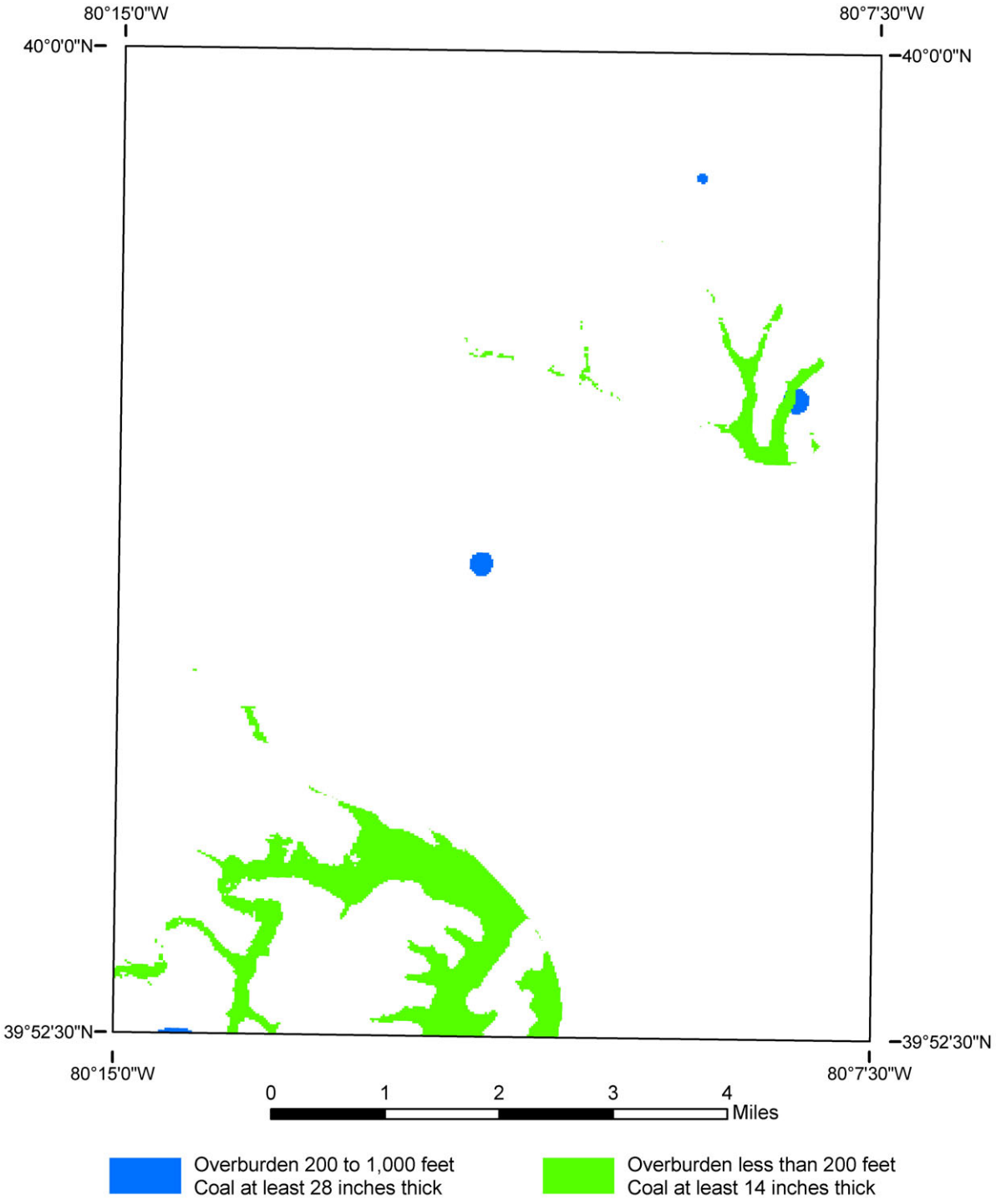

Figure 39. Distribution of remaining resources for the Waynesburg A coal.

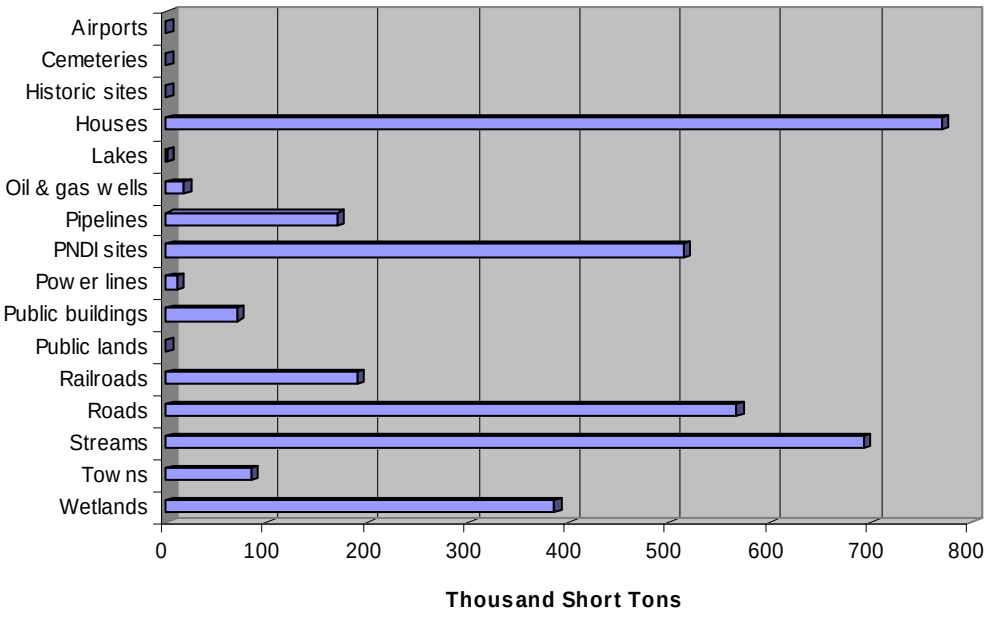

Figure 40. Impact of individual land-use restrictions on the Waynesburg A coal.

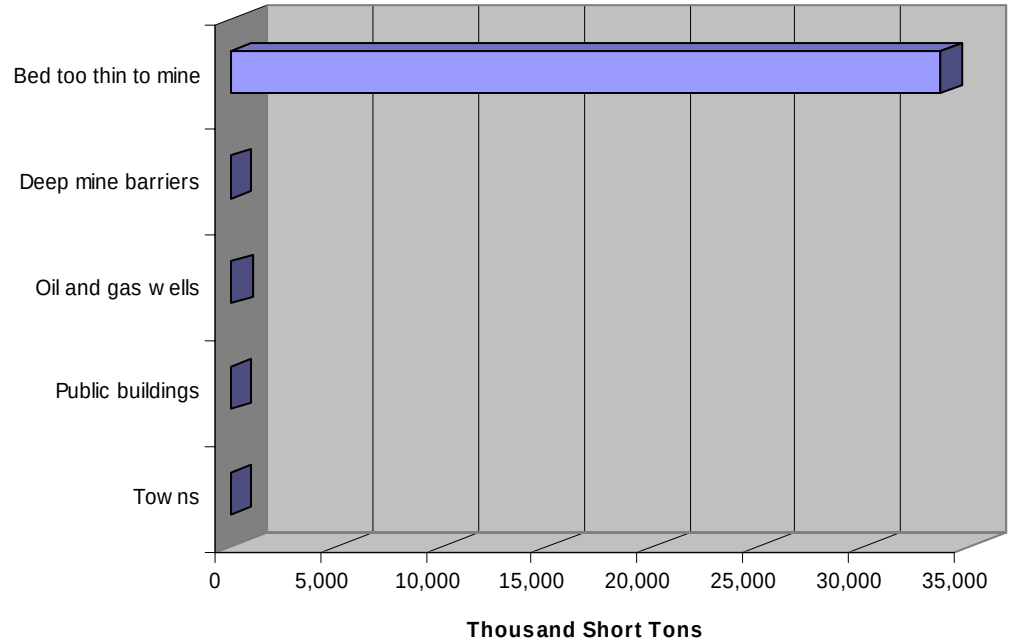

Figure 41. Impact of individual technological restrictions on the Waynesburg A coal.

