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A STUDY OF COAL AVAILABILITY IN THE SAXONBURG 7.5-MINUTE QUADRANGLE, BUTLER COUNTY, PENNSYLVANIA

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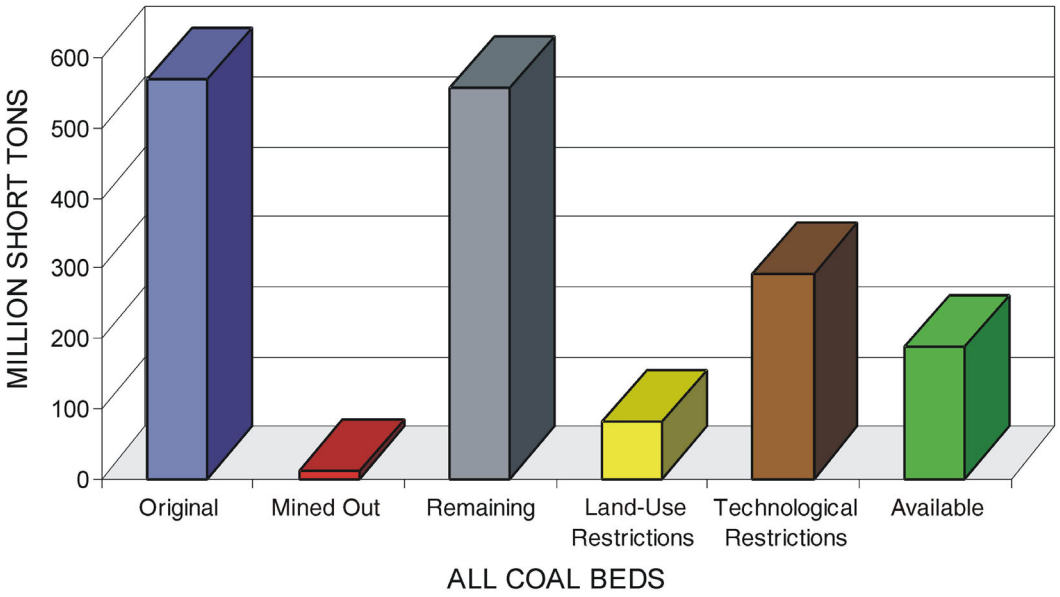

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A STUDY OF COAL AVAILABILITY IN THE SAXONBURG 7.5-MINUTE QUADRANGLE, BUTLER COUNTY, PENNSYLVANIA

by Leonard J. Lentz
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Pennsylvania Geological Survey

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A STUDY OF COAL AVAILABILITY IN THE SAXONBURG 7.5-MINUTE QUADRANGLE, BUTLER COUNTY, PENNSYLVANIA

by
Leonard J. Lentz and John C. Neubaum

ABSTRACT

The Saxonburg 7.5-minute quadrangle in west-central Pennsylvania is underlain by middle Carboniferous rocks, which contain the Sharon to approximately Upper Bakerstown coal-bed sequence. Of this sequence, only the Upper Freeport, Lower Freeport, and Middle Kittanning coal beds have been mined to any extent during the last century, accounting for only about 2 percent of the original coal removed.

The Saxonburg quadrangle is one of six quadrangles chosen for study in the bituminous coal fields of Pennsylvania, and was selected to help demonstrate how much coal on average remains available for extraction in a typical mature mining district. Results from the study indicate that of the approximately 570 million short tons of bituminous coal originally in the Saxonburg quadrangle, 11 million short tons has been mined out. An additional 373 million short tons of coal can be excluded due to resource restrictions, such as land-use and technological restraints to mining, leaving only about 187 million short tons, or 33 percent, of the original amount of coal available for mining.

INTRODUCTION

The Coal Resources Branch (now known as Eastern Energy Resources Team of the Energy Resources Program) of the U.S. Geological Survey in cooperation with the Kentucky Geological Survey initiated a pilot study in 1987 to quantify coal resources available for mining in the Matewan 7.5-minute quadrangle, located in eastern Kentucky, by looking at the additional effect of land-use and technological restrictions to mining. Formally termed a Coal Availability Study, this pilot study provided the guidelines used in subsequent quadrangle studies in Virginia and West Virginia, and eventually in Pennsylvania.

The U.S. Geological Survey in 1992 decided to expand the scope of the Coal Availability Study program from the central Appalachian Basin into the northern Appalachian Basin. The

Pennsylvania Bureau of Topographic and Geologic Survey (Pennsylvania Geological Survey) responded by proposing six 7.5-minute quadrangle Coal Availability Studies of its own to do for the Pennsylvania portion of the northern Appalachian Basin. This proposal was accepted by the U.S. Geological Survey and funding was initiated for the cooperative agreement in late 1992 under grant #1434-92-A-0987. The Hackett quadrangle, located in Washington County, was chosen as the first quadrangle for study in late 1993. Funding was initially provided for the Saxonburg quadrangle by grant #1434-95-A-01343.

Data collected for the study include restriction categories based upon the regulations of the Commonwealth of Pennsylvania; coal drill-holes; outcrop and strip-mine highwall descriptions; and maps delineating mined-out areas. The coal drill hole data were incorporated into a computer database of stratigraphic data called the National Coal Resources Data System (NCRDS) maintained by the U.S. Geological Survey in Reston, Virginia. This database was searched and data were retrieved for inclusion into the geographic analysis program called GRASS (Geographical Resources Analysis Support System) to calculate available coal based upon various coal and overburden thickness categories. These various elements will be further explained in the methods portion of this paper (Appendix C).

The Hackett quadrangle was chosen for study because the authors felt it typified the mining history of southwestern Pennsylvania—a mature mining region where only one seam is predominantly mined (i.e., Pittsburgh coal). The Saxonburg quadrangle on the other hand was chosen because it incorporated a different part of the geologic section, and any one particular seam does not dominate mining. The Saxonburg quadrangle turned out to be similar to another Coal Availability Study quadrangle (i.e., Clymer quadrangle, currently in review) in regard to stratigraphic complexity, requiring an additional amount of time to verify coal-bed names in the database. Data points were also comparatively fewer in number.

The study area incorporates coal stratigraphic point data from nine quadrangles—the Saxonburg quadrangle, and approximately 3 miles into the eight surrounding/adjacent quadrangles—in an effort to minimize quadrangle "edge effects" which may occur when isopaching coal-bed thickness and deriving coal-bed structure maps. Final resources are calculated, however, only from those line and point data (i.e., data points, mined-out areas, coal crop lines, restrictions to mining, etc.) that are only relevant to the study quadrangle.

Overall goals of the Coal Availability grant for Pennsylvania include the following:

1. Develop an operational Internet connection at the Pennsylvania Geological Survey that would link it to the federally maintained National Coal Resource Data System located in Reston, Va.
2. The choice of quadrangles for study that is representative of the bituminous coal measures of Pennsylvania and for which data exist.
3. Determine the original, mined-out, and remaining coal for 7.5-minute-quadrangle-sized study areas.
4. 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.
5. 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 Saxonburg study, providing estimates of the original, mined-out, remaining, restricted, and available resources only. The economics of mining the coal is not within the scope of this study, but rather it is to be part of a follow-up study by members of the former U.S. Bureau of Mines, Denver, Colo., who are currently located at the USGS in Reston, Va. This economics study is known as Coal Recoverability. Factors such as coal chemistry, amount of interburden between seams, number and nature of the partings in the coal, and coal block size are considered in that study.

LOCATION

The Saxonburg quadrangle is located in southeastern Butler County (Figure 1), in west-central Pennsylvania, approximately 20 miles northeast of the city of Pittsburgh, about 30 miles east of Beaver Creek, and about 15 miles west of the Allegheny River. Drainage (Figure 2) via Little Buffalo Creek, Little Buffalo Run, Sarver Run, and Rough Run is generally towards the east-southeast into the Allegheny River. A drainage divide in the north central part of the quadrangle bends into the southwestern part of the quadrangle and directs Patterson Run, Coal Run, Thorn Creek, and Bonnie Brook and their tributaries some distance westward into the southwestward flowing Slippery Rock Creek. The Borough of Saxonburg is located at the south-central border of the quadrangle, and the Borough of East Butler is located along the border in

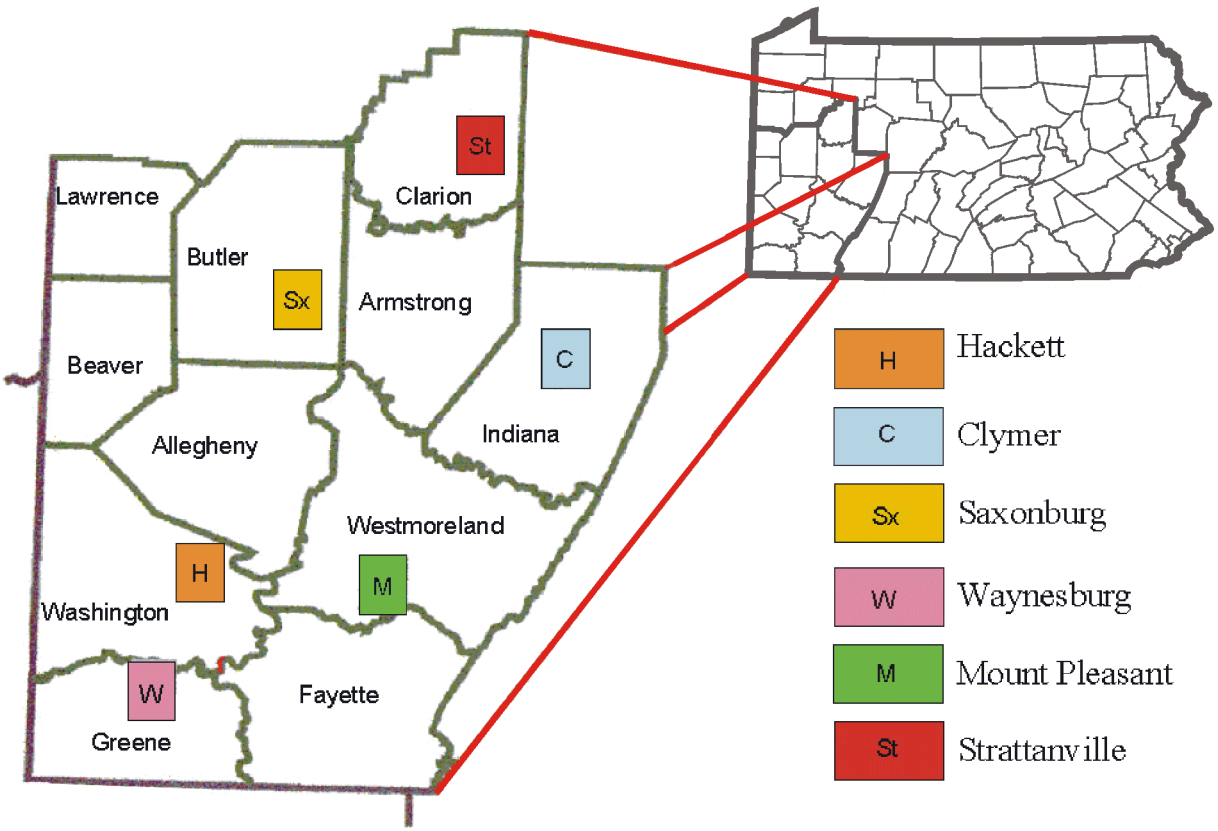

Figure 1. Location map of the Saxonburg 7.5-minute quadrangle in relation to the other study quadrangles for Pennsylvania.

the northwest corner of the quadrangle. Other smaller villages are located in the northern part of the quadrangle, mainly along Bonnie Brook and Coal Run, and in the southern part of the quadrangle along Little Buffalo and Thorn Creeks (Figure 2). U. S. (Divided) Highway 422 traverses east-west across the northern part of the study area. State Route 356 runs northwest to southeast through almost the center of the quadrangle, whereas State Route 2002 (i.e., Vogleyville highway), another main artery, begins heading southeastward but turns eastward at Brinkley and continues across the quadrangle (see Figure 2). Additionally, a number of county and township roads also transect the study area in a general northwest-southeast direction.

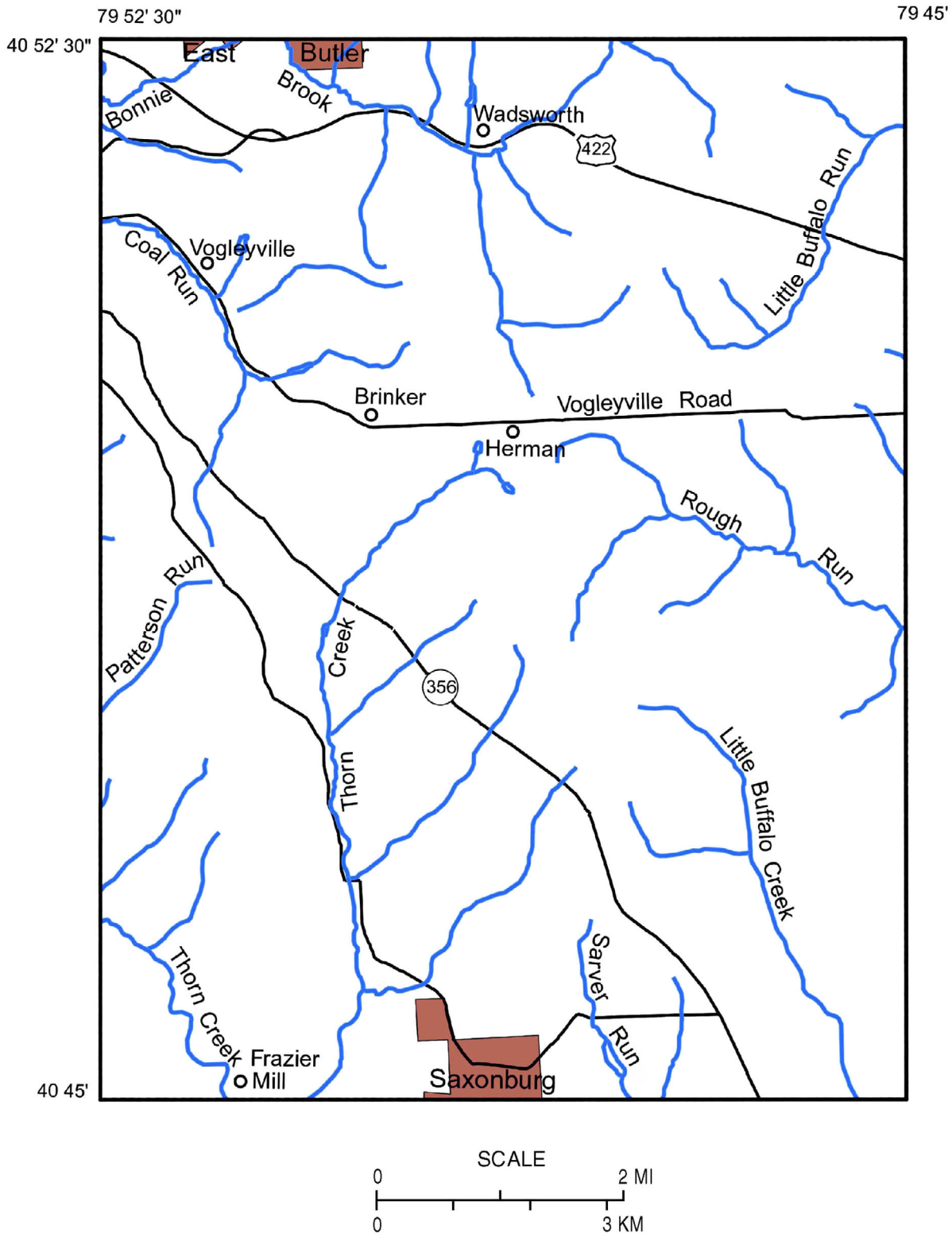

Figure 2. Locations of selected roads, streams, and population centers in the Saxonburg quadrangle.

GEOLOGY

PHYSIOGRAPHY

The Saxonburg quadrangle lies within the Appalachian Plateaus physiographic province, Pittsburgh Low Plateau section. This province is moderately dissected with relatively low rolling hills and narrow valleys. Maximum topographic relief within the study quadrangle is about 340 feet in the vicinity of the communications tower located about a mile southeast of Wadsworth. The average relief of the quadrangle, though, is about 200 feet. Relief tends to increase from south to north. Average surface elevation in the quadrangle is about 1300 feet above sea level.

STRUCTURE

Although the strata in the Pittsburgh Low Plateau are typically flat lying, the Plateau can be found to have a number of asymmetrical, gently to moderately folded rock layers formed into broad anticlines and synclines. Three such folds pass through this study quadrangle (Dodge, 1985). They are the Kellersburg Anticline, the Bradys Bend Syncline, and the Millerstown Anticline counting from southeast to northwest across the map, respectively (Figure 3). These structural features strike northeast-southwest with a southwestwardly plunge. Regional dip is low and to the south. The amount of dip of the beds, locally, is low and fairly uniform, except for the slight increase in the gradient in the northwest limb of the Kellersburg Anticline in the southern part of the quadrangle, and also where a cross-strike flexure offsets or "bends" the Bradys Bend Syncline into a broad S-shape in the center of the quadrangle east-southeast of Herman. Coincident with this bend or offset in the syncline is a change in the plunge direction. The plunge of the Bradys Bend synclinal axis is to the southwest for most of its length; however, at the southwestern end of this bend in its axis, the plunge direction shifts to the northeast. This reverse in plunge orientation continues for a short distance to the northeastern end of the "S"-bend, where the plunge direction reverses to its prevailing southwestward direction, in effect creating a local structural depression along the synclinal axis at this location. Another possible expression of one of these cross-strike flexures is found in the southwest corner of the quadrangle, where the strike of the Bradys Bend Syncline has been subtly redirected to a more southerly direction. Thorn Creek seems to provide a surface expression of this structure, too.