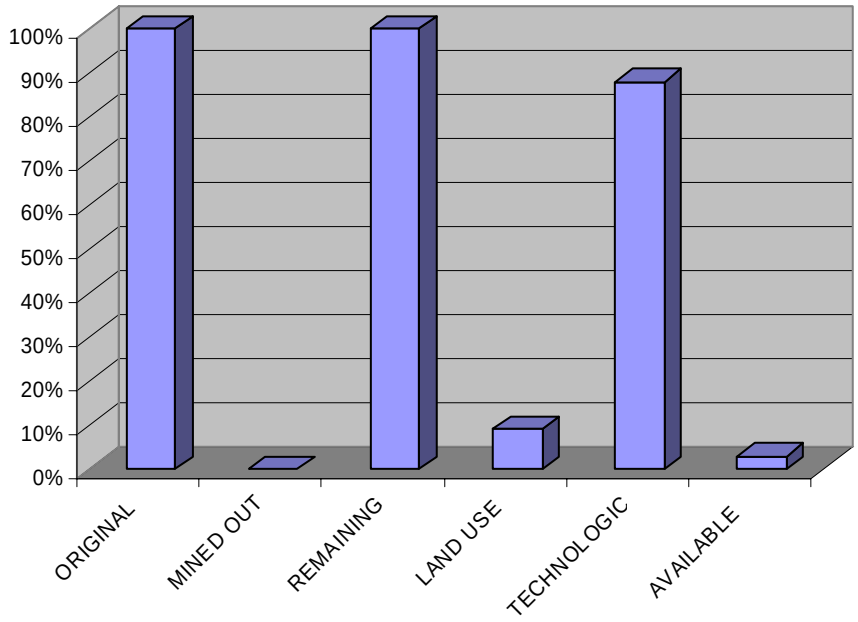

Figure 42. Original, mined-out, remaining, restricted, and available coal-resources for the Waynesburg A coal in the Waynesburg quadrangle.

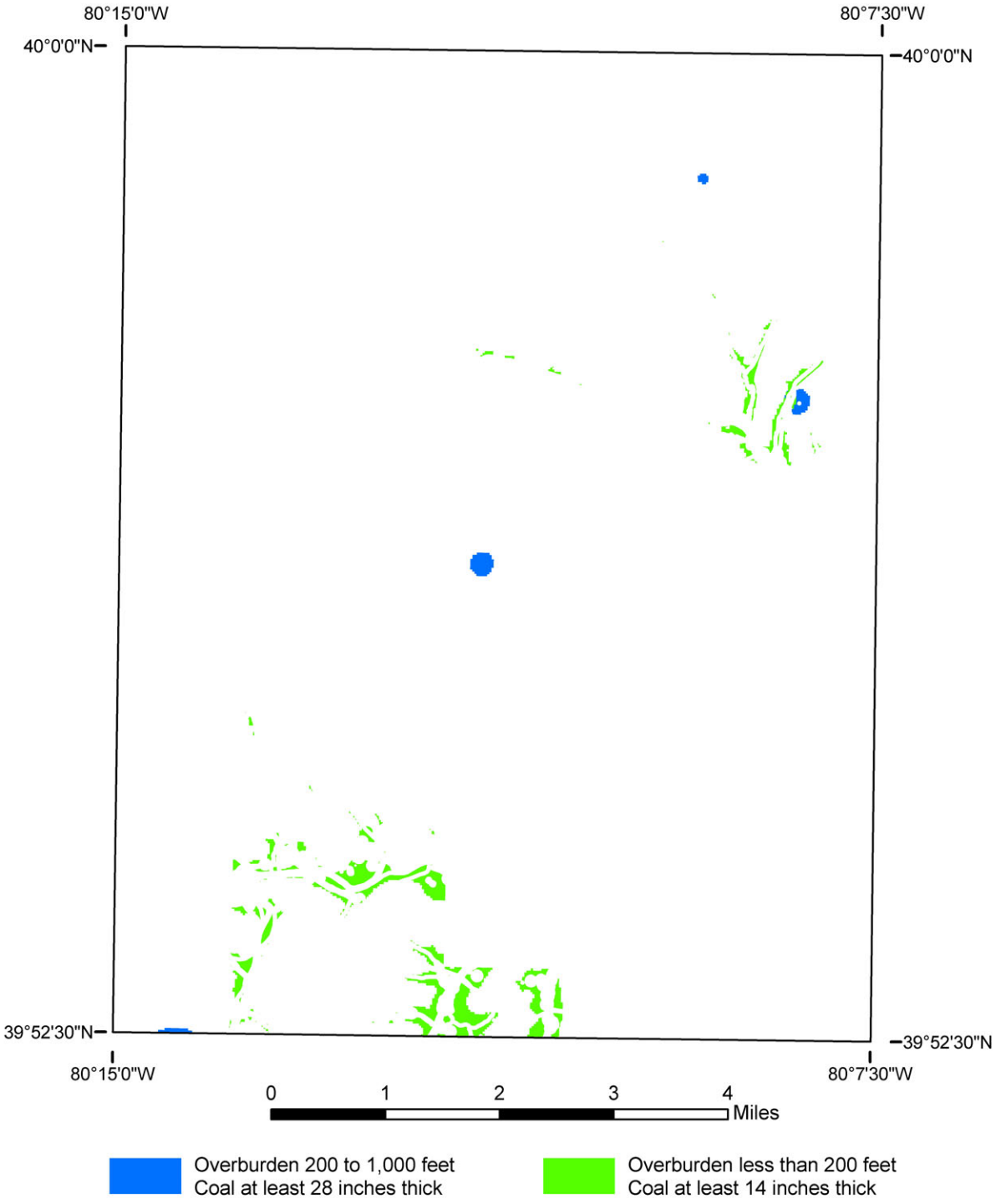

Figure 43. Distribution of available resources for the Waynesburg A coal.

SUMMARY

Resources were calculated for six coal seams: the Upper Freeport, Lower Bakerstown, Pittsburgh, Sewickley, Waynesburg and Waynesburg A. By aggregating two thickness categories - 14-18 inches, and greater than 28 inches - with three overburden categories - less than 200 feet of cover (representing strip-minable resources), 200-1,000 feet of cover (representing deep-minable resources), and greater than 1,000 feet of cover for each bed, tonnages for mined-out and remaining coal could be calculated. All land-use and technological restrictions to mining and their appropriate buffers were compiled and subtracted from the remaining coal tonnages yielding coal available for mining. The reliability of the resource estimates is expressed by the categories measured, indicated, inferred, and hypothetical. Each category defines a decreasing degree of assurance in the extrapolated thickness value of a known data point for incrementally greater (pre-defined) distances away from that point. Fortuitously, enough closely spaced data points existed for the Waynesburg quadrangle, so it was only necessary to calculate tonnages for the measured, indicated, and inferred categories for all but the Lower Bakerstown coal. Fewer data points existed from which to optimally define the resource, as a result hypothetical calculations had to be used for a minor part of this resource (Table B-3 and B-4).

Based on those criteria from above, the original, remaining, restricted, and available resources for those six coal seams in the Waynesburg quadrangle were calculated and have been placed in the accompanying tables, charts, and figures of this report, and then summarized in Table A-2. Of an estimated original resource of nearly 1,169 million short tons in the Waynesburg quadrangle, 127 million short tons, or 11 percent, have been mined-out or lost in mining, virtually all of this in the Pittsburgh coal seam. An additional 145 million short tons, or 12 percent, were restricted due to modern day regulatory statutes or technological impedances which impact surface and underground mining, leaving a resource of about 897 million short tons of coal, or about 77 percent, available for future development and extraction.

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APPENDICES

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

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

[Quantities are in short tons.]