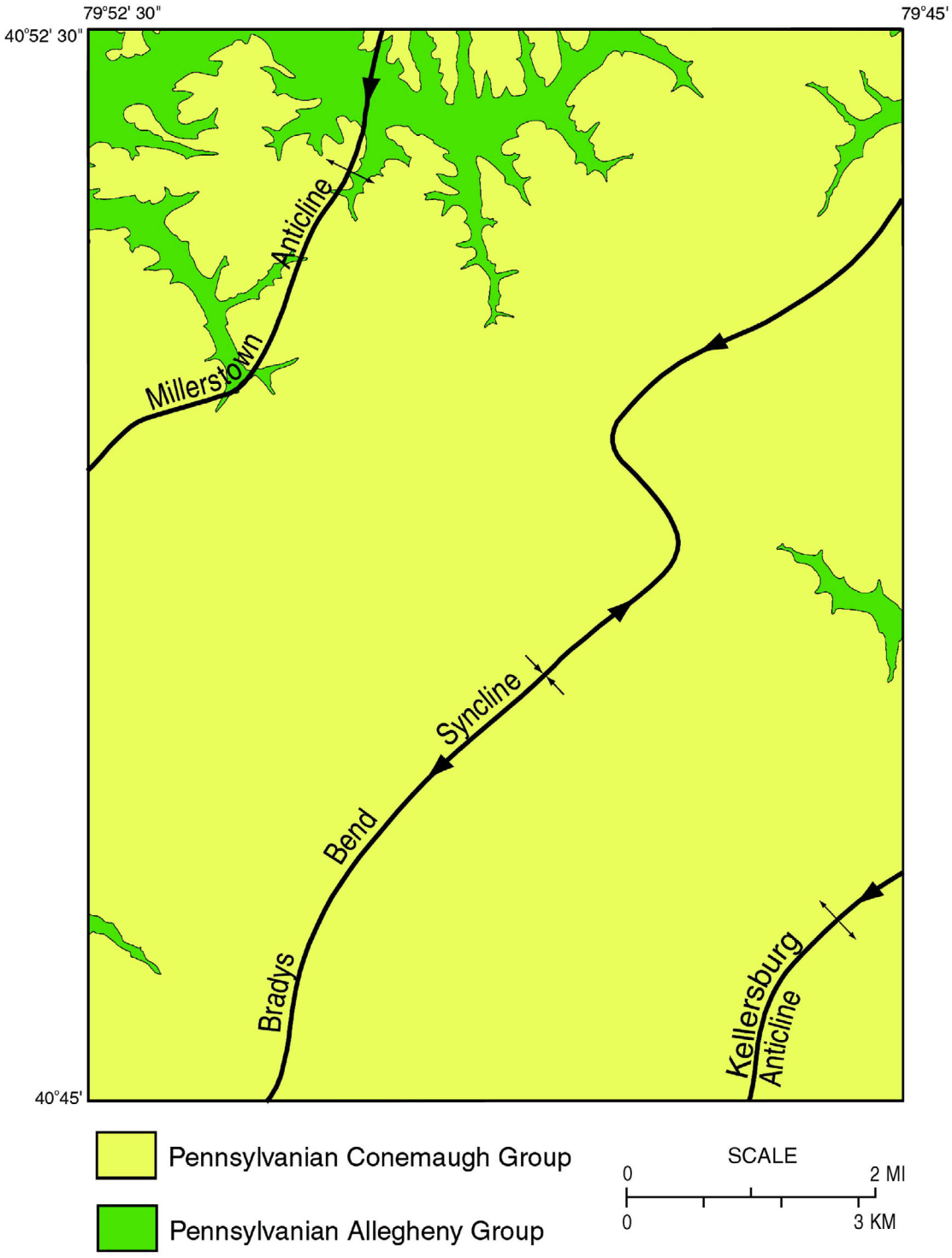

Figure 3. Simplified geologic map of the Saxonburg quadrangle (derived from Dodge, 1985).

Thorn Creek flows southwardly from its origin in the center of the quadrangle near the community of Herman. However, in the southwestern corner of the quadrangle, about a half-mile east of Frazier Mill, Thorn Creek takes a turn more towards the west. At the west side of Frazier Mill this same creek makes another turn, this time north, and it broadens as well. At about a quarter mile north of Frazier Mill, Thorn Creek turns toward the northwest and continues to flow in a northwesterly direction out of the quadrangle. The resultant U-shaped path roughly coincides with the slight southwardly offset created in the Bradys Bend Syncline and the nose of the unnamed antiform (a distinctly different feature than just a lobe of the Millerstown anticline). This antiform appears to also generally coincide with a southwestern extension of themajor drainage divide, which is found in the northern part of the quadrangle. Overall, the structure does not seem to greatly modify the general dendritic drainage pattern established in this region.

DEPOSITIONAL SETTING

The study area includes rocks of the Pennsylvanian System, composed of the Conemaugh Group, and the Allegheny and Pottsville Formations. These strata are comprised typically of shale, limestone, claystone, sandstone, and coal in varying ratios. In general, the Pottsville and Allegheny Formations tend to have a higher percentage of coarse clastic sediments compared to the Conemaugh Group. The stratigraphic interval penetrated by drill core or that outcrops in the quadrangle includes strata from about the Conemaugh Upper Bakerstown coal, at or near the surface, down to the Pottsville Sharon coal in the deep subsurface near the base of the Pennsylvanian (Figure 4).

Pottsville Group sediments occur at depths of 600 feet or more. Little is known of the thickness and lateral continuity of the coals found this deep in the subsurface. However, a few deep cores drilled in the study area did encounter coal beds in the Pottsville Group that were locally thick and perhaps correlative to both the Mercer coal complex and the Sharon coal. Pottsville peat swamps in this area probably formed near a high-energy fluvial environment, perhaps in close proximity to the coastline because these swamps were often terminated by a brackish-marine or marine transgression. Recognizing that brackish-marine to marine sediments may be associated with Pottsville coals should make correlation of these deep coal beds easier over wide areas. The association of brackish and marine zones with the peat suggests coal

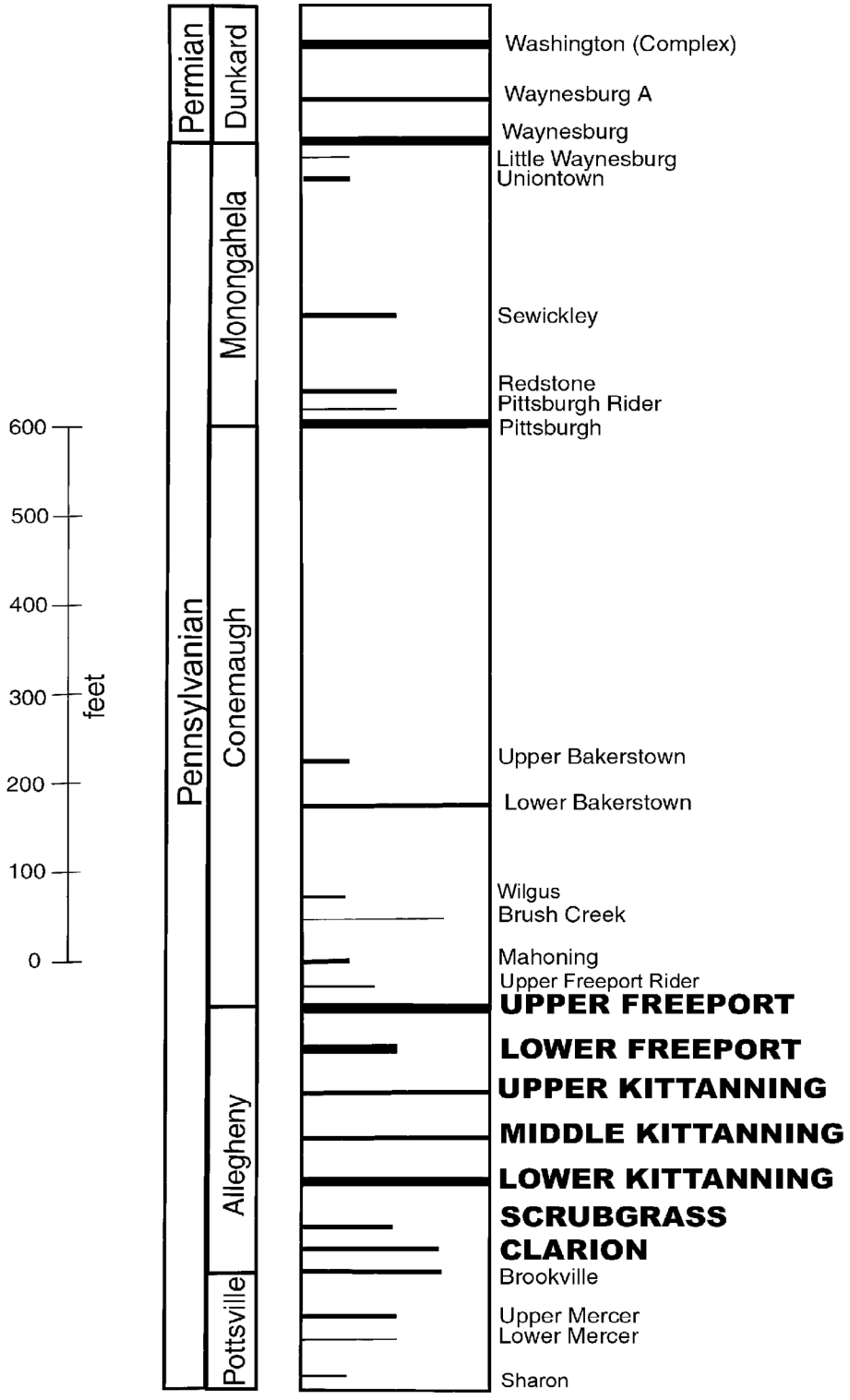

Figure 4. Generalized columnar section showing the main coals of this report (bold uppercase). The stratigraphic interval in the Saxonburg quadrangle includes Upper Bakerstown to Sharon coals.

chemistry would be of higher ash and higher sulfur than those coals in this part of the section that are associated with clastic sediments (i.e., Sharon or Brookville coal beds).

Those characteristics, of sand-filled stream channels crossing a coastal plain, and marine transgressions that sometimes terminate peat development, continue into the Allegheny Formation. An exception to this may be the Scrubgrass coal bed. Instead of developing in a fluvial setting, the Scrubgrass peat swamp probably formed in a lagoonal setting at or near mean sea level, where such proximity to the ocean could result in the peat's inundation by a major marine transgression (i.e., Vanport marine zone). The Vanport marine zone is a rather thick and laterally continuous, highly fossiliferous, limestone and shale deposit, which suggests that a prolonged period of open marine conditions remained in this area. This transgression introduced sulfate-bearing marine waters in to the Scrubgrass peat swamp resulting in iron sulfide being precipitated out in the peat; the coal formed from this peat is typically high in sulfur content. Less important marine transgressions occurred after the Vanport marine event and are associated with termination of the Lower Kittanning and Middle Kittanning peat swamps. They are often defined by a thin, brackish to shallow-marine shale deposit. The Middle Kittanning event is the last transgression to occur in the Allegheny Group. After this event a significant change in depositional environment occurred; marine limestones and shales disappear and freshwater limestones and shales become common and persist into the early Conemaugh, until Brush Creek time. Also evident is a shift from small sand channel complexes to large, stacked sand channel systems, which triggered a corresponding change in peat geometry from relatively thick, laterally persistent peat swamps to laterally discontinuous and, in places, very thick peat swamps.

The transformation to a freshwater environment suggests that a rapid build up of an alluvial plain, or a major regression of the sea occurred across the area. The first indication of this change is seen around Upper Kittanning time with the formation of freshwater limestone or shale. Although not of widespread occurrence in the study area, a freshwater limestone or shale is occasionally found underlying the Upper Kittanning coal bed. Another indication of a change in deposition is peat geometry. Coal is thickest only in isolated, discontinuous pod-shaped bodies. The discontinuous nature of the limestone and coal suggests that perhaps the water table was initially low at this time in this area, either due to a decrease in rainfall or to a local decrease in mean base level. Another sign that the water table may have been initially low in this area is that often an underclay rather than coal is found associated with the Upper Kittanning coal

horizon. This underclay is sometimes limey or sandy in nature, a reflection of the previous sedimentary regime.

With the passage of time the water table level rose, perhaps due to an increase in the annual rainfall rate, because the relative amount of freshwater limestone to shale or sandstone increased with each subsequent peat-forming episode, so that by Upper Freeport time large freshwater lakes existed over rather large areas. To further substantiate that a slow rise in the water table might have occurred in this area for this period of time, examine peat formation. Production of thickest peat occurred over ever-larger areas in the Upper Kittanning to Upper Freeport time interval, and culminated with the greatest peat swamp being formed during Upper Freeport time.

The Upper Freeport coal bed, which denotes the top of the Allegheny Group, is the most widespread and thickest of all the coals in the study interval. It is usually underlain by freshwater limestone of varying thickness. The rather limited extent and pod-like geometry of thickest coal and its association with limestone suggests that the coal-forming peat probably grew as domed peat islands within a lake-dominated, distal alluvial to coastal plain environment. Freshwater limestones also sometimes underlie the Lower Freeport and Upper Kittanning coal beds, and because of this association it is assumed that they, too, were probably formed in an environment similar to the Upper Freeport coal bed. In a domed, peat island depositional setting one would expect low to moderate ash and low sulfur associated with the peat (Neuzil and Cecil, 1984; Cecil, et al, 1985). These three coals generally reflect that expectation, with the Upper Freeport coal having the lowest average sulfur content of the three.

Clastic material (silt and sand) continued to be brought into the area by a few rivers and streams. Forming channel bar deposits during relatively quiet times, and overbank and crevasse splay deposits during flood events, these clastics often killed off existing peat swamps or filled in low areas associated with lakes. From the middle to upper Allegheny, the amount of clastic material input decreased overall.

In the Pottsville, the lower to middle Allegheny, and most of the Conemaugh Group the coal-bearing rocks generally lack the freshwater limestone and shales found in the upper Allegheny. Instead, they are dominated by a greater percentage of sandstone, siltstone, and shale, along with an increasing frequency of marine deposits. At least three major episodes of

clastic deposition appear to have occurred and perhaps represent a time of maximum marine regression. Channel complexes filled with sand and silt covered relatively large areas and lasted for significant intervals of time; some even formed stacked sequences of thick sandstone. The oldest channeling began upon termination of the Middle Kittanning peat swamp. This channel fill event continued to nearly Upper Kittanning time at which point depositional conditions became quieter and muds and lime settled out in abandoned channels and in interfluves, and peat swamps once again began to become established. The next (younger) episode of major channel development is associated with termination of the Upper Freeport peat swamp at the end of the Allegheny. In some areas the Upper Freeport swamp was terminated by the return of freshwater lakes (high water table?) drowning out the peat, while in other locations sand-filled channels buried the peat swamp in clastics. Some of the channel complexes became entrenched for an extended period of time, over relatively small areas, forming a series of stacked sandstone-filled channels. This basal Conemaugh event in some places persisted until Brush Creek time, while in other places it continued uninterrupted to Wilgus time. A third, relatively short-lived, very high energy channel complex formed about the time of Brush Creek peat swamp formation, and is marked by the presence of channel-bottom lag deposits of shale, siderite, and quartz pebbles. This event persisted through Wilgus time. In certain locations, this third episode of channeling has merged with the earlier basal Conemaugh event and may just reflect a continuation of that earlier channel system, whereas in other areas of the quadrangle this is probably an entirely new event.

Where these lower Conemaugh channels were not so persistent, peat swamps readily formed upon termination of the sand deposition and encroached across the region. But where these channels remained persistent, the peat swamps could only develop within the interfluvial areas. The Upper Freeport Rider and Mahoning coal beds appear to have been created in this way. Also within this depositional setting, freshwater lakes formed in some of the channel interfluves instead of peat, and may be indicative of a time when the water table was high enough to prevent the formation of peat. These freshwater lake limestones tend to be very thin and discontinuous. The last occurrence of freshwater limestone in this part of the lower Conemaugh Group is found underlying the lower Brush Creek coal bed or horizon. The aforementioned sedimentary characteristics probably indicate that deposition had occurred on a

lower alluvial to upper coastal plain and that peat swamp health was linked to variability in water table levels and the influx of clastics.

In several locations, the Brush Creek peat swamp was interrupted by short-lived impulses of coarser-grained clastics, thus destroying the swamp. After a short period of time, conditions were once again favorable for peat formation and a new peat swamp encroached over the clastics. This event created in many places two separate coal beds, commonly referred to as a "double" Brush Creek. In most areas two beds, or some combination of a bed and a horizon can be discerned. These beds/horizons are consistently 10-20 feet apart with sandstone as the interburden. The Brush Creek depositional process in this area also seems to represent a transitional period from which deposition changed from an alluvial dominated setting to more of a shoreline setting. The first marine transgression since Middle Kittanning time occurs at this time and it essentially terminates the Brush Creek swamp. This could not occur without a rapid lowering in base level or sea level rise. This may be further complicated by the high-energy environment recorded in the sediments (and discussed above). Because river systems remained vigorous in this area, much of the Brush Creek marine transgression is absent and appears only as a localized event in many places. With the passage of time, however, these streams began to eventually provide less sediment into the area, and subsidence soon outpaced deposition to the point that by Wilgus time, this area would experience a second, more widespread marine transgression (i.e., Pine Creek marine zone). Most of the rest of the middle Conemaugh Group is characterized by a series of continuing marine transgressive events that periodically interrupt coastal plain sedimentation and peat swamp development.