	LAND-USE RESTRICTIONS (SURFACE, 0 to 200 feet)							
Coal bed	Airports	Cemeteries	Historic sites	Houses	Lakes	Oil & gas wells	Pipelines	PNDI sites
WAYNESBURG A	0	0	0	771,703	1,690	18,036	170,910	514,217
WAYNESBURG	374,779	18,464	16,438	6,935,344	37,244	105,048	2,470,689	9,432,933
SEWICKLEY	0	0	7,539	97,152	0	1,117	16,353	666,472
PITTSBURGH	0	0	0	0	0	0	0	0
LOWER BAKERSTOWN	0	0	0	0	0	0	0	0
UPPER FREEPORT	0	0	0	0	0	0	0	0
TOTALS	**374,779**	**18,464**	**23,977**	**7,804,199**	**38,934**	**124,201**	**2,657,952**	**10,613,622**

	LAND-USE RESTRICTIONS (SURFACE, 0 to 200 feet)-continued								
Coal bed	Power lines	Public buildings	Public lands	Railroads	Roads	Streams	Towns	Wetlands	**TOTALS**
WAYNESBURG A	10,959	70,266	0	189,474	567,084	693,658	84,083	385,959	**3,478,039**
WAYNESBURG	0	1,495,737	0	427,577	5,073,784	3,477,563	1,250,838	878,817	**31,995,255**
SEWICKLEY	0	49,160	0	69,848	128,606	166,521	0	116,217	**1,318,984**
PITTSBURGH	0	0	0	0	0	0	0	0	**0**
LOWER BAKERSTOWN	0	0	0	0	0	0	0	0	**0**
UPPER FREEPORT	0	0	0	0	0	0	0	0	**0**
Totals	**10,959**	**1,615,163**	**0**	**686,899**	**5,769,474**	**4,337,742**	**1,334,921**	**1,380,993**	**36,792,278**

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**
WAYNESBURG A	33,620,479	0	3,561	0	0	**33,624,040**
WAYNESBURG	5,392,900	0	830,616	620,264	1,158,328	**8,002,107**
SEWICKLEY	25,274,768	0	513,336	2,689,498	2,952,851	**31,430,454**
PITTSBURGH	131,304	4,920,033	886,967	5,094,389	5,245,793	**16,278,486**
LOWER BAKERSTOWN	94,340	0	757,476	2,722,177	2,606,731	**6,180,724**
UPPER FREEPORT	10,208,883	0	381,034	1,967,241	118,051	**12,675,208**
TOTALS	**74,722,674**	**4,920,033**	**3,372,989**	**13,093,569**	**12,081,754**	**108,191,019**

COMBINED DEEP AND SURFACE RESTRICTIONS			
Coal bed	Total Land Use	Total Technologic	**GRAND TOTAL**
WAYNESBURG A	3,478,039	33,624,040	**37,102,079**
WAYNESBURG	31,995,255	8,002,107	**39,997,362**
SEWICKLEY	1,318,984	31,430,454	**32,749,438**
PITTSBURGH	0	16,278,486	**16,278,486**
LOWER BAKERSTOWN	0	6,180,724	**6,180,724**
UPPER FREEPORT	0	12,675,208	**12,675,208**
TOTALS	**36,792,278**	**108,191,019**	**144,983,297**

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

[Quantities are in short tons.]

Coal bed	ORIGINAL RESOURCES			MINED OUT TONNAGES			REMAINING RESOURCES		
	0 - 200 FT	> 200 FT	TOTAL	0 - 200 FT	> 200 FT	TOTAL	0 - 200 FT	> 200 FT	TOTAL
WAYNESBURG A	4,441,604	33,837,103	38,278,707	0	0	0	4,441,604	33,837,103	38,278,707
WAYNESBURG	42,238,924	219,412,224	261,651,148	0	0	0	42,238,924	219,412,224	261,651,148
SEWICKLEY	1,359,507	177,754,737	179,114,244	0	0	0	1,359,507	177,674,242	179,114,244
PITTSBURGH	0	390,412,150	390,412,150	0	127,219,444	127,219,444	0	263,192,706	263,192,706
LOWER BAKERSTOWN	0	196,160,476	196,160,476	0	0	0	0	196,160,476	196,160,476
UPPER FREEPORT	0	103,467,422	103,467,422	0	0	0	0	103,467,422	103,467,422
TOTALS	**58,040,035**	**1,121,044,112**	**1,169,084,147**	**0**	**127,219,444**	**127,219,444**	**58,040,035**	**993,744,173**	**1,041,864,703**

Coal bed	RESTRICTED RESOURCES			AVAILABLE RESOURCES		
	0 - 200 FT	> 200 FT	TOTAL	0 - 200 FT	> 200 FT	TOTAL
WAYNESBURG A	3,478,039	33,624,040	37,102,079	963,565	213,063	**1,176,628**
WAYNESBURG	31,995,255	8,002,107	39,997,362	10,243,669	211,410,117	**221,653,786**
SEWICKLEY	1,318,984	31,430,454	32,749,438	40,523	146,324,283	**146,364,806**
PITTSBURGH	0	16,278,486	16,278,486	0	246,914,220	**246,914,220**
LOWER BAKERSTOWN	0	6,180,724	6,180,724	0	189,979,752	**189,979,752**
UPPER FREEPORT	0	12,675,208	12,675,208	0	90,792,214	**90,792,214**
TOTALS	**36,792,278**	**108,191,019**	**144,983,297**	**11,247,757**	**885,633,649**	**896,881,406**

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

Table B-1. *Estimated Coal Resources of the Upper 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). 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	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	0	109,206	109,206	5,773	362,835	368,608	22,580	3,969,059	3,991,639	0	0	0	28,353	4,441,100	4,469,453
		>1000	444,530	15,963,070	16,407,600	5,489,505	49,984,723	55,474,228	4,246,495	22,869,646	27,116,141	0	0	0	10,180,530	88,817,439	98,997,969
		TOTAL	444,530	16,072,276	16,516,806	5,495,278	50,347,558	55,842,836	4,269,075	26,838,705	31,107,780	0	0	0	10,208,883	93,258,539	103,467,422
Mined Out	Surface	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
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	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	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
Remaining		0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	0	109,206	109,206	5,773	362,835	368,608	22,580	3,969,059	3,991,639	0	0	0	28,353	4,441,100	4,469,453
		>1000	444,530	15,963,070	16,407,600	5,489,505	49,984,723	55,474,228	4,246,495	22,869,646	27,116,141	0	0	0	10,180,530	88,817,439	98,997,969
		TOTAL	444,530	16,072,276	16,516,806	5,495,278	50,347,558	55,842,836	4,269,075	26,838,705	31,107,780	0	0	0	10,208,883	93,258,539	103,467,422

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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	0	109,206	109,206	5,773	362,835	368,608	22,580	3,969,059	3,991,639	0	0	0	28,353	4,441,100	4,469,453
		>1000	444,530	15,963,070	16,407,600	5,489,505	49,984,723	55,474,228	4,246,495	22,869,646	27,116,141	0	0	0	10,180,530	88,817,439	98,997,969
		TOTAL	444,530	16,072,276	16,516,806	5,495,278	50,347,558	55,842,836	4,269,075	26,838,705	31,107,780	0	0	0	10,208,883	93,258,539	103,467,422
Restrictions	Land-use	0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	0	0	0	Land-use Restrictions do no apply for overburden thickness > 200 feet									0	0	0
		>1000	0	0	0										0	0	0
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Technologic	0-200	0	0	0	Technologic restrictions do not apply for overburden <=200 feet									0	0	0
		200-1000	0	0	0	5,773	0	5,773	22,580	435,625	458,205	0	0	0	28,353	435,625	463,978
		>1000	444,530	43,704	488,234	5,489,505	379,576	5,869,081	4,246,495	1,607,420	5,853,915	0	0	0	10,180,530	2,030,700	12,211,230
		TOTAL	444,530	43,704	488,234	5,495,278	379,576	5,874,854	4,269,075	2,043,045	6,312,120	0	0	0	10,208,883	2,466,325	12,675,208
	Total	0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	0	0	0	5,773	0	5,773	22,580	435,625	458,205	0	0	0	28,353	435,625	463,978
		>1000	444,530	43,704	488,234	5,489,505	379,576	5,869,081	4,246,495	1,607,420	5,853,915	0	0	0	10,180,530	2,030,700	12,211,230
		TOTAL	444,530	43,704	488,234	5,495,278	379,576	5,874,854	4,269,075	2,043,045	6,312,120	0	0	0	10,208,883	2,466,325	12,675,208
Available		0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	0	109,206	109,206	0	362,835	362,835	0	3,533,434	3,533,434	0	0	0	0	4,005,475	4,005,475
		>1000	0	15,919,366	15,919,366	0	49,605,147	49,605,147	0	21,262,226	21,262,226	0	0	0	0	86,786,739	86,786,739
		TOTAL	0	16,028,572	16,028,572	0	49,967,982	49,967,982	0	24,795,660	24,795,660	0	0	0	0	90,792,214	90,792,214

Table B-2. *Estimated Remaining Coal Resources of the Upper 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		14-28	>28	TOTAL	14-28	>28	TOTAL	14-28	>28	TOTAL
200 – 1000 feet	Bed too thin to mine	0	---	0	5,773	---	5,773	22,580	---	22,580	0	---	0	28,353	--	28,353
	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	20,494	20,494	0	0	0	0	20,494	20,494
	Public buildings	0	0	0	0	0	0	0	405,292	405,292	0	0	0	0	405,292	405,292
	Towns	0	0	0	0	0	0	0	9,840	9,840	0	0	0	0	9,840	9,840
	Total**	0	0	0	5,773	0	5,773	22,580	435,625	458,205	0	0	0	28,353	435,625	463,978
> 1000 feet	Bed too thin to mine	444,530	--	444,530	5,489,505	--	5,489,505	4,246,495	--	4,246,495	0	--	0	10,180,530	--	10,180,530
	Deep mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	43,704	43,704	0	227,839	227,839	0	88,998	88,998	0	0	0	0	360,540	360,540
	Public Buildings	0	0	0	0	151,738	151,738	0	1,410,212	1,410,212	0	0	0	0	1,561,949	1,561,949
	Towns	0	0	0	0	0	0	0	108,211	108,211	0	0	0	0	108,211	108,211
	Total**	444,530	43,704	488,234	5,489,505	379,576	5,869,081	4,246,495	1,607,420	5,853,915	0	0	0	10,180,530	2,030,700	12,211,230
TOTAL	Bed too thin to mine	444,530	--	444,530	5,495,278	--	5,495,278	4,269,075	--	4,269,075	0	--	0	10,208,883	--	10,208,883
	Deep mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	43,704	43,704	0	227,839	227,839	0	109,491	109,491	0	0	0	0	381,034	381,034
	Public Buildings	0	0	0	0	151,738	151,738	0	1,815,503	1,815,503	0	0	0	0	1,967,241	1,967,241
	Towns	0	0	0	0	0	0	0	118,051	118,051	0	0	0	0	118,051	118,051
	Total**	444,530	43,704	488,234	5,495,278	379,576	5,874,854	4,269,075	2,043,045	6,312,120	0	0	0	10,208,883	2,466,325	12,675,208

Table B-3. *Estimated Coal Resources of the Lower Bakerstown 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). 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	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	0	2,196,773	2,196,773	0	12,519,783	12,519,783	0	27,995,593	27,995,593	0	851,691	851,691	0	43,563,840	43,563,840
		>1000	0	9,961,955	9,961,955	0	43,376,071	43,376,071	94,340	86,508,820	86,603,160	0	12,655,450	12,655,450	94,340	152,502,296	152,596,636
		TOTAL	0	12,158,728	12,158,728	0	55,895,854	55,895,854	94,340	114,504,413	114,598,753	0	13,507,141	13,507,141	94,340	196,066,136	196,160,476
Mined Out	Surface	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
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	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	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**
Remaining		0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	0	2,196,773	2,196,773	0	12,519,783	12,519,783	0	27,995,593	27,995,593	0	851,691	851,691	0	43,563,840	43,563,840
		>1000	0	9,961,955	9,961,955	0	43,376,071	43,376,071	94,340	86,508,820	86,603,160	0	12,655,450	12,655,450	94,340	152,502,296	152,596,636
		TOTAL	0	12,158,728	12,158,728	0	55,895,854	55,895,854	94,340	114,504,413	114,598,753	0	13,507,141	13,507,141	94,340	196,066,136	196,160,476

Table B-3. *(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	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	0	2,196,773	2,196,773	0	12,519,783	12,519,783	0	27,995,593	27,995,593	0	851,691	851,691	0	43,563,840	43,563,840
		>1000	0	9,961,955	9,961,955	0	43,376,071	43,376,071	94,340	86,508,820	86,603,160	0	12,655,450	12,655,450	94,340	152,502,296	152,596,636
		TOTAL	0	12,158,728	12,158,728	0	55,895,854	55,895,854	94,340	114,504,413	114,598,753	0	13,507,141	13,507,141	94,340	196,066,136	196,160,476
Restrictions	Land-use	0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	0	0	0	Land-use Restrictions do no apply for overburden thickness > 200 feet									0	0	0
		>1000	0	0	0										0	0	0
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Technologic	0-200	0	0	0	Technologic restrictions do not apply for overburden <=200 feet									0	0	0
		200-1000	0	562,446	562,446	0	1,968,379	1,968,379	0	2,187,183	2,187,183	0	0	0	0	4,718,008	4,718,008
		>1000	0	142,308	142,308	0	595,642	595,642	94,340	544,607	638,947	0	85,819	85,819	94,340	1,368,376	1,462,716
		TOTAL	0	704,754	704,754	0	2,564,021	2,564,021	94,340	2,731,790	2,826,130	0	85,819	85,819	94,340	6,086,384	6,180,724
	Total	0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	0	562,446	562,446	0	1,968,379	1,968,379	0	2,187,183	2,187,183	0	0	0	0	4,718,008	4,718,008
		>1000	0	142,308	142,308	0	595,642	595,642	94,340	544,607	638,947	0	85,819	85,819	94,340	1,368,376	1,462,716
		TOTAL	0	704,754	704,754	0	2,564,021	2,564,021	94,340	2,731,790	2,826,130	0	85,819	85,819	94,340	6,086,384	6,180,724
Available		0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	0	1,634,327	1,634,327	0	10,551,404	10,551,404	0	25,808,410	25,808,410	0	851,691	851,691	0	38,845,832	38,845,832
		>1000	0	9,819,647	9,819,647	0	42,780,429	42,780,429	0	85,964,213	85,964,213	0	12,569,631	12,569,631	0	151,133,920	151,133,920
		TOTAL	0	11,453,974	11,453,974	0	53,331,833	53,331,833	0	111,772,623	111,772,623	0	13,421,322	13,421,322	0	189,979,752	189,979,752

Table B-4. *Estimated Remaining Coal Resources of the Lower Bakerstown 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		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	9,432	9,432	0	83,274	83,274	0	109,679	109,679	0	0	0	0	202,385	202,385
	Public buildings	0	27,860	27,860	0	383,839	383,839	0	2,077,504	2,077,504	0	0	0	0	2,489,202	2,489,202
	Towns	0	525,155	525,155	0	1,501,267	1,501,267	0	0	0	0	0	0	0	2,026,422	2,026,422
	Total**	0	562,446	562,446	0	1,968,379	1,968,379	0	2,187,183	2,187,183	0	0	0	0	4,718,008	4,718,008
> 1000 feet	Bed too thin to mine	0	--	0	0	--	0	94,340	--	94,340	0	--	0	94,340	--	94,340
	Deep mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	28,452	28,452	0	116,930	116,930	0	372,700	372,700	0	37,010	37,010	0	555,092	555,092
	Public Buildings	0	45,327	45,327	0	49,616	49,616	0	89,223	89,223	0	48,810	48,810	0	232,975	232,975
	Towns	0	68,530	68,530	0	429,096	429,096	0	82,684	82,684	0	0	0	0	580,310	580,310
	Total**	0	142,308	142,308	0	595,642	595,642	94,340	544,607	638,947	0	85,819	85,819	94,340	1,368,376	1,462,717
TOTAL	Bed too thin to mine	0	--	0	0	--	0	94,340	--	94,340	0	--		94,340	--	94,340
	Deep mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	37,884	37,884	0	200,204	200,204	0	482,379	482,379	0	37,010	37,010	0	757,476	757,476
	Public Buildings	0	73,186	73,186	0	433,455	433,455	0	2,166,727	2,166,727	0	48,810	48,810	0	2,722,177	2,722,177
	Towns	0	593,684	593,684	0	1,930,363	1,930,363	0	82,684	82,684	0	0	0	0	2,606,731	2,606,731
	Total**	0	704,754	704,754	0	2,564,021	2,564,021	94,340	2,731,790	2,826,130	0	85,819	85,819	94,340	6,086,384	6,180,724