In contrast with the upper Allegheny peat swamps, Conemaugh peat swamps on average were probably planar and of more uniform thickness, were often associated with marine transgressive events, and had higher ash and sulfur contents.

COAL BEDS

The minable coal seams in the study area are shown in uppercase on Figure 4. The Mahoning and Upper Freeport Rider coal beds have been mined in the past as small country bank mines in the northern part of the quadrangle, but could not be considered for this study due to a lack of data to define the resource. The Pottsville Brookville and Mercer coal beds possibly could be mined, but again there were not enough data available to define them and calculate

meaningful resource estimates. Predefined criteria, stated in Appendix C (methodology), and as originally defined in Wood and others (1983), meant coals had to meet those objectives for which original coal can be computed (i.e., greater than 14 inches thick). These criteria exclude from the study marginal coals like the Wilgus, Brush Creek, and Strasburg because they are too thin (less than 14 inches thick). At the time of data collection in 1996, little data existed for deeper coal beds (Mercers, Sharon, etc.) in this quadrangle study area, and therefore they, too, could not be included in this report. The seven coal beds that met the basic criteria will be described starting with the deepest coal bed (Clarion) and proceeding up-section to the youngest (Upper Freeport).

Clarion Coal Bed

The Clarion (also known as Clarion no.2 or Lower Clarion) coal bed, elsewhere primarily used as steam coal in the electricity-generating industries, underlies nearly the entire quadrangle and is shown on Figure 5. The thickest coal is found in the eastern portion of the quadrangle where it averages 28-33 inches thick. This coal continues to thicken northeast of the Saxonburg quadrangle to locally 4 feet thick. This coal thins towards the west in the quadrangle to the point of being non-existent in places in the southwestern part of the quadrangle. This coal may contain several relatively thick partings of shale or fireclay, or contain coal with bony streaks, which may be removed during post-mining washing at the preparation plant. Occasionally, very thin fusain partings may also occur. Depth of cover for the Clarion coal bed varies from less than 200 feet in the northern and northeastern part of the quadrangle to over 590 feet in the west central and extreme south-central part of the quadrangle.

Scrubgrass Coal Bed

The Scrubgrass coal bed, occurring 30-40 feet above the Clarion coal bed, covers the entire quadrangle, but on average is the thinnest coal bed of the ones studied (Figure 6). Data suggest that it gets thicker, but contains more bone to the northeast of this quadrangle, and is thinner and of better quality to the south and southwest of the study quadrangle. Thickest coal is in pods oriented northwest-southeast through the quadrangle, reaching nearly 20 inches in thickness. There are large areas where the coal is less than 14 inches thick. It is entirely missing in a few areas in the southwestern part of the quadrangle. This coal bed may contain numerous

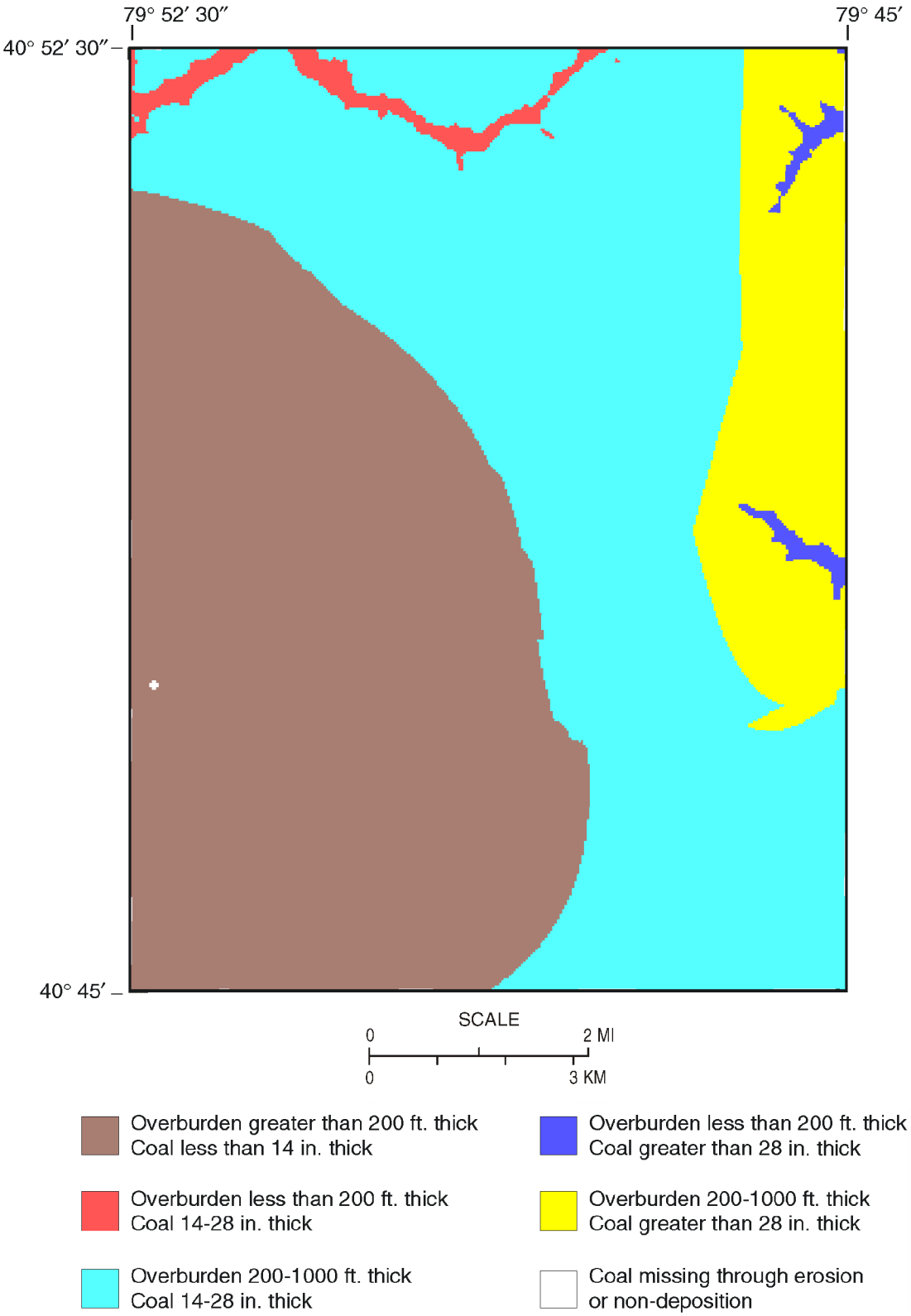

Figure 5. Outcrop extent, amount of overburden, and coal thickness for the Clarion coal bed.

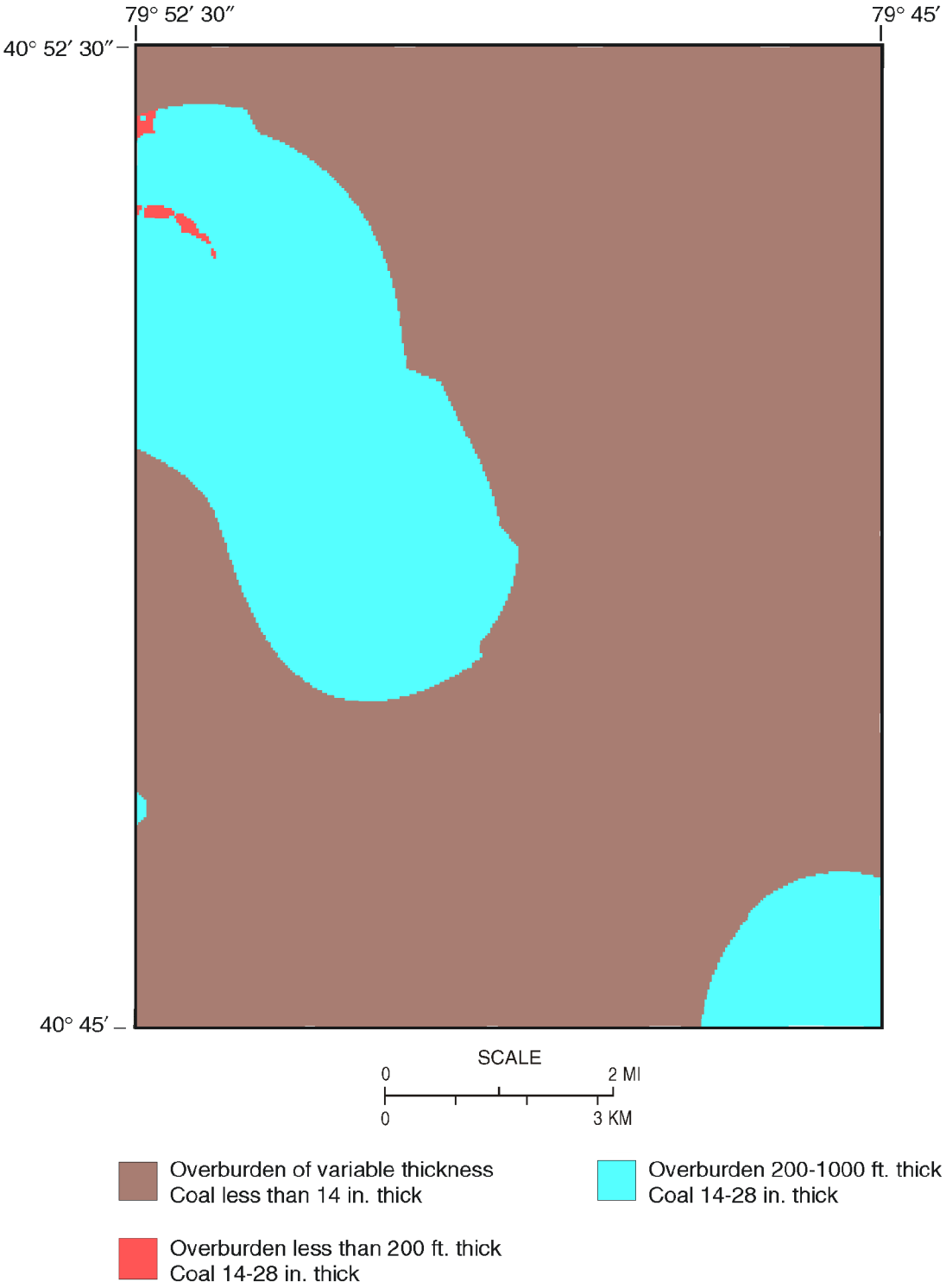

Figure 6. Outcrop extent, amount of overburden, and coal thickness for the Scrubgrass coal bed.

partings or laminations, especially in the upper part of the seam. They are usually very thin bony streaks in coal, or a couple of inches of bone with coal. Due to the thin nature of the coal and the amount of overburden present in the study area, removal of these partings or laminations from the coal is not likely to be economical. Depth of cover ranges from less than 200 feet in the northern and northeastern part of the quadrangle to 550 feet in the west-central part of the quadrangle.

Lower Kittanning Coal Bed

The Lower Kittanning coal bed underlies the entire quadrangle, being absent in only a couple of places in the southwestern part of the quadrangle (Figure 7). Total coal thickness ranges from a couple of inches to almost 51 inches of coal. At one location where total coal was 51 inches thick, the actual total coal seam thickness was 168 inches thick due to the aggregation of numerous thick partings/interbeds that had split the bed. There are other less extreme situations like this in the study area where partings tended to thicken the overall coal seam thickness to perhaps twice the total coal. Thickest coal, up to 51 inches thick, occurs in the northwestern corner of the quadrangle, and then abruptly thins in the south-central part of the quadrangle to less than 24 inches thick. From this point southward and southwestward, the coal bed continues to gradually thin. A smaller 32-inch thick pod of coal extends eastward from the main thick coal body. A leader and rider coal may also be associated with the Lower Kittanning coal, but they never attain minable thickness in the study area. The coal is of medium to high ash and of medium sulfur content due to partings. Commonly there are a number of thin shale, fireclay or claystone, and bone partings in the coal. The coal itself may contain pyrite and bone layers or bone streaks. Thickest partings and interbeds can probably be selectively removed during mining, while most other thin partings can be removed during washing at the preparation plant. This should improve the ash and sulfur content of the coal. Depth of cover ranges from less than 60 feet (in valley at northern edge of quad) to about 540 feet in the center of the quadrangle.

Middle Kittanning Coal Bed

The Middle Kittanning coal bed can be found outcropping in the valleys in the northern and northwestern part of the quadrangle (Figure 8). Thickest coal is found in a band running

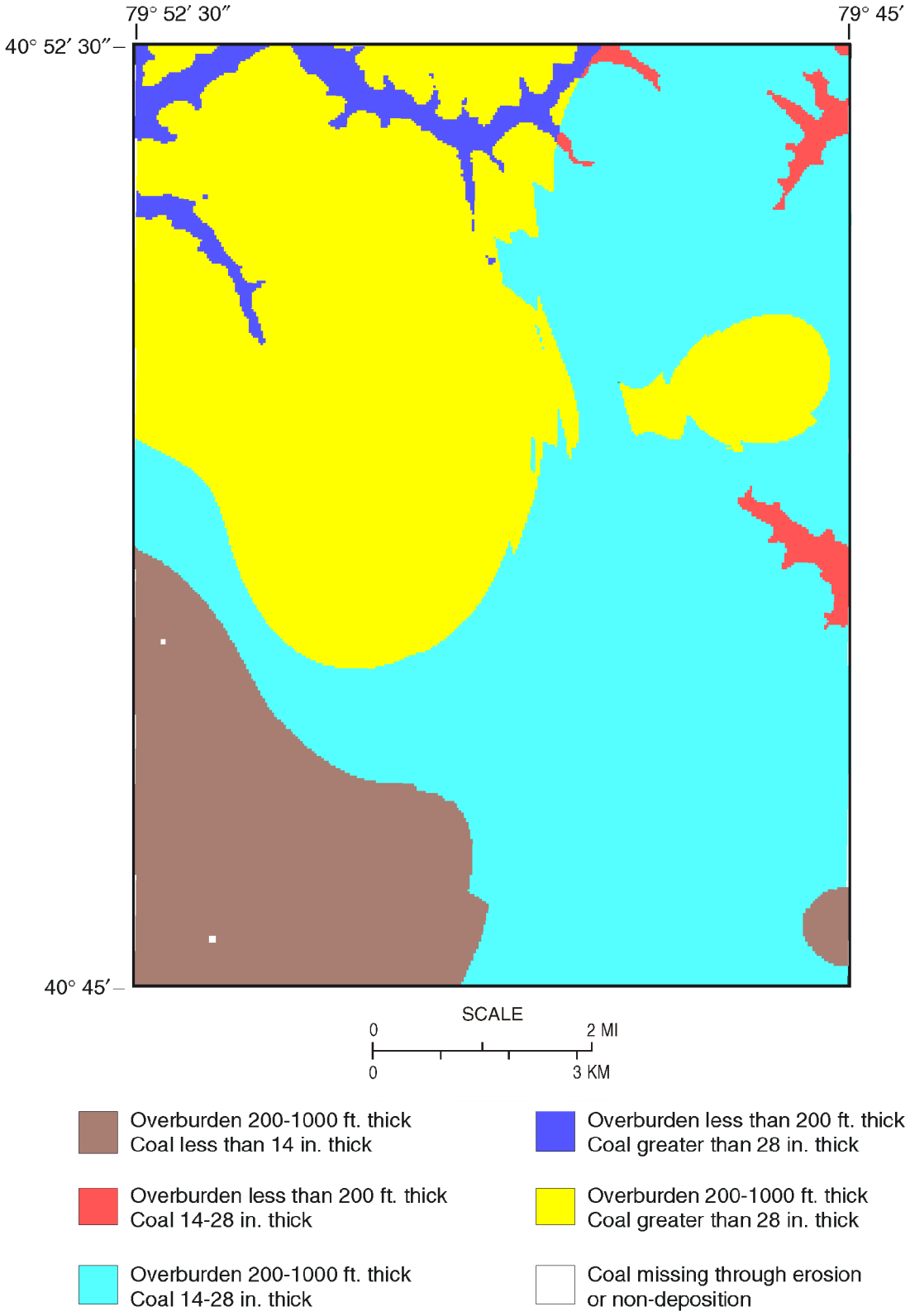

Figure 7. Outcrop extent, amount of overburden, and coal thickness for the Lower Kittanning coal bed.