Table B-5. *Estimated Coal Resources of the Pittsburgh 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). 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	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	131,304	70,691,582	70,822,886	0	188,377,228	188,377,228	0	116,588,323	116,588,323	0	0	0	131,304	375,657,133	375,788,437
		>1000	0	1,050,375	1,050,375	0	6,003,609	6,003,609	0	7,569,729	7,569,729	0	0	0	0	14,623,713	14,623,713
		TOTAL	131,304	71,741,957	71,873,261	0	194,380,837	194,380,837	0	124,158,052	124,158,052	0	0	0	131,304	390,280,846	390,412,150
Mined Out	Surface	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
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Deep	0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	0	37,492,409	37,492,409	0	70,301,358	70,301,358	0	18,490,091	18,490,091	0	0	0	0	216,283,858	216,283,858
		>1000	0	188,989	188,989	0	725,008	725,008	0	21,589	21,589	0	0	0	0	935,586	935,586
		TOTAL	0	37,681,398	37,681,398	0	71,026,366	71,026,366	0	18,511,680	18,511,680	0	0	0	0	127,219,444	127,219,444
	Total	0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	0	37,492,409	37,492,409	0	70,301,358	70,301,358	0	18,490,091	18,490,091	0	0	0	0	216,283,858	216,283,858
		>1000	0	188,989	188,989	0	725,008	725,008	0	21,589	21,589	0	0	0	0	935,586	935,586
		TOTAL	**0**	**37,681,398**	**37,681,398**	**0**	**71,026,366**	**71,026,366**	**0**	**18,511,680**	**18,511,680**	**0**	**0**	0	0	127,219,444	127,219,444
Remaining		0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	131,304	33,199,173	33,330,477	0	118,075,870	118,075,870	0	98,098,232	98,098,232	0	0	0	131,340	249,373,275	249,504,579
		>1000	0	861,386	861,386	0	5,278,601	5,278,601	0	7,548,140	7,548,140	0	0	0	0	13,688,127	13,688,127
		TOTAL	131,304	34,060,559	34,191,863	0	123,354,471	123,354,471	0	105,646,372	105,646,372	0	0	0	131,340	263,061,402	263,192,706

Table B-5. *(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	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	131,304	33,199,173	33,330,477	0	118,075,870	118,075,870	0	98,098,232	98,098,232	0	0	0	131,340	249,373,275	249,504,579
		>1000	0	861,386	861,386	0	5,278,601	5,278,601	0	7,548,140	7,548,140	0	0	0	0	13,688,127	13,688,127
		TOTAL	131,304	34,060,559	34,191,863	0	123,354,471	123,354,471	0	105,646,372	105,646,372	0	0	0	131,340	263,061,402	263,192,706
Restrictions	Land-use	0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	0	0	0	Land-use Restrictions do no apply for overburden thickness > 200 feet									0	0	0
		>1000	0	0	0										0	0	0
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Technologic	0-200	0	0	0	Technologic restrictions do not apply for overburden <=200 feet									0	0	0
		200-1000	131,304	3,718,306	3,849,610	0	9,845,766	9,845,766	0	2,406,224	2,406,224	0	0	0	131,304	15,970,296	16,101,600
		>1000	0	8,772	8,772	0	21,165	21,165	0	146,949	146,949	0	0	0	0	176,886	176,886
		TOTAL	131,304	3,727,078	3,858,382	0	9,866,931	9,866,931	0	2,553,173	2,553,173	0	0	0	131,304	16,147,182	16,278,486
	Total	0-200	0	0	0	0	0	0	0	00	0	0	0	0	0	0	0
		200-1000	131,304	3,718,306	3,849,610	0	9,845,766	9,845,766	0	2,406,224	2,406,224	0	0	0	131,304	15,970,296	16,101,600
		>1000	0	8,772	8,772	0	21,165	21,165	0	146,949	146,949	0	0	0	0	176,886	176,886
		TOTAL	131,304	3,727,078	3,858,382	0	9,866,931	9,866,931	0	2,553,173	2,553,173	0	0	0	131,304	16,147,182	16,278,486
Available		0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		200-1000	0	29,480,867	29,480,867	0	108,230,104	108,230,104	0	95,692,008	95,692,008	0	0	0	0	233,402,979	233,402,979
		>1000	0	852,614	852,614	0	5,257,436	5,257,436	0	7,401,191	7,401,191	0	0	0	0	13,511,241	13,511,241
		TOTAL	0	30,333,481	30,333,481	0	113,487,540	113,487,540	0	103,093,199	103,093,199	0	0	0	0	246,914,220	246,914,220

Table B-6. *Estimated Remaining Coal Resources of the Pittsburgh 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		14-28	>28	TOTAL	14-28	>28	TOTAL	14-28	>28	TOTAL
200 – 1000 feet	Bed too thin to mine	131,304	--	131,304	0	--	0	0	--	0	0	0	0	131,304	--	131,304
	Deep mine barriers	0	1,992,840	1,992,840	0	2,264,446	2,264,446	0	662,747	662,747	0	0	0	0	4,920,033	4,920,033
	Oil and gas wells	0	74,905	74,905	0	445,282	445,282	0	299,882	299,882	0	0	0	0	820,068	820,068
	Public buildings	0	400,420	400,420	0	3,140,387	3,140,387	0	1,443,595	1,443,595	0	0	0	0	4,984,402	4,984,402
	Towns	0	1,250,141	1,250,141	0	3,995,652	3,995,652	0	0	0	0	0	0	0	5,245,793	5,245,793
	Total**	131,304	3,718,306	3,849,610	0	9,845,766	9,845,766	0	2,406,224	2,406,224	0	0	0	131,304	15,970,296	16,101,600
> 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	8,772	8,772	0	21,165	21,165	0	36,962	36,962	0	0	0	0	66,899	66,899
	Public Buildings	0	0	0	0	0	0	0	109,988	109,988	0	0	0	0	109,988	109,988
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total**	0	8,772	8,772	0	21,165	21,165	0	146,949	146,949	0	0	0	0	176,886	176,886
TOTAL	Bed too thin to mine	131,304	--	131,304	0	--	0	0	--	0	0	--	0	131,304	--	131,304
	Deep mine barriers	0	1,992,840	1,992,840	0	2,264,446	2,264,446	0	662,747	662,747	0	0	0	0	4,920,033	4,920,033
	Oil and gas wells	0	83,677	83,677	0	466,447	466,447	0	336,844	336,844	0	0	0	0	886,967	886,967
	Public Buildings	0	400,420	400,420	0	3,140,387	3,140,387	0	1,553,583	1,553,583	0	0	0	0	5,094,389	5,094,389
	Towns	0	1,250,141	1,250,141	0	3,995,652	3,995,652	0	0	0	0	0	0	0	5,245,793	5,245,793
	Total**	131,304	3,727,078	3,858,382	0	9,866,931	9,866,931	0	2,553,173	2,553,173	0	0	0	131,304	16,147,182	16,278,486

Table B-7. *Estimated Coal Resources of the Sewickley 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). 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	128,509	424,570	553,079	0	804,830	804,830	0	1,598	1,598	0	0	0	128,509	1,230,998	1,359,507
		200-1000	4,917,872	25,754,076	30,671,948	10,116,021	73,320,237	83,436,258	10,240,875	53,325,161	63,566,036	0	0	0	25,274,768	152,399,474	177,674,242
		>1000	0	0	0	0	79,259	79,259	0	1,236	1,236	0	0	0	0	80,495	80,495
		TOTAL	5,046,381	26,178,646	31,225,027	10,116,021	74,204,326	84,320,347	10,240,875	53,327,995	63,568,870	0	0	0	25,403,277	153,710,967	179,114,244
Mined Out	Surface	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
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	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	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**
Remaining		0-200	128,509	424,570	553,079	0	804,830	804,830	0	1,598	1,598	0	0	0	128,509	1,230,998	1,359,507
		200-1000	4,917,872	25,754,076	30,671,948	10,116,021	73,320,237	83,436,258	10,240,875	53,325,161	63,566,036	0	0	0	25,274,768	152,399,474	177,674,242
		>1000	0	0	0	0	79,259	79,259	0	1,236	1,236	0	0	0	0	80,495	80,495
		TOTAL	5,046,381	26,178,646	31,225,027	10,116,021	74,204,326	84,320,347	10,240,875	53,327,995	63,568,870	0	0	0	25,403,277	153,710,967	179,114,244

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	128,509	424,570	553,079	0	804,830	804,830	0	1,598	1,598	0	0	0	128,509	1,230,998	1,359,507
		200-1000	4,917,872	25,754,076	30,671,948	10,116,021	73,320,237	83,436,258	10,240,875	53,325,161	63,566,036	0	0	0	25,274,768	152,399,474	177,674,242
		>1000	0	0	0	0	79,259	79,259	0	1,236	1,236	0	0	0	0	80,495	80,495
		TOTAL	5,046,381	26,178,646	31,225,027	10,116,021	74,204,326	84,320,347	10,240,875	53,327,995	63,568,870	0	0	0	25,403,277	153,710,967	179,114,244
Restrictions	Land-use	0-200	128,509	388,436	516,945	0	800,441	800,441	0	1,598	1,598	0	0	0	128,509	1,190,475	1,318,984
		200-1000	0	0	0	Land-use Restrictions do no apply for overburden thickness > 200 feet									0	0	0
		>1000	0	0	0										0	0	0
		TOTAL	**128,509**	**388,436**	**516,945**	**0**	**800,441**	**800,441**	**0**	**1,598**	**1,598**	**0**	**0**	0	128,509	1,190,475	1,318,984
	Technologic	0-200	0	0	0	Technologic restrictions do not apply for overburden <=200 feet									0	0	0
		200-1000	4,917,872	854,596	5,772,468	10,116,021	4,265,575	14,381,596	10,240,875	1,035,515	11,276,390	0	0	0	25,274,768	6,155,686	31,430,454
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	**4,917,872**	**854,596**	**5,772,468**	**10,116,021**	**4,265,575**	**14,381,596**	**10,240,875**	**1,035,515**	**11,276,390**	**0**	**0**	0	25,274,768	6,155,686	31,430,454
	Total	0-200	128,509	388,436	516,945	0	800,441	800,441	0	1,598	1,598	0	0	0	128,509	1,190,475	1,318,984
		200-1000	4,917,872	854,596	5,772,468	10,116,021	4,265,575	14,381,596	10,240,875	1,035,515	11,276,390	0	0	0	25,274,768	6,155,686	31,430,454
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	**5,046,381**	**1,243,032**	**6,289,413**	**10,116,021**	**5,066,016**	**15,182,037**	**10,240,875**	**1,037,113**	**11,277,988**	**0**	**0**	0	**25,403,277**	**7,346,161**	**32,749,438**
Available		0-200	0	36,134	36,134	0	4,389	4,389	0	0	0	0	0	0	0	40,523	40,523
		200-1000	0	24,899,480	24,899,480	0	69,054,662	69,054,662	0	52,289,646	52,289,646	0	0	0	0	146,243,788	146,243,788
		>1000	0	0	0	0	79,259	79,259	0	1,236	1,236	0	0	0	0	80,495	80,495
		TOTAL	**0**	**24,935,614**	**24,935,614**	**0**	**69,138,310**	**69,138,310**	**0**	**52,290,882**	**52,290,882**	**0**	**0**	**0**	**0**	**146,364,806**	**146,364,806**

Table B-8. *Estimated Remaining Coal Resources of the Sewickley Coal Unavailable Due to Land-Use 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.]

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	7,539	7,539	0	0	0	0	0	0	0	7,539	7,539
Houses	2,090	62,246	64,335	0	32,461	32,461	0	356	356	0	0	0	2,090	95,062	97,152
Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil & gas wells	0	0	0	0	1,117	1,117	0	0	0	0	0	0	0	1,117	1,117
Pipelines	15,537	815	16,353	0	0	0	0	0	0	0	0	0	15,537	815	16,353
PNDI sites	53,616	151,477	205,094	0	461,378	461,378	0	0	0	0	0	0	53,616	612,856	666,472
Power lines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public buildings	9,880	17,344	27,224	0	21,936	21,936	0	0	0	0	0	0	9,880	39,280	49,160
Public lands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	10,425	19,897	30,322	0	39,526	39,526	0	0	0	0	0	0	10,425	59,423	69,848
Roads	7,897	49,654	57,551	0	71,054	71,054	0	0	0	0	0	0	7,897	120,708	128,606
Streams	15,879	51,602	67,480	0	98,419	98,419	0	621	621	0	0	0	15,879	150,642	166,521
Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	13,185	35,401	48,585	0	67,011	67,011	0	621	621	0	0	0	13,185	103,032	116,217
Total	128,509	388,436	516,945	0	800,441	800,441	0	1,598	1,598	0	0	0	128,509	1,190,475	1,318,984

Table B-9. *Estimated Remaining Coal Resources of the Sewickley 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		14-28	>28	TOTAL	14-28	>28	TOTAL	14-28	>28	TOTAL
200 – 1000 feet	Bed too thin to mine	4,914,872	--	4,914,872	10,116,021	--	10,116,021	10,240,875	--	10,240,875	0	--	0	25,274,768	--	25,274,768
	Deep mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	76,533	76,533	0	312,558	312,558	0	124,246	124,246	0	0	0	0	513,336	513,336
	Public buildings	0	131,712	131,712	0	1,646,517	1,646,517	0	911,270	911,270	0	0	0	0	2,689,498	2,689,498
	Towns	0	646,351	646,351	0	2,306,501	2,306,501	0	0	0	0	0	0	0	2,952,851	2,952,851
	Total**	4,914,872	854,596	5,772,468	10,116,021	4,265,575	14,381,596	10,240,875	1,035,515	11,276,390	0	0	0	25,274,768	6,155,686	31,430,454
> 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	4,914,872	--	4,914,872	10,116,021	--	10,116,021	10,240,875	--	10,240,875	0	--	0	25,274,768	--	25,274,768
	Deep mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	76,533	76,533	0	312,558	312,558	0	124,246	124,246	0	0	0	0	513,336	513,336
	Public Buildings	0	131,712	131,712	0	1,646,517	1,646,517	0	911,270	911,270	0	0	0	0	2,689,498	2,689,498
	Towns	0	646,351	646,351	0	2,306,501	2,306,501	0	0	0	0	0	0	0	2,952,851	2,952,851
	Total**	4,914,872	854,596	5,772,468	10,116,021	4,265,575	14,381,596	10,240,875	1,035,515	11,276,390	0	0	0	25,274,768	6,155,686	31,430,454

Table B-10. *Estimated Coal Resources of the Waynesburg 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). 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	3,712	5,249,613	5,253,325	0	19,233,297	19,233,297	0	17,752,302	17,752,302	0	0	0	3,712	42,235,212	42,238,924
		200-1000	802,605	41,328,456	42,131,061	4,434,209	99,640,073	104,074,282	156,086	73,050,795	73,206,881	0	0	0	5,392,900	214,019,324	219,412,224
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	806,317	46,578,069	47,384,386	4,434,209	118,873,370	123,307,579	156,086	90,803,097	90,959,183	0	0	0	5,396,612	256,254,536	261,651,148
Mined Out	Surface	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
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	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	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**
Remaining		0-200	3,712	5,249,613	5,253,325	0	19,233,297	19,233,297	0	17,752,302	17,752,302	0	0	0	3,712	42,235,212	42,238,924
		200-1000	802,605	41,328,456	42,131,061	4,434,209	99,640,073	104,074,282	156,086	73,050,795	73,206,881	0	0	0	5,392,900	214,019,324	219,412,224
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	806,317	46,578,069	47,384,386	4,434,209	118,873,370	123,307,579	156,086	90,803,097	90,959,183	0	0	0	5,396,612	256,254,536	261,651,148