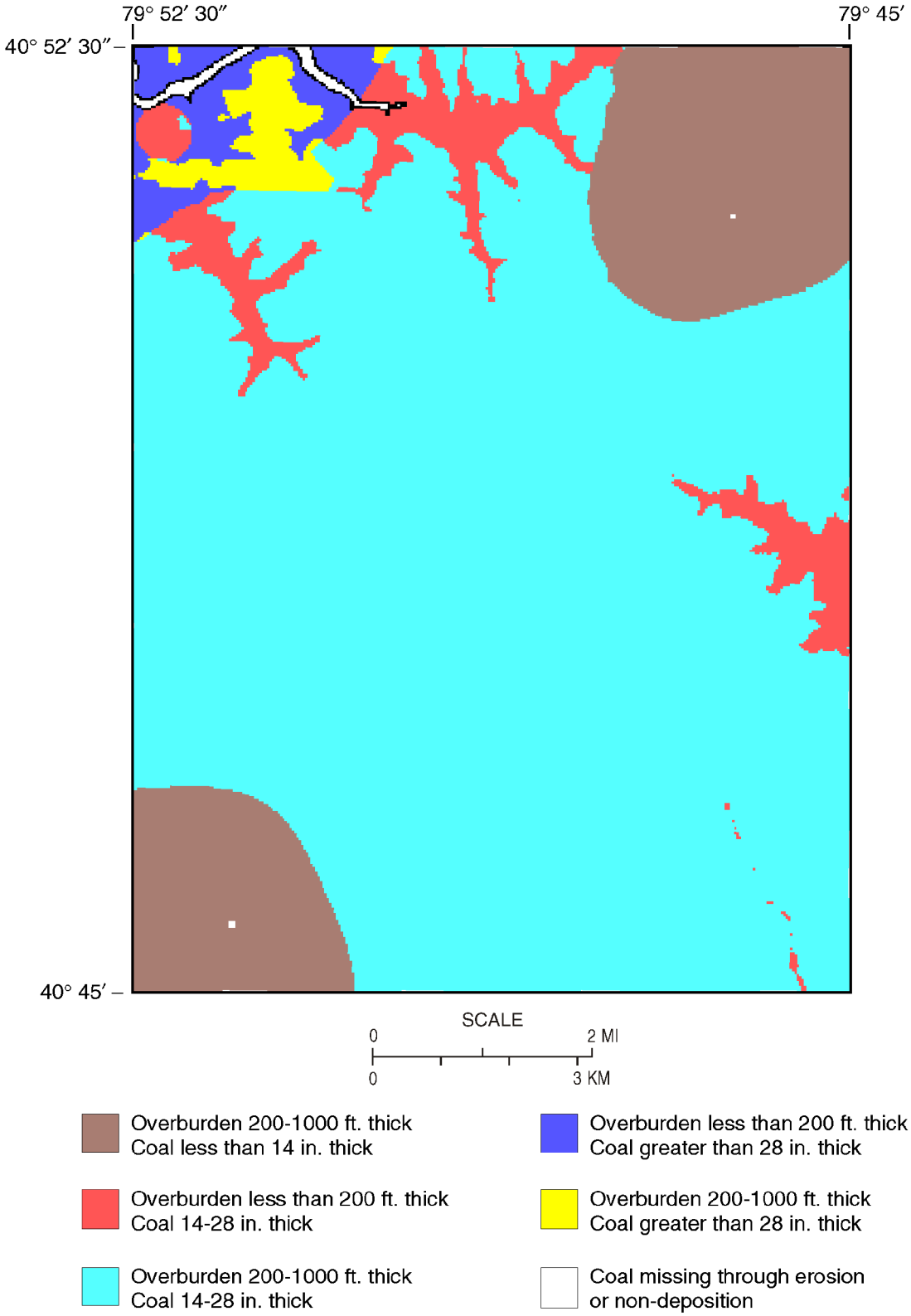

Figure 8. Outcrop extent, amount of overburden, and coal thickness for the Middle Kittanning coal bed.

northwest to southeast through the study quadrangle. It ranges in thickness from a zero (missing due to non-deposition or erosion) inches thick in the southwestern corner of the quadrangle and a few inches thick in the northeastern corner of the quadrangle to nearly 31 inches thick in the northwestern corner of the quadrangle. Isolated locations in the center of the Saxonburg quadrangle have coal of about 25 inches thick, which consists of few or no partings. In adjacent Butler and East Butler quadrangles the coal bed approaches 45 inches thick. For approximately half of the quadrangle the Middle Kittanning coal bed averages about 20-24 inches thick. It is commonly comprised of two distinct benches separated by a 1-2 inch thick shale or bony coal parting, or an occasional pyrite band. The upper bench is the thinner of the two benches averaging about 6-9 inches thick. The bottom bench is generally 20-24 inches thick. Because the partings are thin in this coal bed, it may be possible to remove them during washing at the preparation plant, if determined to be economically practical to do so. Depth of cover ranges from 0 feet (at outcrop) to about 480 feet in the south-central part of the quadrangle.

Upper Kittanning Coal Bed

The Upper Kittanning coal bed, occurring on average about 50 feet above the Middle Kittanning coal bed, ranges in thickness from 0 inches (i.e., missing in a few isolated places) to as much as 26 inches in the southwestern part of the quadrangle (Figure 9). In many places it has been cut out by sandstone channels. This coal bed contains numerous bone, shale, and claystone partings that can vary greatly in thickness to the point of becoming an interbed within the coal. For example, at one location the total seam height is about 60 inches thick, but the amount of coal within it is only about 22 inches thick. The Upper Kittanning coal outcrops in the Bonnie Brook river valley in the vicinity of East Butler borough (see Figure 2). Depth of cover varies from 0 feet (at outcrop) to about 420 feet in the center of the quadrangle.

Lower Freeport Coal Bed

The Lower Freeport coal bed is of highly variable thickness and occurs throughout the study quadrangle (Figure 10). It outcrops in the valleys of the northern and east-central part of the quadrangle. Total seam height varies from 0 in the northwestern part of the quadrangle, due to sandstone cutouts or non-deposition, to 37.5 inches thick in the north-central part of the quadrangle. Removing the numerous thin partings in the coal bed yields a lower total coal

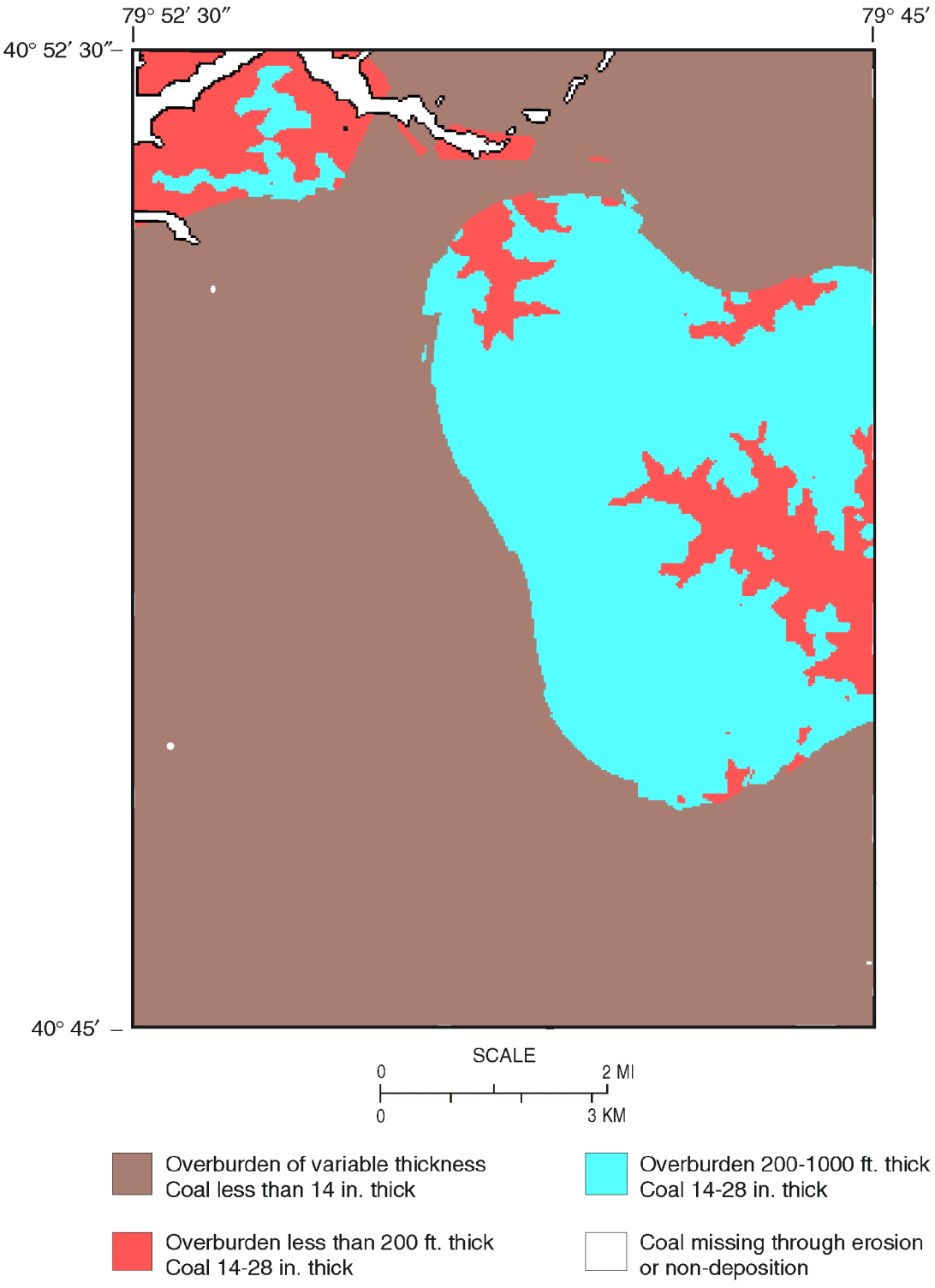

Figure 9. Outcrop extent, amount of overburden, and coal thickness for the Upper Kittanning coal bed.

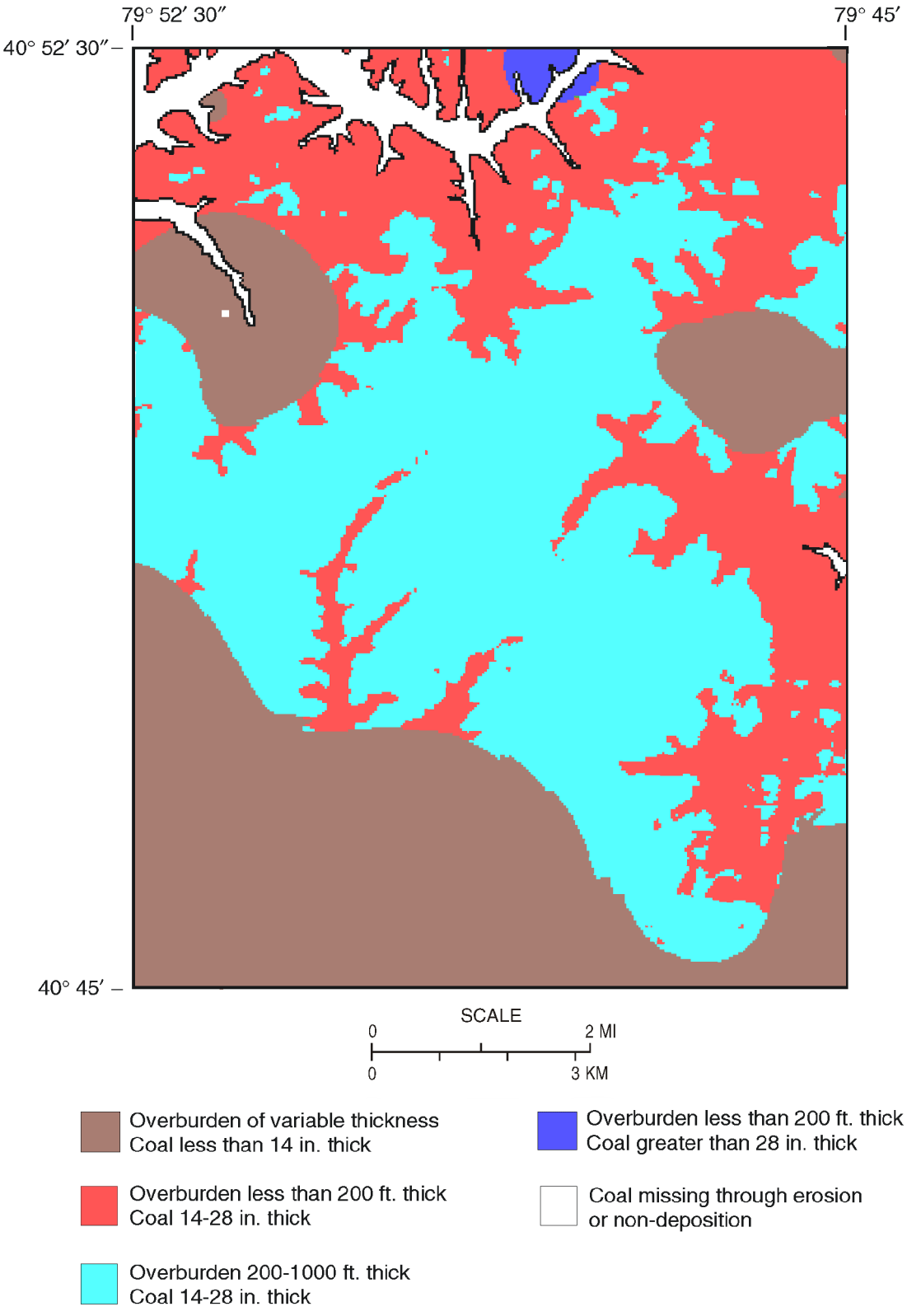

Figure 10. Outcrop extent, amount of overburden, and coal thickness for the Lower Freeport coal bed.

thickness at certain locations. For example at one location, an 18-inch total seam thickness becomes an 11-inch thick coal once the partings are taken out. Partings are highly variable in number are composed of varying lithologies, such as clay, shale, and claystone, and are of variable thickness, ranging from less than an inch thick to many feet thick. One particularly persistent claystone parting occurs within the middle of the coal in the northeastern part of the quadrangle and thickens to nearly 6 feet thick to the north and northeast of the Saxonburg quadrangle. Associated with this claystone parting is two benches of coal, one above it and one below it that is each 1-2 foot thick and occur wherever the claystone is present. Depth of overburden varies from 0 feet thick (at outcrop) to about 380 feet thick in the north central portion of the quadrangle.

Upper Freeport Coal Bed

The Upper Freeport coal bed outcrops in many valley locations in the study area, namely, Bonnie Brook, Little Buffalo Run, Rough Run, Thorn Creek, and Coal Run. The Upper Freeport coal bed varies in coal thickness from 0 inches in the southeastern and northeastern part of the quadrangle to about 50 inches thick, also in the northeastern part of the quadrangle (Figure 11). Include partings and total seam height reaches about 60 inches thick. The area of consistently thickest coal is found in the southern part of the quadrangle. Often the thickest coal is found near areas of no coal. Such great lateral variability in peat thickness perhaps owes itself to the origin of the pod-like nature of the coal, which in turn was due to the location of numerous river channels on the alluvial plain. These channels either cut out or thinned the existing peat swamp in selected locations, creating a juxtaposition of very thick peat to the channels. The distance between thick coal and no coal is sometimes just a few hundred feet. In most areas, though, thickest peat formed within channel interfluves. Partings in the coal are numerous, but rather predictable. On average, partings in the coal account for about 10-12 inches of the total seam height. These partings consist of claystone, bone, and shale, which are generally a quarter of an inch to a few inches thick. Occasionally, they may be up to 3-6 inches thick. The physical appearance of the Upper Freeport coal is distinctive. Often, most of the partings are associated with the upper one-fourth of the seam's thickness, in which thin partings are interbedded with relatively thick coal. A relatively clean, 2-4 foot thick lower bench of coal directly underlies this bench. In general mining practice, a parting-rich top bench of coal is commonly left behind

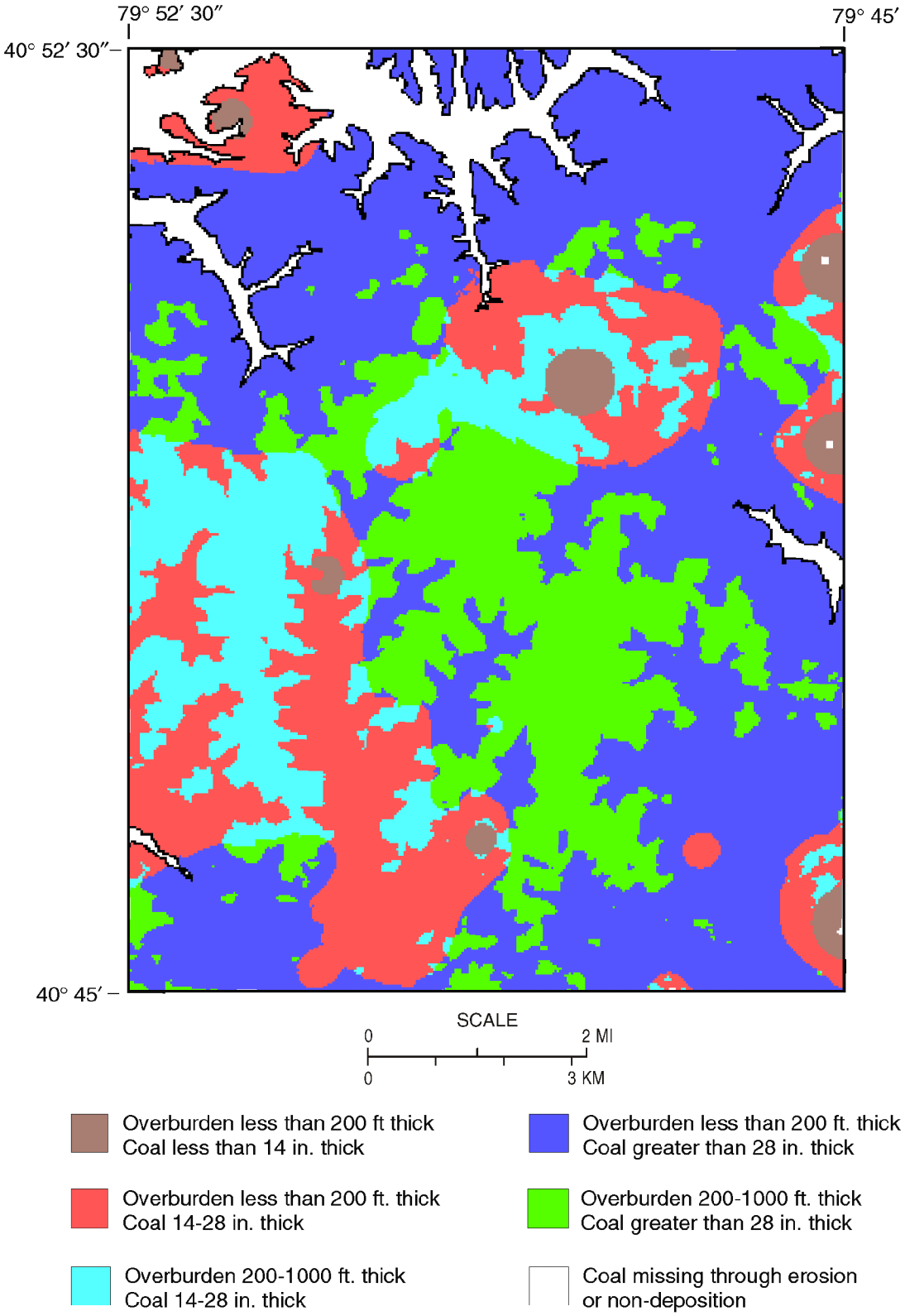

Figure 11. Outcrop extent, amount of overburden, and coal thickness for the Upper Freeport coal bed.

during mining (bolted to roof). However, not enough information is available to determine if that practice was used in this study area when mining the Upper Freeport. In those areas where the percentage of coal to partings was high in the upper bench, it may have been mined and most of the partings removed by washing, leaving a low to moderate ash and low sulfur coal. Due to the variability of partings in the coal bed, the removal of partings from the calculation of remaining and available coal should not significantly affect the resource estimate for this seam. Further analysis of this affect would be considered by the follow-up Coal Recoverability Study undertaken by personnel of the former U.S. Bureau of Mines. Depth of overburden ranges from 0 feet (at outcrop) in the northern part of the quadrangle to about 330 feet thick in the north central part of the quadrangle.