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	3,712	5,249,613	5,253,325	0	19,233,297	19,233,297	0	17,752,302	17,752,302	0	0	0	3,712	42,235,212	42,238,924
		200-1000	802,605	41,328,456	42,131,061	4,434,209	99,640,073	104,074,282	156,086	73,050,795	73,206,881	0	0	0	5,392,900	214,019,324	219,412,224
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	806,317	46,578,069	47,384,386	4,434,209	118,873,370	123,307,579	156,086	90,803,097	90,959,183	0	0	0	5,396,612	256,254,536	261,651,148
Restrictions	Land-use	0-200	1,690	4,232,687	4,234,377	0	14,975,610	14,975,610	0	12,785,268	12,785,268	0	0	0	1,690	31,993,565	31,995,255
		200-1000	0	0	0	Land-use Restrictions do no apply for overburden thickness > 200 feet									0	0	0
		>1000	0	0	0										0	0	0
		TOTAL	1,690	4,232,687	4,234,377	0	14,975,610	14,975,610	0	12,785,268	12,785,268	0	0	0	1,690	31,993,565	31,995,255
	Technologic	0-200	0	0	0	Technologic restrictions do not apply for overburden <=200 feet									0	0	0
		200-1000	802,605	500,442	1,303,047	4,434,209	1,571,978	6,006,187	156,086	536,787	692,873	0	0	0	5,392,900	2,609,207	8,002,107
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	802,605	500,442	1,303,047	4,434,209	1,571,978	6,006,187	156,086	536,787	692,873	0	0	0	5,392,900	2,609,207	8,002,107
	Total	0-200	1,690	4,232,687	4,234,377	0	14,975,610	14,975,610	0	12,785,268	12,785,268	0	0	0	1,690	31,993,565	31,995,255
		200-1000	802,605	500,442	1,303,047	4,434,209	1,571,978	6,006,187	156,086	536,787	692,873	0	0	0	5,392,900	2,609,207	8,002,107
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	804,295	4,733,129	5,537,424	4,434,209	16,547,588	20,981,797	156,086	13,322,055	13,478,141	0	0	0	5,394,590	34,602,772	39,997,362
Available		0-200	2,022	1,016,926	1,018,948	0	4,257,687	4,257,687	0	4,967,034	4,967,034	0	0	0	2,022	10,241,647	10,243,669
		200-1000	0	40,828,014	40,828,014	0	98,068,095	98,068,095	0	72,514,008	72,514,008	0	0	0	0	211,410,117	211,410,117
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	**2,022**	41,844,940	41,846,962	0	102,325,782	102,325,782	0	77,481,042	77,481,042	0	0	0	2,022	221,651,764	221,653,786

Table B-11. *Estimated Remaining Coal Resources of the Waynesburg Coal Unavailable Due to Land-Use 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.]

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	182,720	182,720	0	192,059	192,059	0	0	0	0	374,779	374,779
Cemeteries	0	0	0	0	0	0	0	18,464	18,464	0	0	0	0	18,464	18,464
Historic sites	0	0	0	0	13,331	13,331	0	3,107	3,107	0	0	0	0	16,438	16,438
Houses	70	465,584	465,654	0	2,366,419	2,366,419	0	4,103,271	4,103,271	0	0	0	70	6,935,274	6,935,344
Lakes	0	250	250	0	22,606	22,606	0	14,389	14,389	0	0	0	0	37,244	37,244
Oil & gas wells	0	24,888	24,888	0	54,122	54,122	0	26,038	26,038	0	0	0	0	105,048	105,048
Pipelines	0	322,401	322,401	0	1,172,118	1,172,118	0	976,170	976,170	0	0	0	0	2,470,689	2,470,689
PNDI sites	0	2,061,234	2,061,234	0	4,921,558	4,921,558	0	2,450,141	2,450,141	0	0	0	0	9,432,933	9,432,933
Power lines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public buildings	0	12,700	12,700	0	346,292	346,292	0	1,136,744	1,136,744	0	0	0	0	1,495,737	1,495,737
Public lands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	302,073	302,073	0	125,504	125,504	0	0	0	0	427,577	427,577
Roads	0	311,348	311,348	0	2,221,504	2,221,504	0	2,540,933	2,540,933	0	0	0	0	5,073,784	5,073,784
Streams	706	571,591	572,297	0	1,886,750	1,886,750	0	1,018,516	1,018,516	0	0	0	706	3,476,856	3,477,563
Towns	0	438,574	438,574	0	812,264	812,264	0	0	0	0	0	0	0	1,250,838	1,250,838
Wetlands	914	24,119	25,033	0	673,852	673,852	0	179,933	179,933	0	0	0	914	877,903	878,817
Total	**1,690**	**4,232,687**	**4,234,377**	**0**	**14,975,610**	**14,975,610**	**0**	**12,785,268**	**12,785,268**	**0**	**0**	**0**	**1,690**	**31,993,565**	**31,995,255**

Table B-12. *Estimated Remaining Coal Resources of the Waynesburg 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		14-28	>28	TOTAL	14-28	>28	TOTAL	14-28	>28	TOTAL
200 – 1000 feet	Bed too thin to mine	802,605	--	802,605	4,434,209	--	4,434,209	156,086	--	156,086	0	--	0	5,392,900	--	5,392,900
	Deep mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	136,321	136,321	0	443,918	443,918	0	250,377	250,377	0	0	0	0	830,616	830,616
	Public buildings	0	143,264	143,264	0	190,589	190,589	0	286,411	286,411	0	0	0	0	620,264	620,264
	Towns	0	220,857	220,857	0	937,471	937,471	0	0	0	0	0	0	0	1,158,328	1,158,328
	Total**	802,605	550,442	1,303,047	4,434,209	1,571,978	6,006,187	156,086	536,787	692,873	0	0	0	5,392,900	2,609,207	8,002,107
> 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	802,605	--	802,605	4,434,209	--	4,434,209	156,086	--	156,086	0	--	0	5,392,900	--	5,392,900
	Deep mine barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	136,321	136,321	0	443,918	443,918	0	250,377	250,377	0	0	0	0	830,616	830,616
	Public Buildings	0	143,264	143,264	0	190,589	190,589	0	286,411	286,411	0	0	0	0	620,264	620,264
	Towns	0	220,857	220,857	0	937,471	937,471	0	0	0	0	0	0	0	1,158,328	1,158,328
	Total**	802,605	550,442	1,303,047	4,434,209	1,571,978	6,006,187	156,086	536,787	692,873	0	0	0	5,392,900	2,609,207	8,002,107

Table B-13. *Estimated Coal Resources of the Waynesburg A 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). 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	141,474	45,754	187,228	2,174,443	0	2,174,443	2,079,933	0	2,079,933	0	0	0	4,395,850	45,754	4,441,604
		200-1000	4,544,919	204,463	4,749,382	16,832,557	12,161	16,844,718	12,243,003	0	12,243,003	0	0	0	33,620,479	216,624	33,837,103
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	4,686,393	250,217	4,936,610	19,007,000	12,161	19,019,161	14,322,936	0	14,322,936	0	0	0	38,016,329	262,378	38,278,707
Mined Out	Surface	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
		TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	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	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**
Remaining		0-200	141,474	45,754	187,228	2,174,443	0	2,174,443	2,079,933	0	2,079,933	0	0	0	4,395,850	45,754	4,441,604
		200-1000	4,544,919	204,463	4,749,382	16,832,557	12,161	16,844,718	12,243,003	0	12,243,003	0	0	0	33,620,479	216,624	33,837,103
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	4,686,393	250,217	4,936,610	19,007,000	12,161	19,019,161	14,322,936	0	14,322,936	0	0	0	38,016,329	262,378	38,278,707

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	141,474	45,754	187,228	2,174,443	0	2,174,443	2,079,933	0	2,079,933	0	0	0	4,395,850	45,754	4,441,604
		200-1000	4,544,919	204,463	4,749,382	16,832,557	12,161	16,844,718	12,243,003	0	12,243,003	0	0	0	33,620,479	216,624	33,837,103
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	4,686,393	250,217	4,936,610	19,007,000	12,161	19,019,161	14,322,936	0	14,322,936	0	0	0	38,016,329	262,378	38,278,707
Restrictions	Land-use	0-200	68,554	38,168	106,722	1,783,323	0	1,783,323	1,587,994	0	1,587,994	0	0	0	3,439,871	38,168	3,478,039
		200-1000	0	0	0	Land-use Restrictions do no apply for overburden thickness > 200 feet									0	0	0
		>1000	0	0	0										0	0	0
		TOTAL	68,554	38,168	106,722	1,783,323	0	1,783,323	1,587,994	0	1,587,994	0	0	0	3,439,871	38,168	3,478,039
	Technologic	0-200	0	0	0	Technologic restrictions do not apply for overburden <=200 feet									0	0	0
		200-1000	4,544,919	3,561	4,548,480	16,832,557	0	16,832,557	12,243,003	0	12,243,003	0	0	0	33,620,479	3,561	33,624,040
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	4,544,919	3,561	4,548,480	16,832,557	0	16,832,557	12,243,003	0	12,243,003	0	0	0	33,620,479	3,561	33,624,040
	Total	0-200	68,554	38,168	106,722	1,783,323	0	1,783,323	1,587,994	0	1,587,994	0	0	0	3,439,871	38,168	3,478,039
		200-1000	4,544,919	3,561	4,548,480	16,832,557	0	16,832,557	12,243,003	0	12,243,003	0	0	0	33,620,479	3,561	33,624,040
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	4,613,473	41,729	4,655,202	18,615,880	0	18,615,880	13,830,997	0	13,830,997	0	0	0	37,060,350	41,729	37,102,079
Available		0-200	72,920	7,586	80,506	391,120	0	391,120	491,939	0	491,939	0	0	0	955,979	7,586	963,565
		200-1000	0	200,902	200,902	0	12,161	12,161	0	0	0	0	0	0	0	213,063	213,063
		>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	72,920	208,488	281,408	391,120	12,161	403,281	491,939	0	491,939	0	0	0	955,979	220,649	1,176,628

Table B-14. *Estimated Remaining Coal Resources of the Waynesburg A Coal Unavailable Due to Land-Use 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.]

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	14,628	4,311	18,939	350,082	0	350,082	402,682	0	402,682	0	0	0	767,392	4,311	771,703
Lakes	0	0	0	0	0	0	1,690	0	1,690	0	0	0	1,690	0	1,690
Oil & gas wells	0	0	0	11,258	0	11,258	6,779	0	6,779	0	0	0	18,036	0	18,036
Pipelines	385	0	385	84,201	0	84,201	86,325	0	86,325	0	0	0	170,910	0	170,910
PNDI sites	792	0	792	286,804	0	286,804	226,622	0	226,622	0	0	0	514,217	0	514,217
Power lines	0	0	0	0	0	0	10,959	0	10,959	0	0	0	10,959	0	10,959
Public buildings	0	0	0	46,182	0	46,182	24,085	0	24,085	0	0	0	70,266	0	70,266
Public lands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	86,266	0	86,266	103,208	0	103,208	0	0	0	189,474	0	189,474
Roads	17,104	17,986	35,089	272,494	0	272,494	259,501	0	259,501	0	0	0	549,099	17,986	567,084
Streams	31,194	15,872	47,065	362,394	0	362,394	284,199	0	284,199	0	0	0	677,787	15,872	693,658
Towns	0	0	0	84,083	0	84,083	0	0	0	0	0	0	84,083	0	84,083
Wetlands	4,452	0	4,452	199,561	0	199,561	181,945	0	181,945	0	0	0	385,959	0	385,959
Total	**68,554**	**38,168**	**106,722**	**1,783,323**	**0**	**1,783,323**	**1,587,994**	**0**	**1,587,994**	**0**	**0**	**0**	**3,439,871**	**38,168**	**3,478,039**

Table B-15. *Estimated Remaining Coal Resources of the Waynesburg A 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		14-28	>28	TOTAL	14-28	>28	TOTAL	14-28	>28	TOTAL
200 – 1000 feet	Bed too thin to mine	4,544,919	--	4,544,919	16,832,557	--	16,832,557	12,243,003	--	12,243,003	0	--	0	33,620,479	--	33,620,479
	Deep mine barriers	00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	3,561	3,561	0	0	0	0	0	0	0	0	0	0	3,561	3,561
	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**	4,544,919	3,561	4,548,480	16,832,557	0	16,832,557	12,243,003	0	12,243,003	0	0	0	33,620,479	3,561	33,624,040
> 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	4,544,919	--	4,544,919	16,832,557	--	16,832,557	12,243,003	--	12,243,003	0	--	0	33,620,479	--	33,620,479
	Deep mine barriers	00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oil and gas wells	0	3,561	3,561	0	0	0	0	0	0	0	0	0	0	3,561	3,561
	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**	4,544,919	3,561	4,548,480	16,832,557	0	16,832,557	12,243,003	0	12,243,003	0	0	0	33,620,479	3,561	33,624,040

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

by
Michael E. Moore

For the Waynesburg, Clymer, Mount Pleasant, and Strattanville 7.5-minute quadrangles in western Pennsylvania, 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 polyline and 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 re-mined 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 44, where house restrictions are shown in yellow, stream restrictions in blue, and road restrictions in brown. 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.

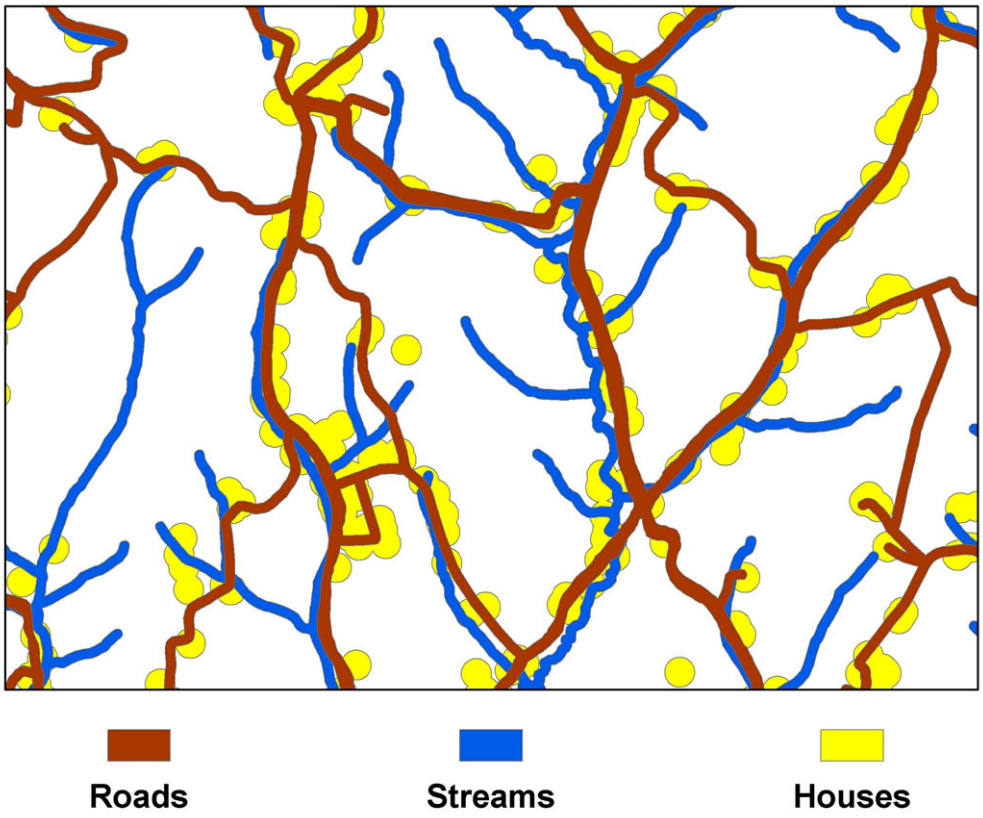

Figure 44. Example of overlapping restriction coverages.

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 from 1/4 mile to 3/4 mile are designated as indicated, those between 3/4 mile and 3 miles are designated as inferred, and those greater than 3 miles are designated as hypothetical. Tonnages were calculated using measured, indicated, and inferred resources for all the coal seams except the Lower Bakerstown coal calculation, which also utilized hypothetical resources.

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 (~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.

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, strip 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).

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	Strip minable - not restricted - measured
7	Strip minable - not restricted - indicated
8	Strip minable - not restricted - inferred
9	Strip minable - not restricted - hypothetical
10	Strip minable - restricted
11	200-foot underground mine buffer
12	Technically not minable
13	Underground mined
14	Surface Mined

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 restricted tonnages for each restriction category. In situations where a record is impacted by more than one restriction (see Figure 44), the queries allocate a proportional amount of the tonnage to each restriction category.