MINING HISTORY

The Upper Freeport coal bed is the most extensively mined of the mined seams in the study area. Mining of some type probably has taken place in the study area since the early 1900s, based upon examination of old maps and reports from that era, with more extensive mining occurring after the 1940s. Underground mining had begun in this area, as drift mines driven from outcrop, in the 1930s along Coal Run northwest of the community of Brinker. Earliest surface mining on the Upper Freeport coal appears to have begun as small surface operations, that removed coal at outcrop along the south side of Bonnie Brook in the vicinity of the village of Wadsworth, and perhaps also along Coal Run near Vogleyville (Figures 2 and 12). These first operations were of limited extent due to the small size of earth moving equipment used at that time. With the advent of larger excavating machinery in the late 1950s, the old deep mines along Coal Run could be daylighted—the practice of surface mining along crop back into the hillside, removing the old coal pillars left behind in the old underground-mined areas. Eventually the amount of overburden encountered would prove cost prohibitive to further surface mining and mining was abandoned. In those areas along the outcrop or a highwall that were absent of these old underground drift mines, auger-mining methods were utilized to provide additional coal extraction. One place this occurred was along Rough Run near the community of Herman. Probably initiated during the early 1960s, additional surface mines and deep mines opened along Bonnie Brook, Coal Run, and Little Buffalo Run. Other surface mines opened along Thorn Creek and Rough Run at this time. More recently, mining activity has focused on

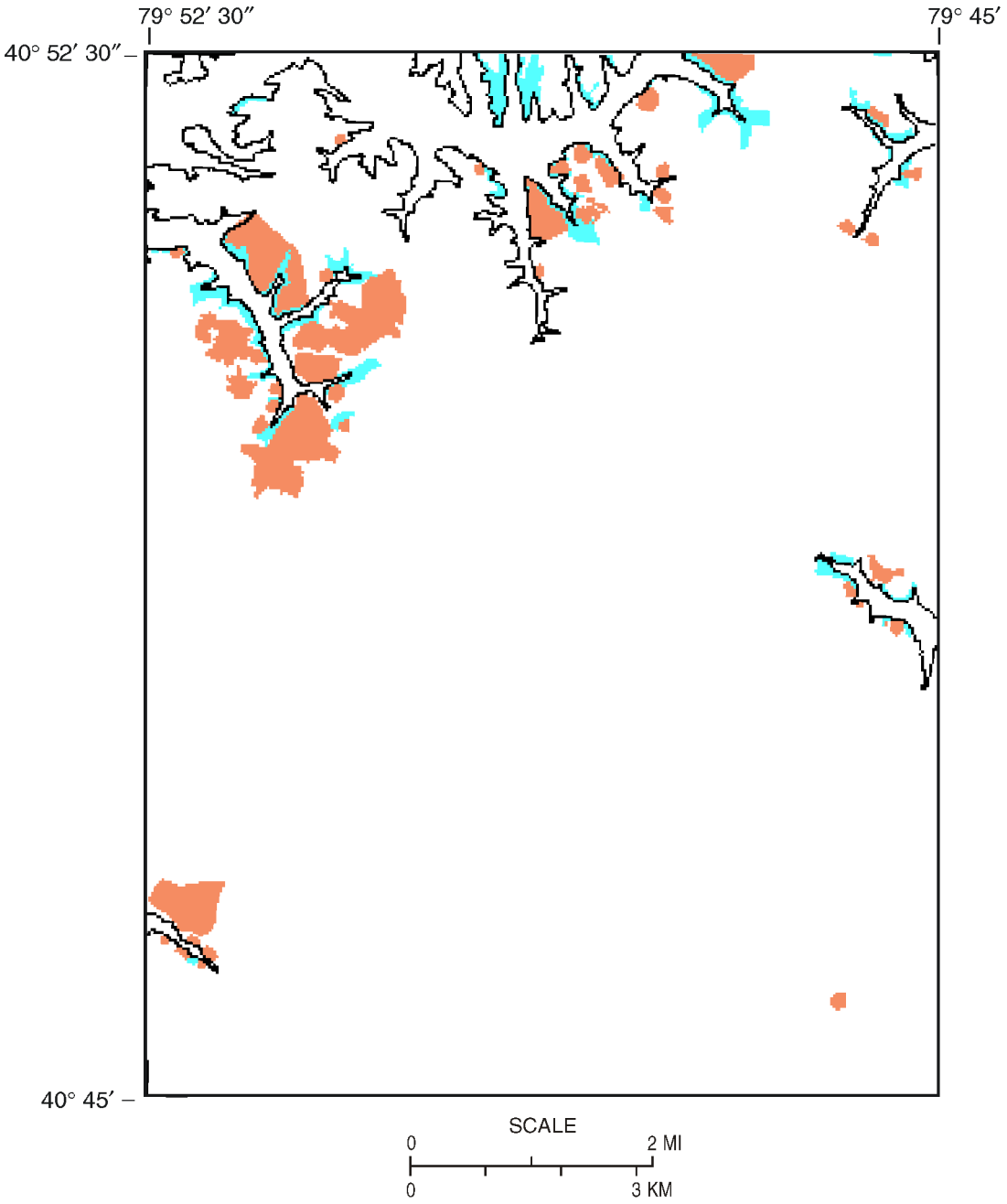

Figure 12. Upper Freeport coal outcrop location (black) with surface-mined-out (blue) and underground-mined-out (orange) areas.

the north side of Bonnie Brook, where a number of large surface mines daylighted older deep mines during the 1970s and 1980s. They have since been reclaimed. A shaft was sunk for a small deep mine in the community of Cabot in the southeastern corner of the quadrangle, as well as a series of small drift-mines and one large drift-mine that opened along Thorn Creek about a mile northwest of Frazier Mill. Because most of the deep mines in this area are drift-type mines, underground mining was often conducted with less than 200 feet of cover. With today's mining methods and extraction philosophy, such shallow coals might have been candidates for surface mining instead. This is important to know, for in the resource tonnage tables given in the appendices of this report, this low-cover coal is classified in the surface-minable coal category, even though it was deep mined in the past. The total amount of coal extracted for the quadrangle is accurate; it just might not be classed correctly that is all. The preferred underground-mining method was the room-and-pillar method. The primary surface-mining method was contour mining, which included a form of mountaintop removal in more recent times. Additionally, some areas along crop and some surface-mine highwalls apparently were auger mined, based on mine records. Total extent of mining is shown on Figure 12.

To a lesser extent, mining has also been conducted on the Lower Freeport and Middle Kittanning coal seams in the study area. These are the only other seams known to have been mined. Mining on the Lower Freeport coal was by contour surface-mining methods in some of the same areas that the Upper Freeport coal was mined, occurring primarily along crop in the Bonnie Brook valley in the vicinity of Wadsworth, and at crop just north of where U.S. Highway 422 crosses Bonnie Brook, south of the Borough of East Butler (Figure 13). These surface mines probably closed during the late 1960s. Most have not been reclaimed. Additionally, one small deep mine was initiated as a drift opening along the northern crop line of the Lower Freeport coal, just across the river from the community of Bonnie Brook. It is not clear when this mine opened or why it ceased operation. The only mining activity associated with the Middle Kittanning coal bed in the study area is found in the northwestern corner of the quadrangle (Figure 14). Here, two deep mines were initiated as drift mines from crop on both sides of Bonnie Brook in the vicinity of where U.S. Highway 422 crosses over the B&O Railroad. These mines are situated in the area of thickest coal, but in mostly thin cover (i.e., less than 200 feet), and operated probably in the 1960s to 1970s.

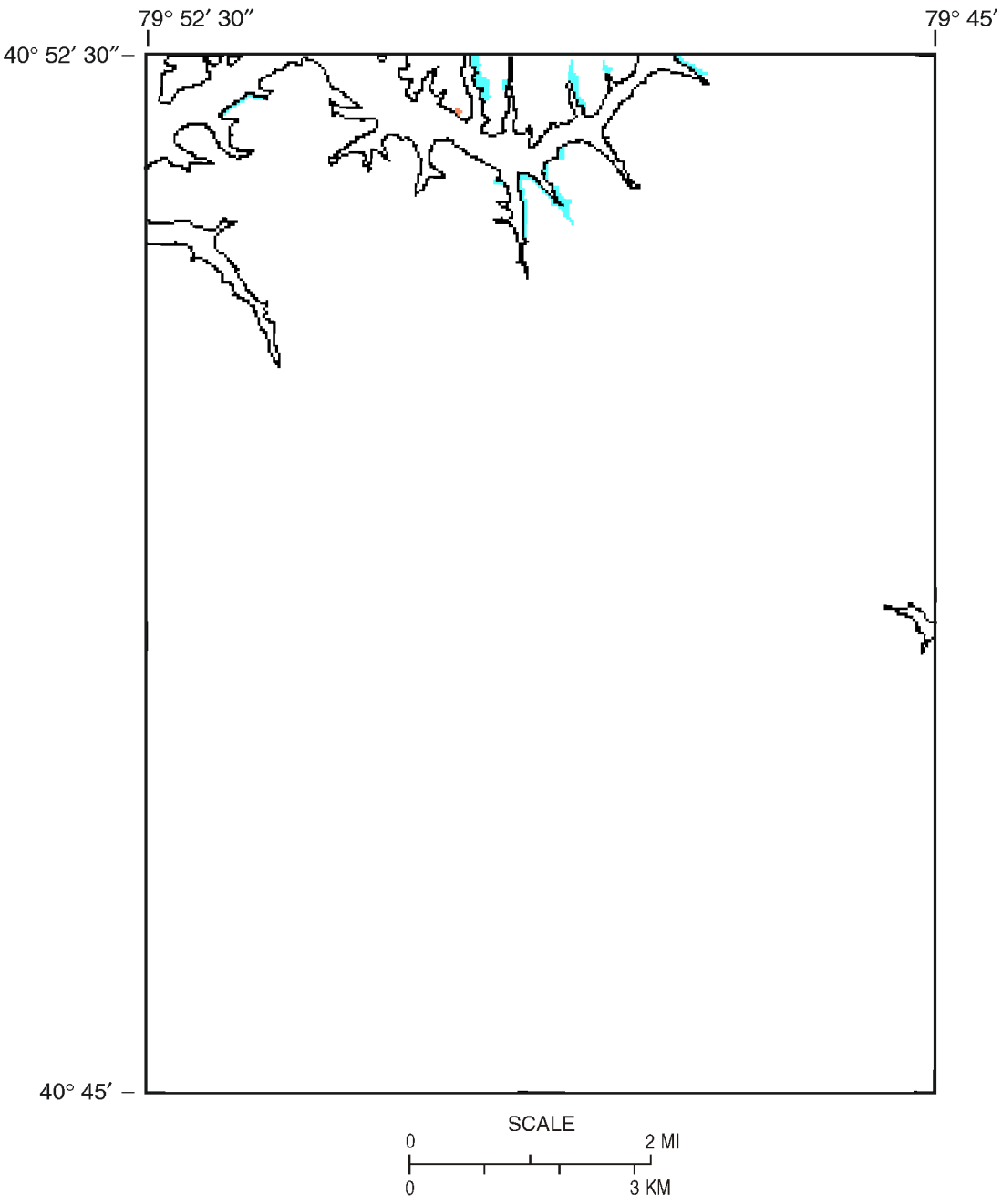

Figure 13. Lower Freeport coal outcrop location (black) with surface-mined-out areas (blue) and underground-mined-out areas (orange).

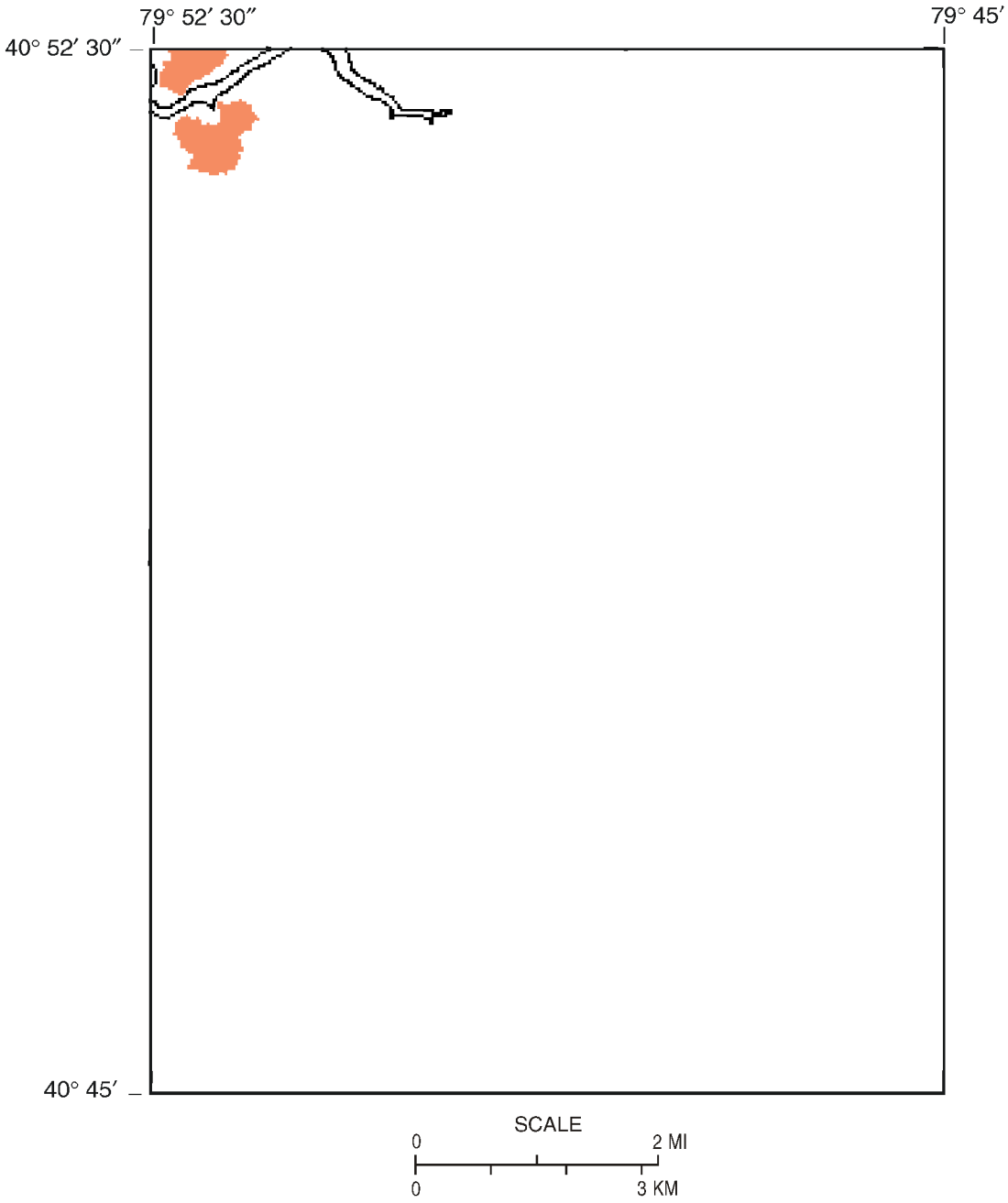

Figure 14. Middle Kittanning coal outcrop location (black) with underground-mined-out areas (orange).

DATA COMPILATION

Data were sparse for the coals stratigraphically lower than the Clarion coal bed, the lowest coal bed for which sufficient data existed for resource calculation. Only a few drill cores penetrated to the base of the coal-bearing strata (i.e., Pennsylvanian). The coals encountered, namely the Brookville, upper, middle, and lower Mercer, and Sharon coals (see Figure 4) may or may not be thicker than the 14 inch minimum required for computing original resources for the entire quadrangle. Yet, some of those deep coals were measured at the two or three data points in the quadrangle to be greater than 28 inches thick, suggesting that they may be worth a look at in more detail once more exploratory drilling can be undertaken. Resource estimates were not attempted based on those two or three points in the existing dataset, because the points are too close together to create a meaningful trend surface for structure and isopach maps for the entire quadrangle. Also, the authors considered it too risky and time-consuming to try and calculate resources for the known thickness points and extrapolate such a small area to the rest of the quadrangle, since coal thickness can change rapidly and unpredictably over short distances in this part of the geologic section.

Initial mining information and coal crop lines were compiled from work maps used by C.H. Dodge (1985) to create the figures for Mineral Resource Report 90, part. 1. These maps were further updated by collecting recent (as of 1996) mining information for the Saxonburg 7.5-minute quadrangle from mining permits stored at the Pennsylvania Department of Environmental Protection district mining offices in McMurray and Greensburg, Pennsylvania. Verification of surface-mining extent was accomplished through the use of aerial photography and limited field reconnaissance. Land-use practices and technological restrictions to mining were determined from state and local regulations, and from mine operation records where available.

COAL RESOURCES OF THE SAXONBURG QUADRANGLE

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 to describe tons (e.g., long ton, metric ton) is not usually used in resource studies,

because values associated with other terminology are usually greater than 2,000 pounds (e.g., 2,200 pounds for long ton).

Seven coal beds of at least 15 seams that were encountered in drilling were chosen for this study, because they met the definition of a resource as defined in Appendix C, and there were sufficient data to perform a coal availability analysis of them; enough drill holes, measured sections, etc. were available to define the coal extent across the quadrangle and drill holes penetrated as much of the stratigraphic section as possible. These 80 data points within the confines of the quadrangle were a combination of driller's logs and geologist's logs of core, and geologist's measured sections. The relative volumes of the original resources for these seven coal seams studied in the Saxonburg quadrangle, as determined by using the USGS-modified GRASS resource program, are depicted on Figure 15. The grand total original coal tonnage for the seven beds studied in the quadrangle is estimated to be roughly 570 million short tons (Figure 16); 11 million short tons, or about 2 percent of the original amount, has been mined out

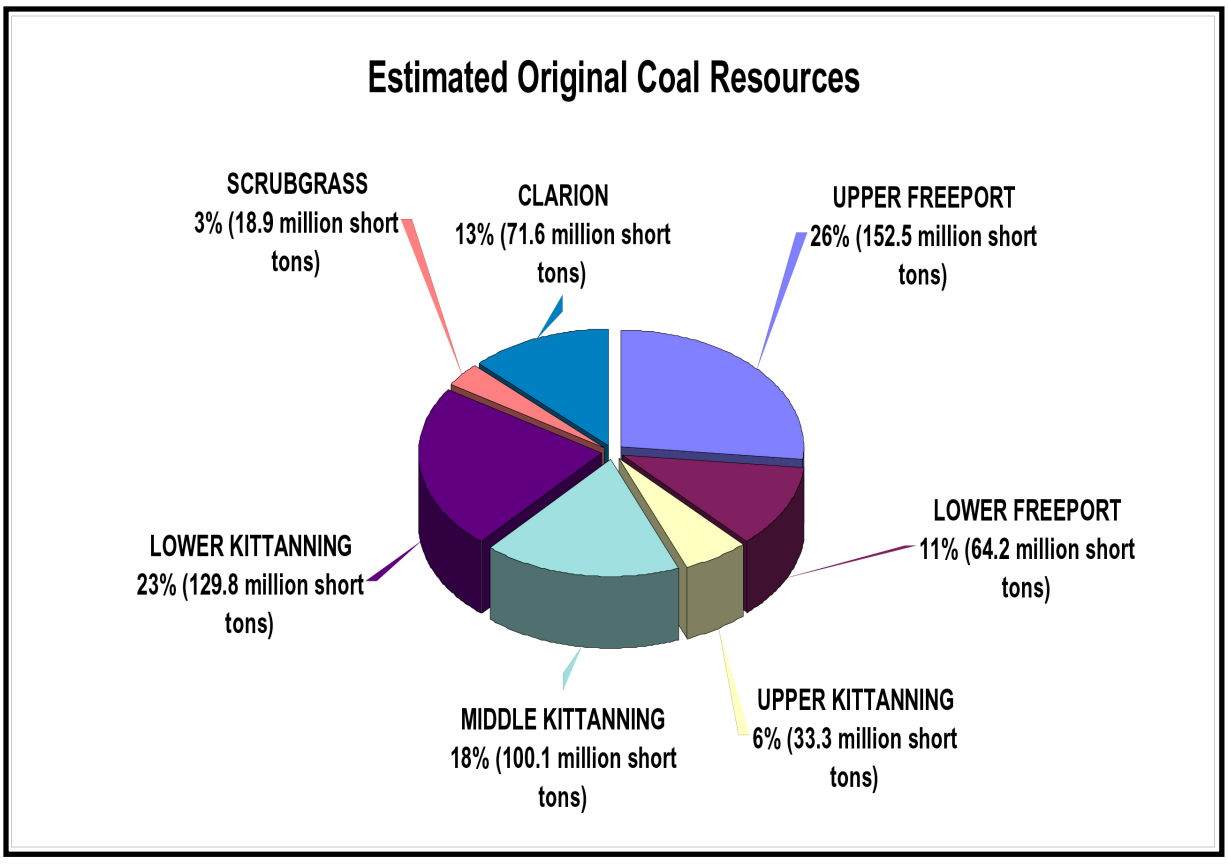

Figure 15. Summary of original coal resources in the Saxonburg quadrangle.

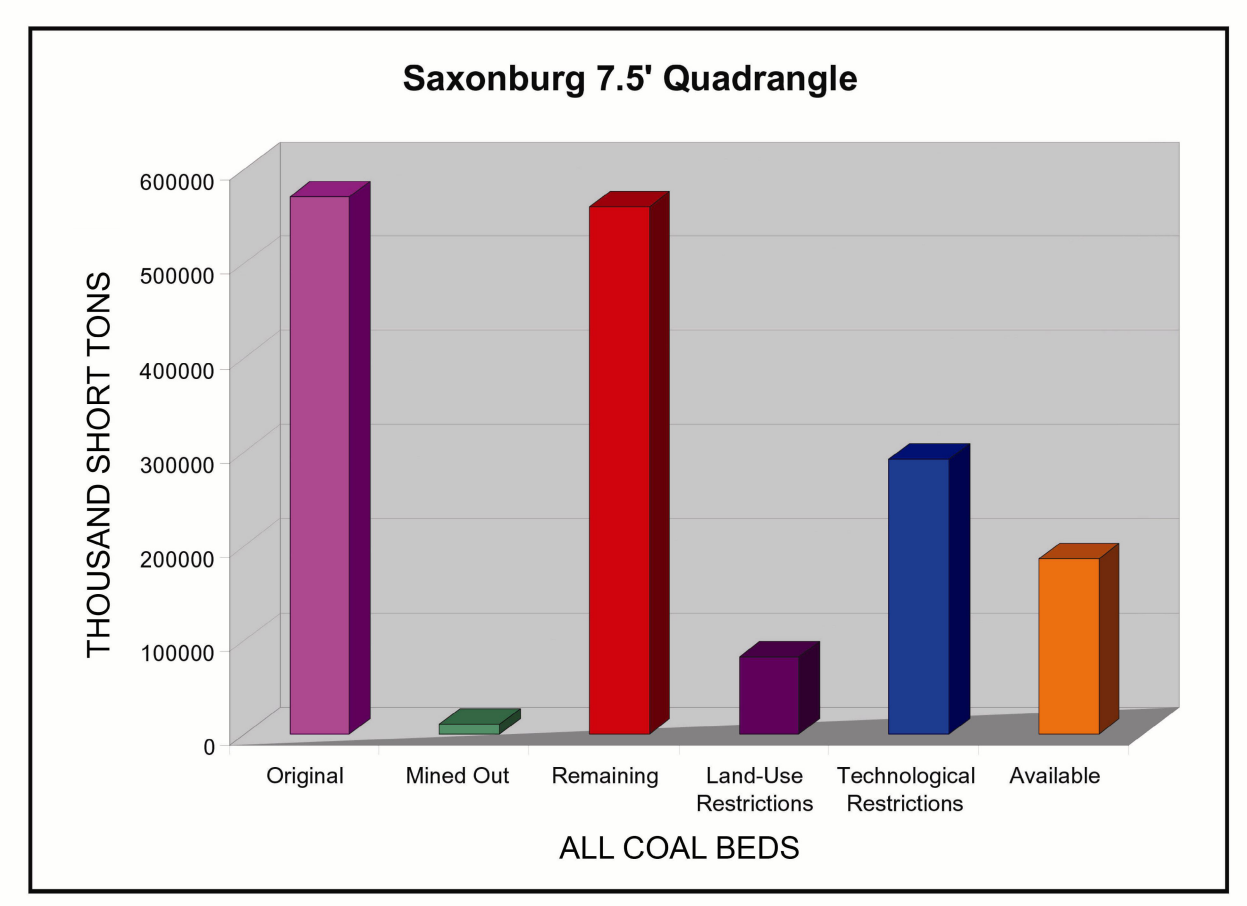

Figure 16. Cumulative tonnages for all coal beds in the Saxonburg quadrangle.

or lost in mining, leaving remaining resources of approximately 559 million short tons, or 98 percent of the original resource (see Figure 16). About 201 million short tons, or nearly 36 percent, of that remaining coal is equal to or greater than 28 inches thick. A majority of the remaining coal equal to or greater than 28 inches thick is attributable to the Upper Freeport and Lower Kittanning coal seams. Additional coal resources may exist in the Brookville, Mercers, and Sharon coal beds, but their lateral extent and thickness are generally unknown, due to the lack of data about those seams.

Thirteen land-use and four technological restrictions to mining were identified for the Saxonburg quadrangle (see Appendix C for restriction categories). Figure 17 is a composite map illustrating the distribution of the 13 land-use restrictions in the quadrangle. Table 1 lists the

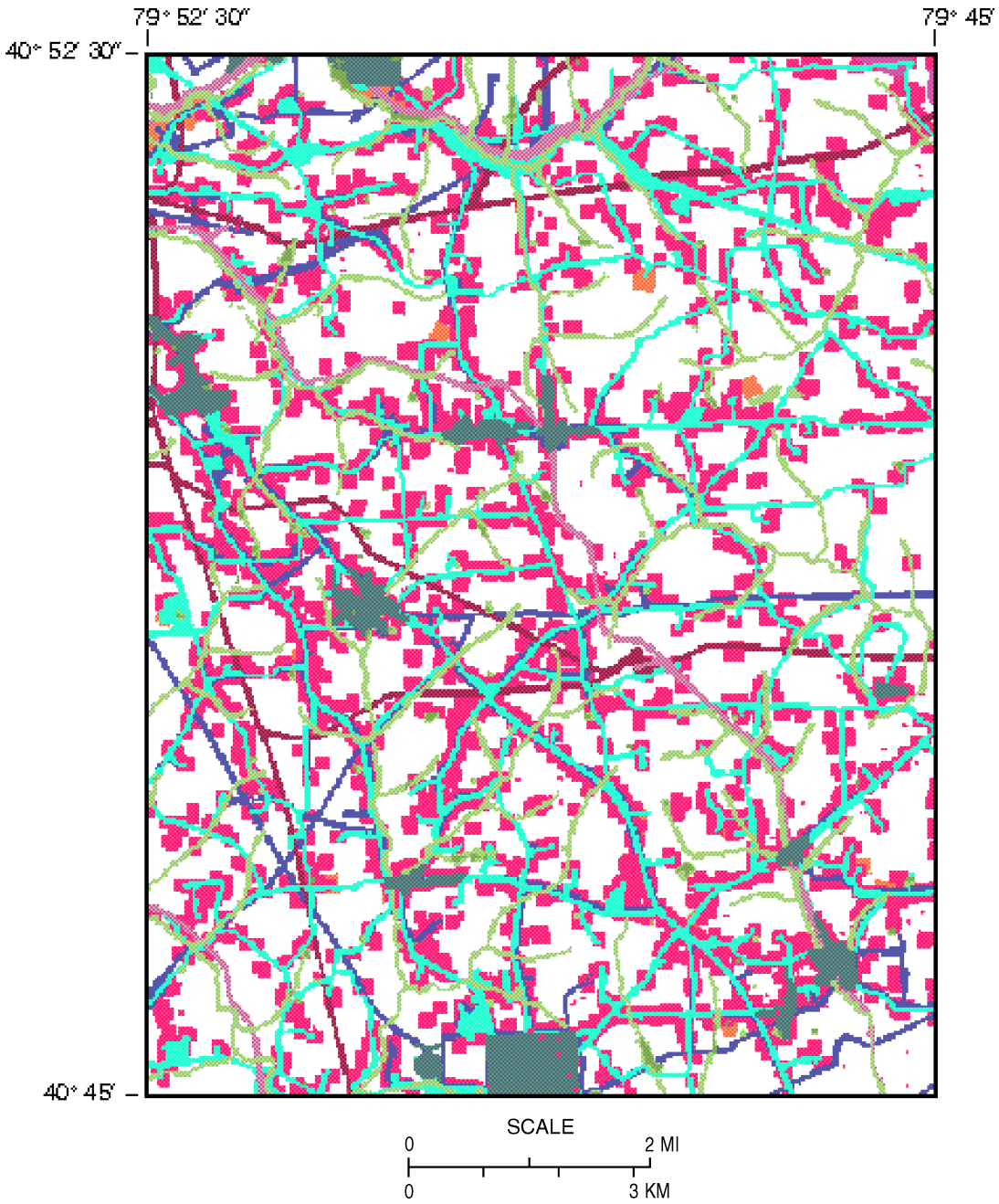

Figure 17. Spatial arrangement of land-use restrictions for the Saxonburg quadrangle. Some of the restrictions are roads, shown as blue-green lines; population clusters and towns, shown in green-gray; houses, cemeteries, a public park, and oil and gas wells, shown in red; large buildings and public facilities, shown in orange; streams, shown in olive green; railroads, shown as violet lines; powerlines, shown as brown lines; and pipelines, shown as dark-blue lines.

Table 1. Estimated Coal Resources Unavailable Due to Land-Use and Technological Restrictions in the Saxonburg Quadrangle (in thousands of short tons)[1]

	SURFACE (0 TO 200')							
	Clarion	**Scrubgrass**	**Lower Kittanning**	**Middle Kittanning**	**Upper Kittanning**	**Lower Freeport**	**Upper Freeport**	**Total**
Cemeteries	0	0	0	0	0	8	165	**173**
Houses	821	17	2,975	3,808	2,424	9,826	35,723	**55,594**
Public Buildings	397	39	943	615	95	116	894	**3,099**
Railroads	605	22	1,436	1,107	52	279	1,252	**4,753**
Towns	191	0	443	395	85	448	2,478	**4,040**
PNDI Sites	0	0	3	0	0	138	266	**407**
Parks	0	0	0	0	0	0	7	**7**
Oil & Gas Wells	5	0	7	17	9	75	229	**342**
Streams & Lakes	969	43	2,333	2,120	1,326	3,022	8,770	**18,583**
Wetlands	56	0	129	46	11	53	369	**664**
Pipelines	362	20	1,122	1,189	540	1,654	6,965	**11,852**
Powerlines	76	3	284	395	253	1,053	154	**2,218**
Roads	562	30	2,061	2,220	1,226	3,838	14,173	**24,110**
Total	**2,088**	**99**	**6,010**	**6,972**	**4,315**	**13,871**	**48,085**	**81,440**

	DEEP (>200')							
	Clarion	**Scrubgrass**	**Lower Kittanning**	**Middle Kittanning**	**Upper Kittanning**	**Lower Freeport**	**Upper Freeport**	**Total**
Coal Too Thin	51,116	18,828	58,936	85,800	24,538	35,873	10,637	**285,728**
Oil & Gas Wells	155	39	216	187	35	46	74	**752**
Towns	1,057	966	3,498	2,995	352	950	1,472	**11,290**
Public Buildings	858	294	1,490	1,291	228	663	992	**5,816**
Total	**51,245**	**18,828**	**62,230**	**85,848**	**24,538**	**35,873**	**12,512**	**291,074**
Grand Total	**53,333**	**18,927**	**68,240**	**92,820**	**28,853**	**49,744**	**60,597**	**372,514**

[1]Table composited from GRASS "tables" directory, v_*.tab files. Summation of these individual restrictions is greater than total shown on appendices tables.

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 subsurface mining of coal, account for an additional resource likely lost to mining of about 373 million short tons (65 percent of total), leaving nearly 187 million short tons, or a little more than 33 percent, of the remaining amount available for future mining. This available amount represents a little less than 33 percent of the original resource (see Figure 16). Of the available coal, 151 million short tons, or 81 percent of this amount, is equal to or greater than 28 inches thick. Original, mined-out, remaining, restricted, and available tonnage totals for the individual coal beds have been summarized in the next few paragraphs, and in Appendix A where they have been rendered as bar graphs. Complete resource tabulations for each bed are given in Appendix B of this report.

CLARION COAL BED SUMMARY

It is estimated that approximately 72 million short tons of Clarion coal was present in the Saxonburg quadrangle, which represents 13 percent of the all the coal initially present in the quadrangle (see Figure 15). There has not been any mining on this seam so far. The remaining coal is shown in Figure 18. Eleven of the 13 identified restrictions for the quadrangle impact the future surface-mining potential and remove a little over 2 million short tons of coal from consideration. Four technological restrictions identified in the quadrangle remove a little more than 51 million short tons from consideration, the largest category being “bed too thin.” The impact of these restrictions have been graphically portrayed in Figures 19 and 20, and tabulated as gross tonnages in Table 1.

Factoring in the effect of these restrictions, that leaves approximately 18 million short tons, or about 26 percent of the original coal for this seam, available (Figure 21) for future mining consideration (Appendix A). The vast majority of the coal is under greater than 200 feet of cover. Where the coal is under less than 200 feet of cover, the coal is often more than 2 feet thick, but land-use restrictions effectively remove all but 507 thousand tons of coal from consideration for surface mining. In these areas, open-pit mining methods, such as a box cut, would be necessary to extract the coal as the coal bed does not outcrop anywhere within the quadrangle, and mining would have to take place in the valley bottoms in order to minimize the

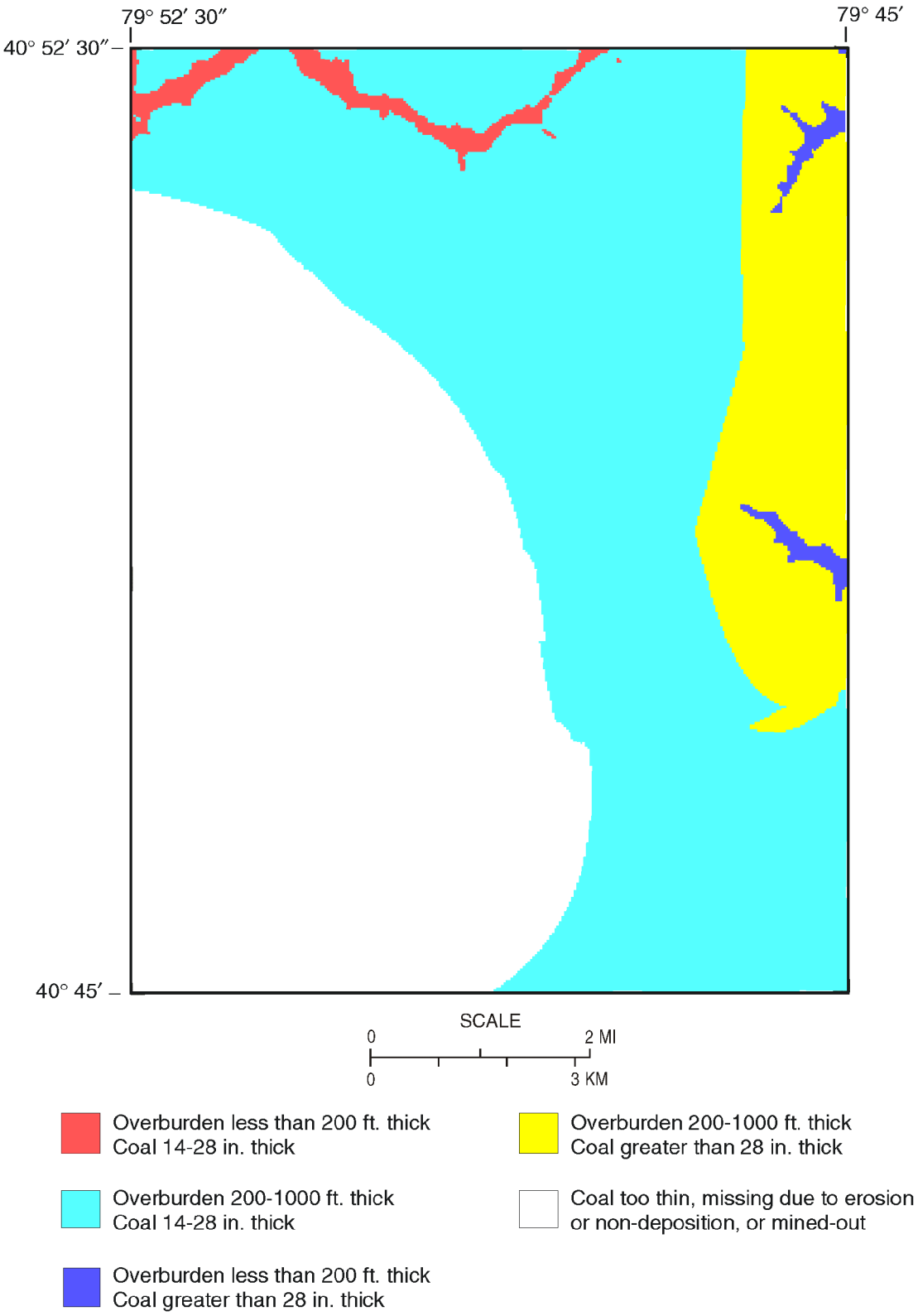

Figure 18. Remaining Clarion coal by coal-bed and overburden thickness categories.

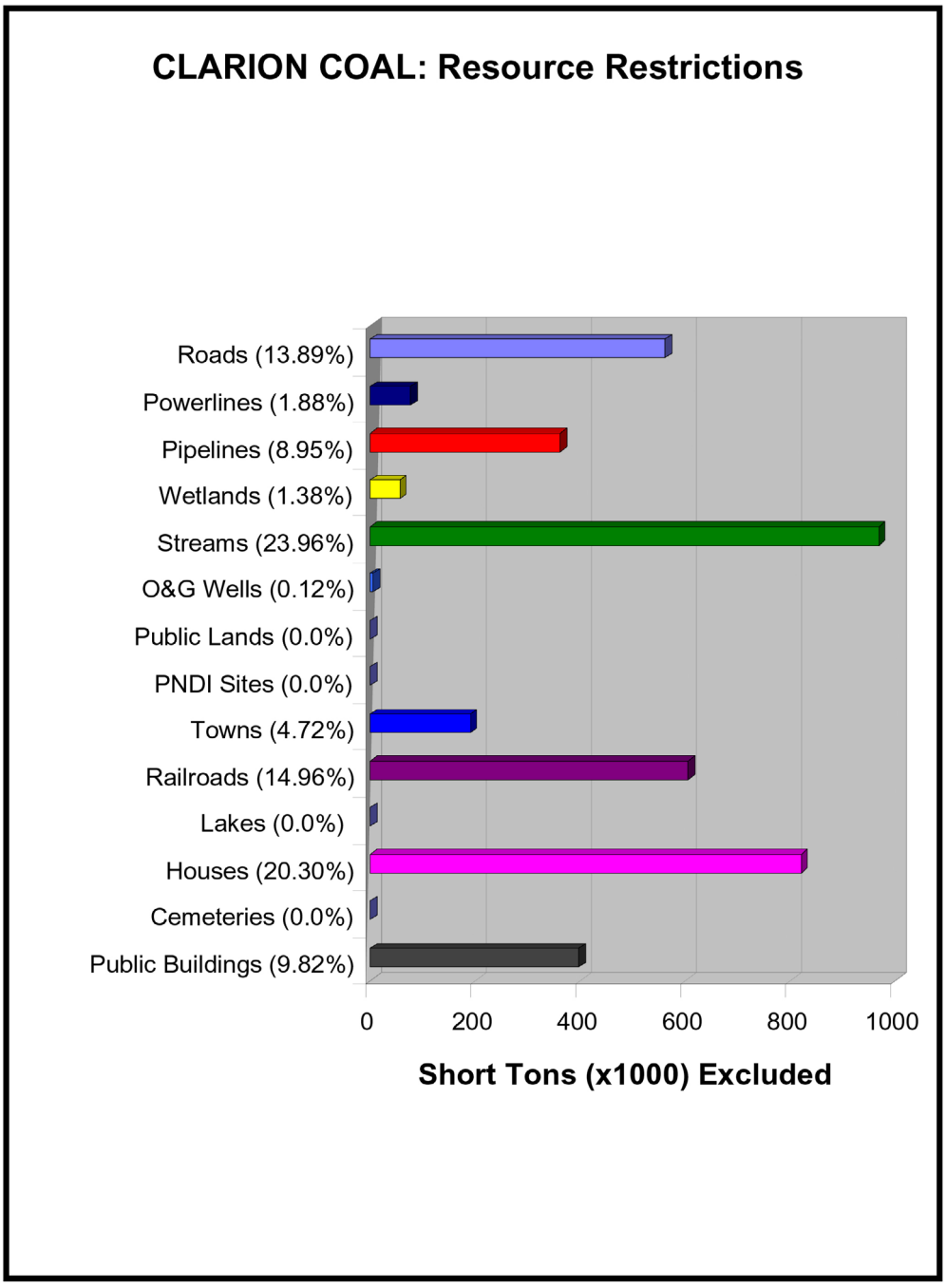

Figure 19. Impact of individual land-use restrictions on the Clarion coal bed.

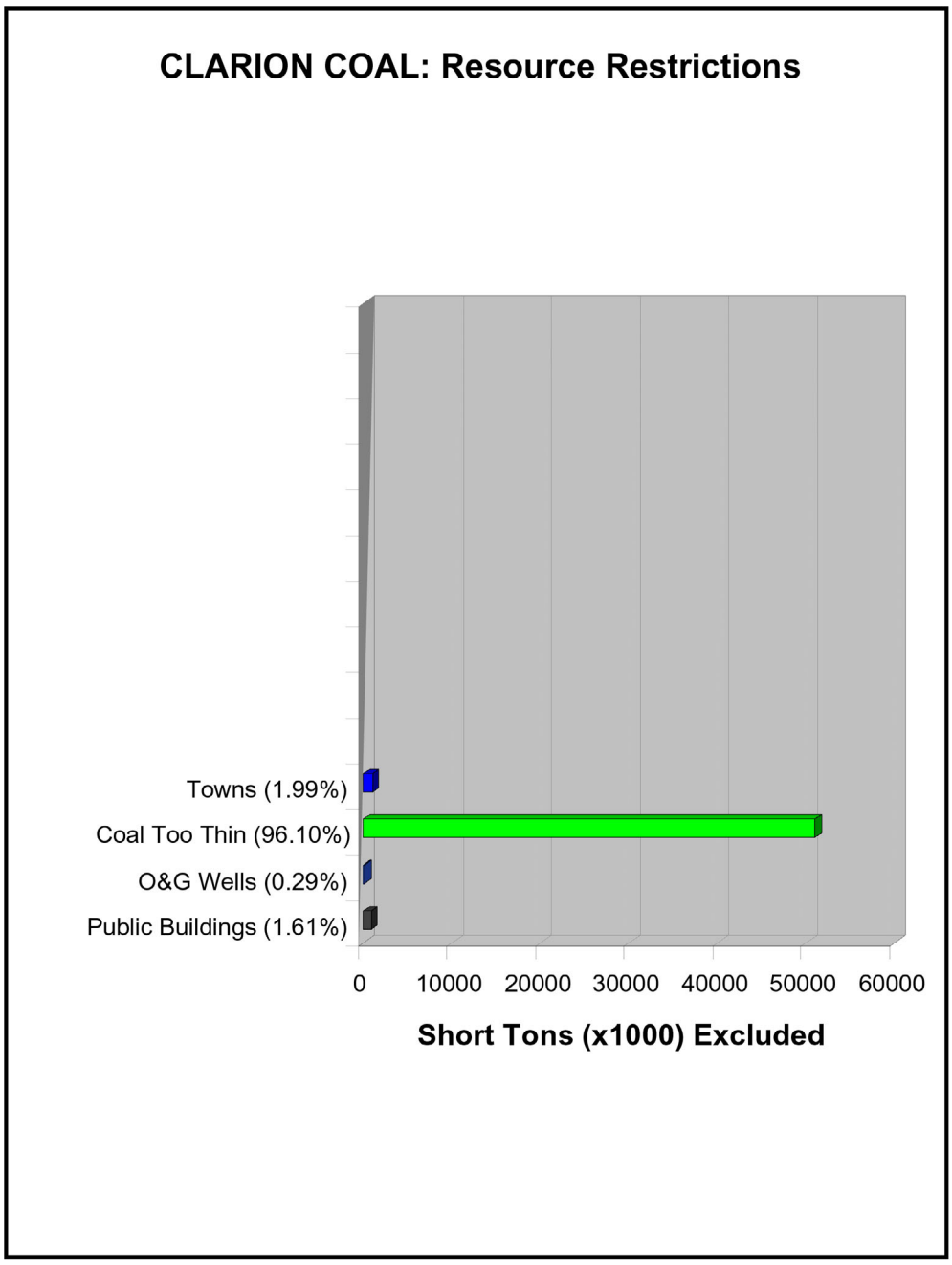

Figure 20. Impact of individual technological restrictions on the Clarion coal bed.

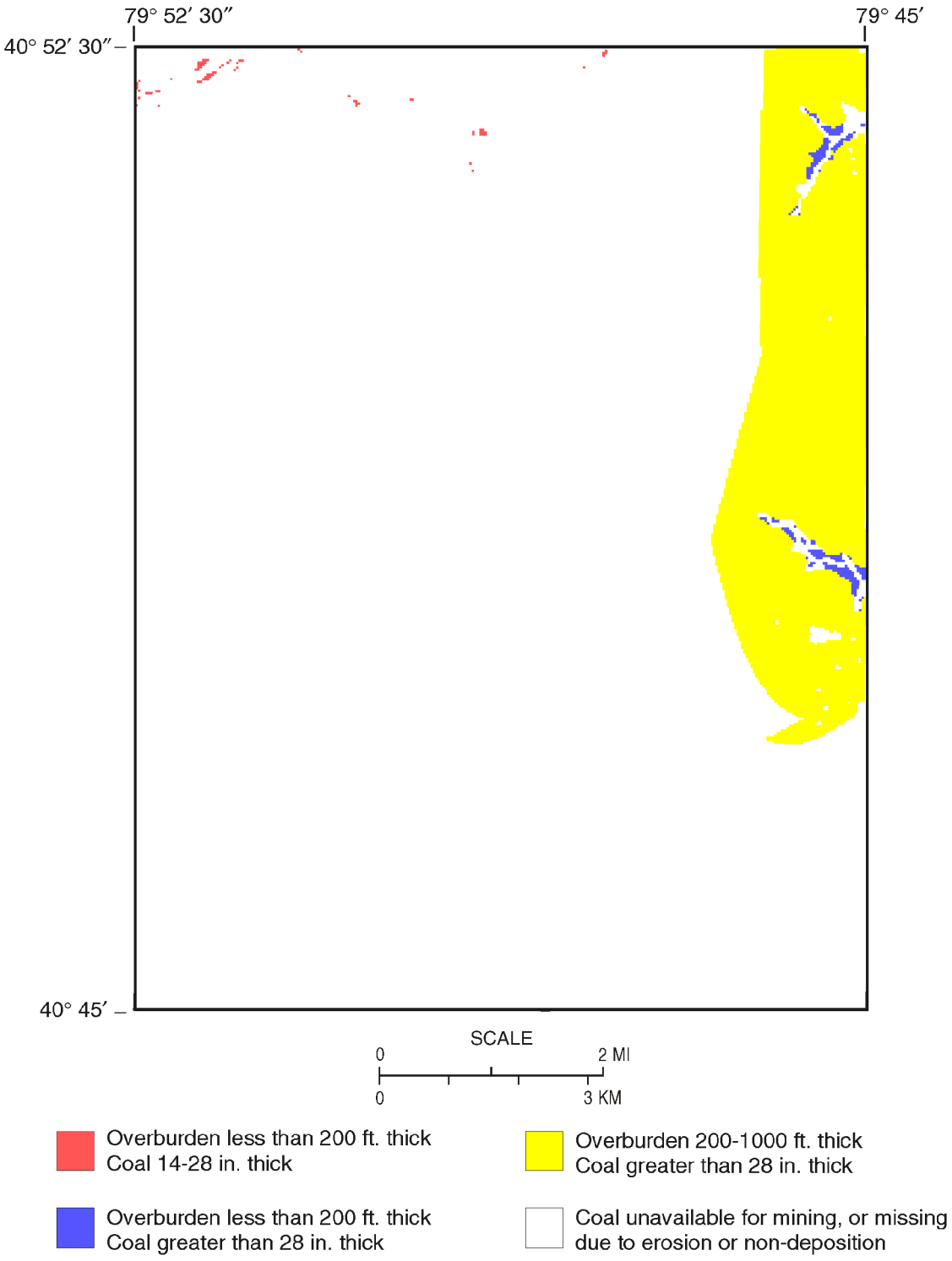

Figure 21. Available Clarion coal by coal-bed and overburden thickness categories.

amount of overburden over the coal seam. A mineshaft would be required for access to the deeper coal.

Due to the lack of closely spaced data, a large proportion of the original, remaining, and available resource falls in the "inferred" and "hypothetical" categories (0.75 to 3 miles, and greater than 3 miles from nearest known value). This hierarchy is further explained in Appendix C.

SCRUBGRASS COAL BED SUMMARY

The Scrubgrass coal bed original resources amount to nearly 19 million short tons of coal, or about 3 percent of the total original coal in the study quadrangle (see Figure 15). Most of the resource falls in the "inferred" category. This coal has never been mined in the quadrangle. The extent of remaining coal is shown in Figure 22.

Seven of the 13 land-use restrictions and all four technological restrictions impact upon the Scrubgrass resource. Gross tonnages have been calculated for these restrictions and have been placed in Table 1. The table has been rendered into bar graphs to depict graphically how the individual restrictions impact this coal bed (Figures 23 and 24). Nearly 19 million tons of coal is excluded from the remaining resource, due to these land-use and technological restrictions, leaving only 24 thousand tons, or less than 1 percent, of the original coal available for mining. The category "bed too thin" accounts for nearly all of the coal loss. Figure 25 indicates where the available coal is located in the quadrangle. Appendix A contains a bar graph depicting the ratio of available to original resources.

In this area over 99 percent of the available resource is less than or equal to 28 inches thick, and therefore is not likely a candidate for underground mining. The 24 thousand tons of available coal is found in less than 200 feet of cover in the valley bottoms, and therefore is potentially surface minable. It often directly underlies the Vanport marine zone/limestone. This relationship of coal to limestone might be of additional benefit if mined, because the limestone would help to mitigate any acid drainage that may be produced during mining of the coal.

None of the original coal resource fell into the "hypothetical" category. Instead, most of the original resource (about 12 million short tons) was categorized as "inferred." A little over 6 million short tons was classified as "measured" or "indicated." Therefore, with only about a

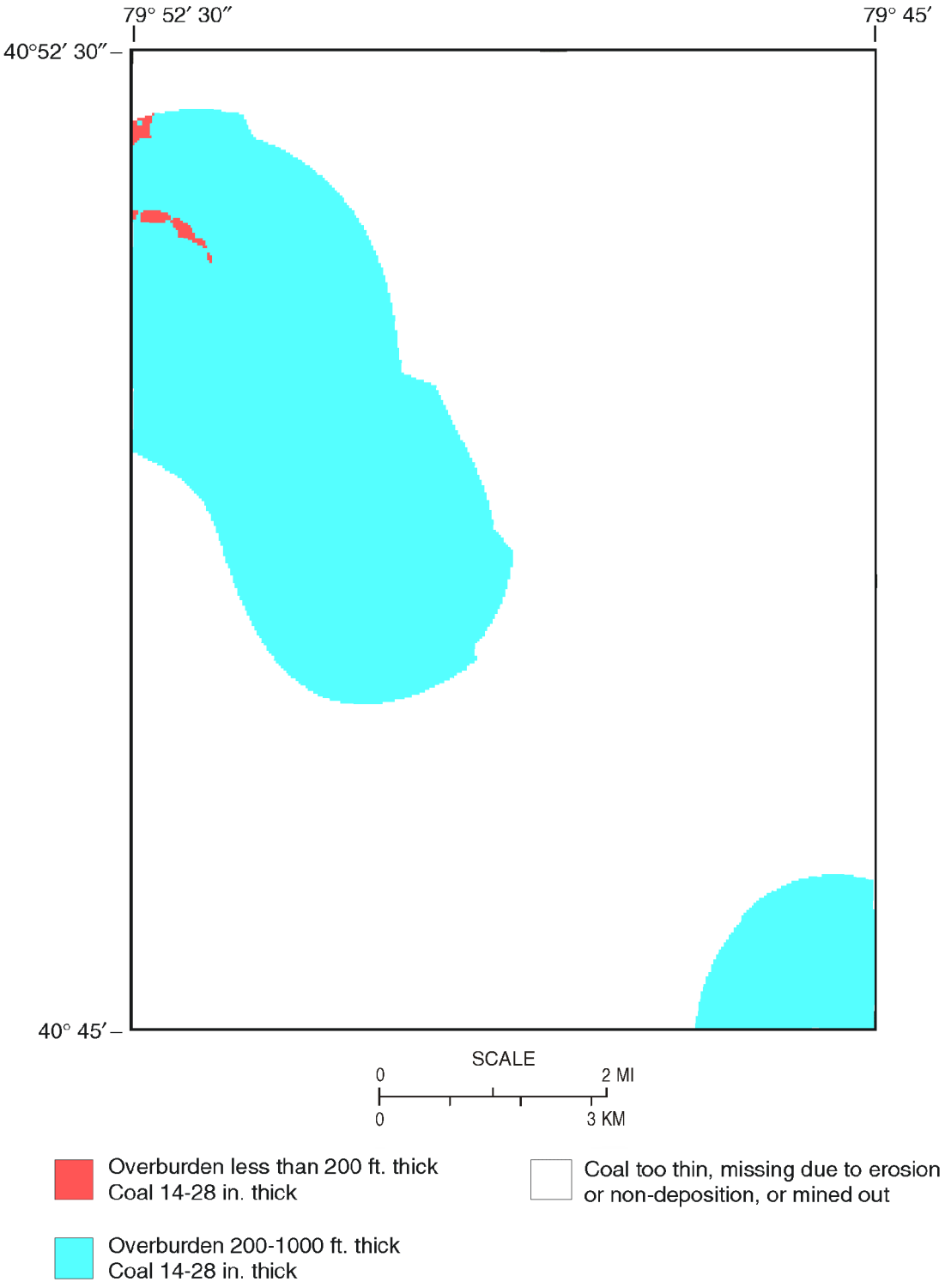

Figure 22. Remaining Scrubgrass coal by coal-bed and overburden thickness categories.

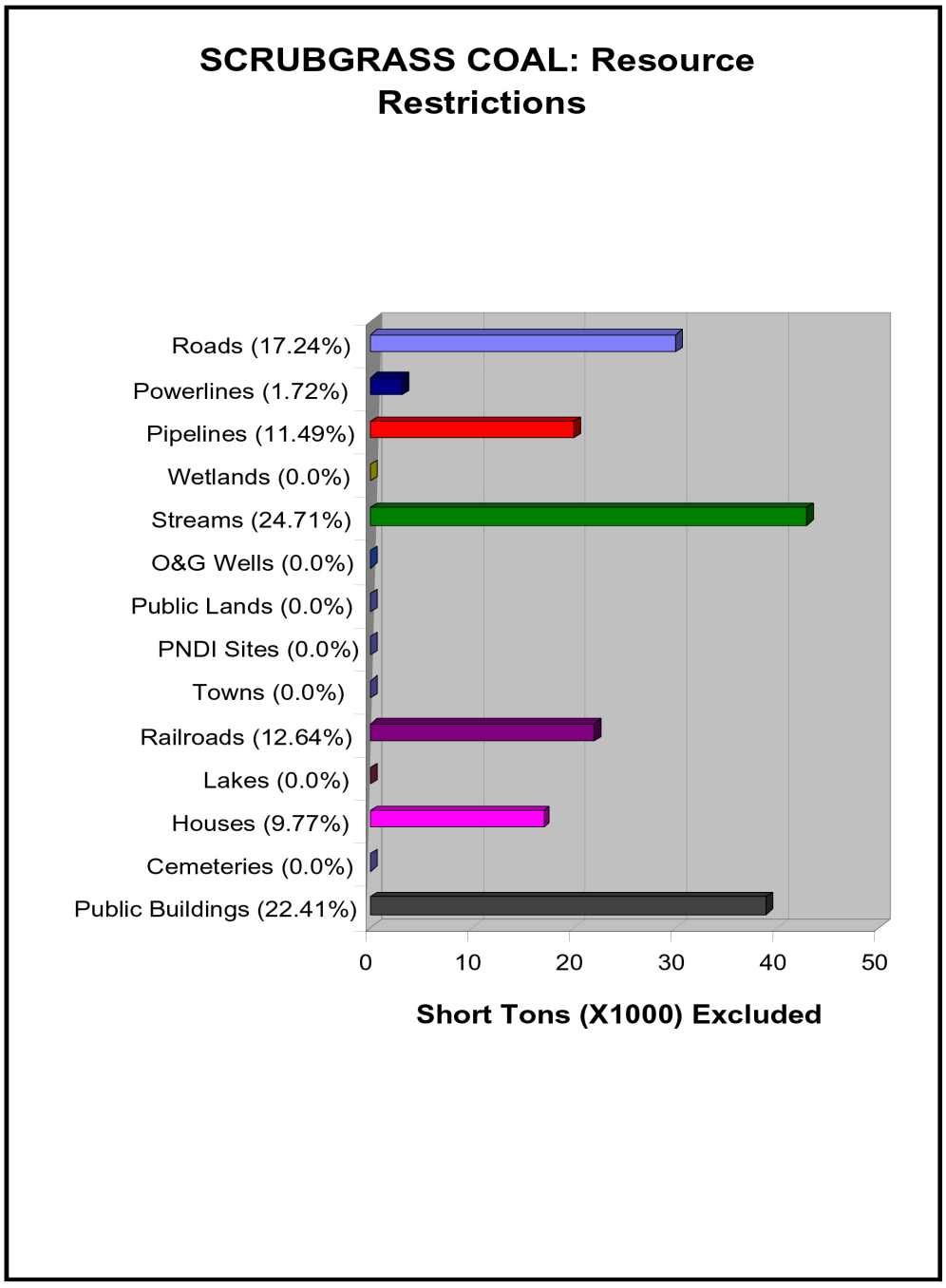

Figure 23. Impact of individual land-use restrictions on the Scrubgrass coal bed.

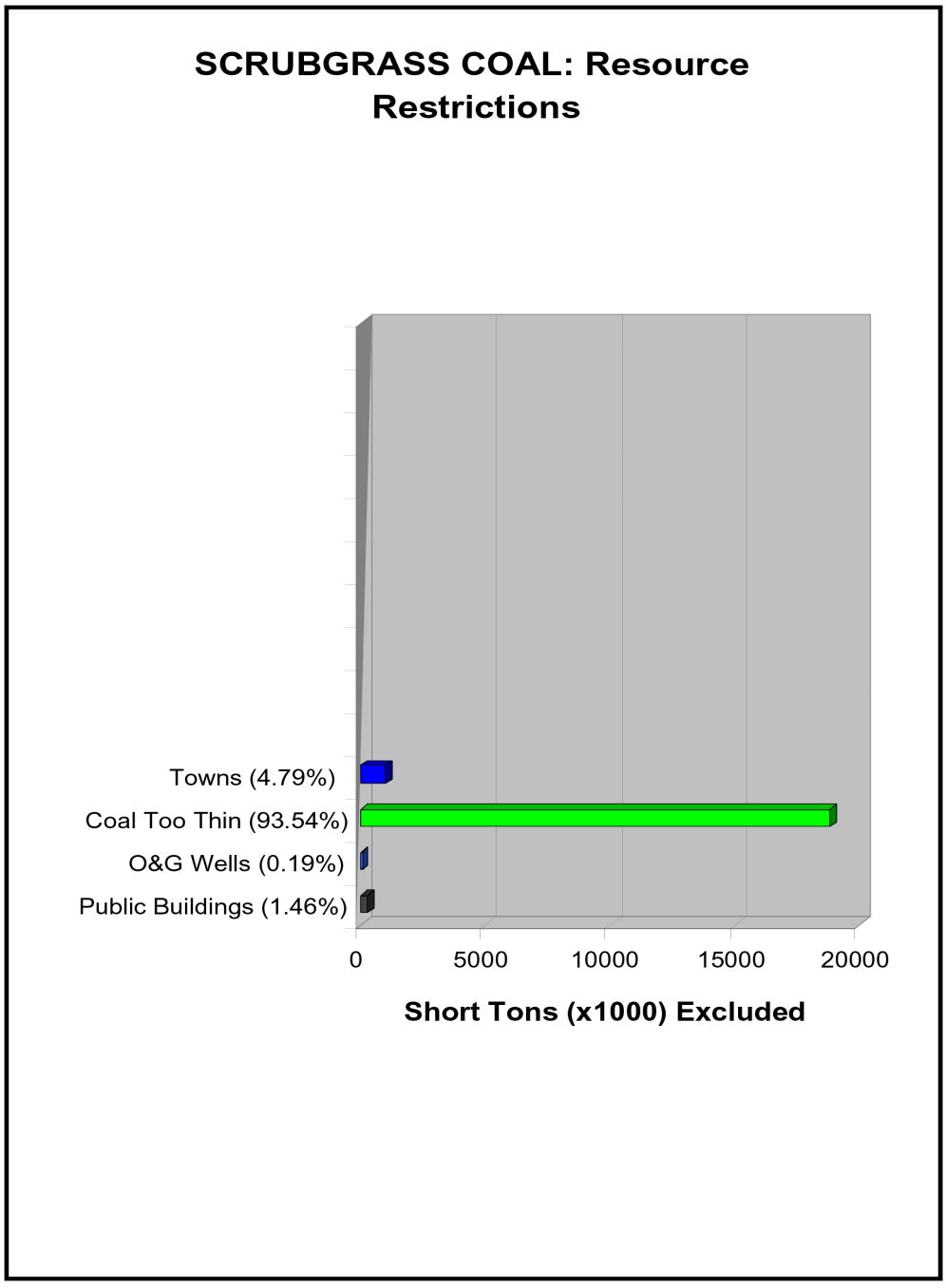

Figure 24. Impact of individual technological restrictions on the Scrubgrass coal bed.

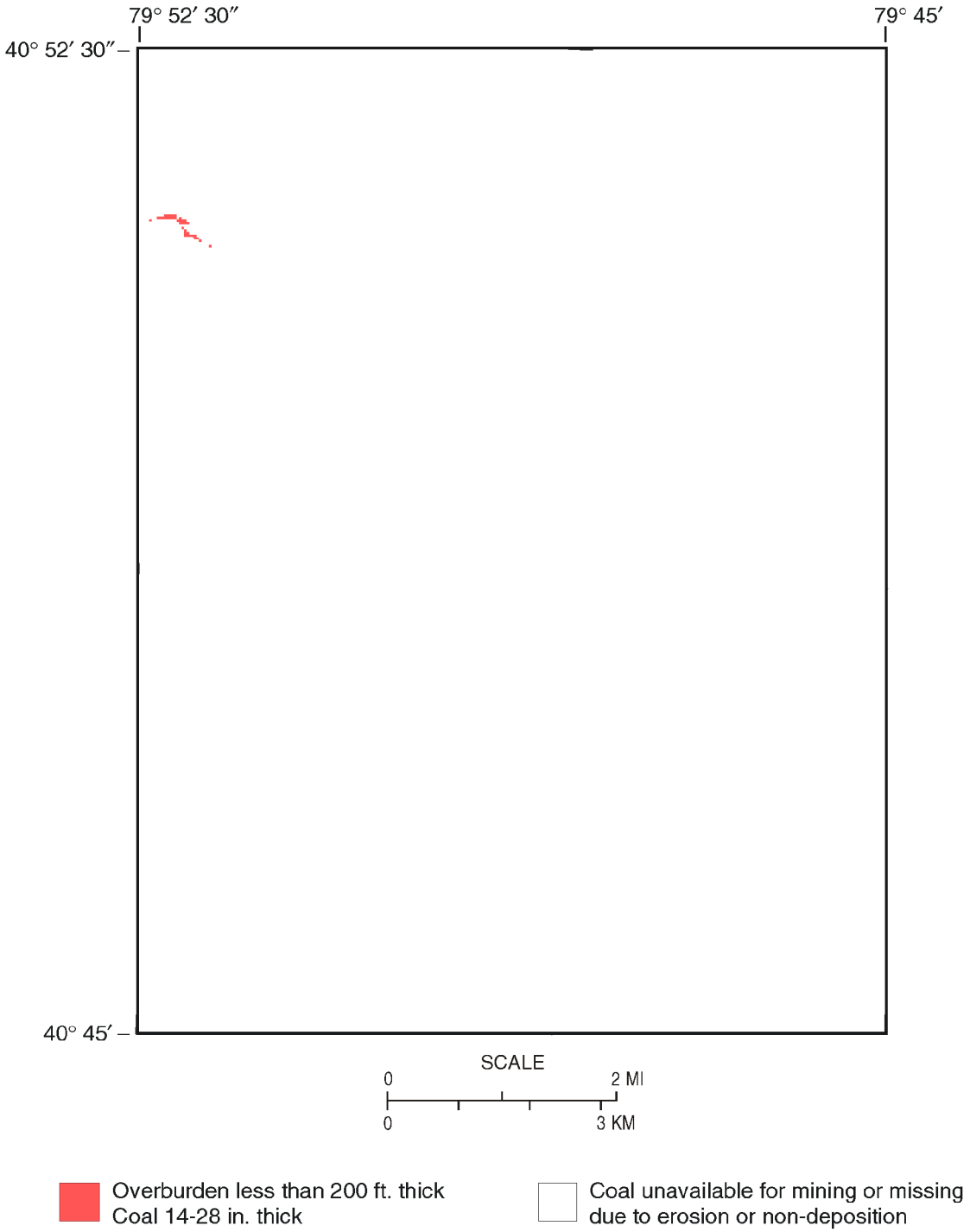

Figure 25. Available Scrubgrass coal by coal-bed and overburden thickness categories.

third of the original resource classified as measured or indicated and two-thirds classified as inferred, the resource is less precisely defined than what one might want if engaged in mining. This occurred because data points were scattered about the quadrangle (up to 3 miles apart), with clusters of points only in certain areas of the quadrangle (0.25 mile apart).

LOWER KITTANNING COAL BED SUMMARY

Although this coal bed has never been mined, the Lower Kittanning coal bed appears to be a significant resource, accounting for nearly 130 million short tons of coal or about 23 percent of the total original resources in this quadrangle (see Figure 15). Figure 26 depicts the extent of remaining coal greater than 14 inches thick.

Eleven of the 13 identified land-use restrictions and all four of the technological restrictions identified for the Saxonburg quadrangle intersect this coal bed. Gross tonnages have been calculated for these restrictions and placed in Table 1. Companion bar graphs summarizing the impact of these restrictions on the resource are shown in Figures 27 and 28. A little over 68 million short tons of coal has been excluded by the various land-use and technological restrictions, leaving almost 62 million short tons or about 47 percent of the original resource available for mining as shown in the histogram summary in Appendix A. Available Lower Kittanning coal for the quadrangle is shown on Figure 29.

Nearly 99 percent of the available coal is greater than or equal to 28 inches thick, and approximately 98 percent of that amount is under more than 200 feet of cover, which suggests that this coal could be a candidate for deep mining in the future. Almost at outcrop in the valleys of northern and eastern sections of the Saxonburg quadrangle, this coal bed may also be a candidate for surface mining with about 1.5 million short tons of coal available for extraction. Approximately 75 percent of the available resource is identified as “inferred,” as shown in the tables of Appendix B for this coal.

MIDDLE KITTANNING COAL BED SUMMARY

It is estimated that a little over 100 million short tons of Middle Kittanning coal originally existed in this quadrangle, which represents about 18 percent of the total original resource calculated in this report (see Figure 15). Of this amount, a little over 1 million short tons has been removed by using the room-and-pillar deep-mining method, leaving 99 million

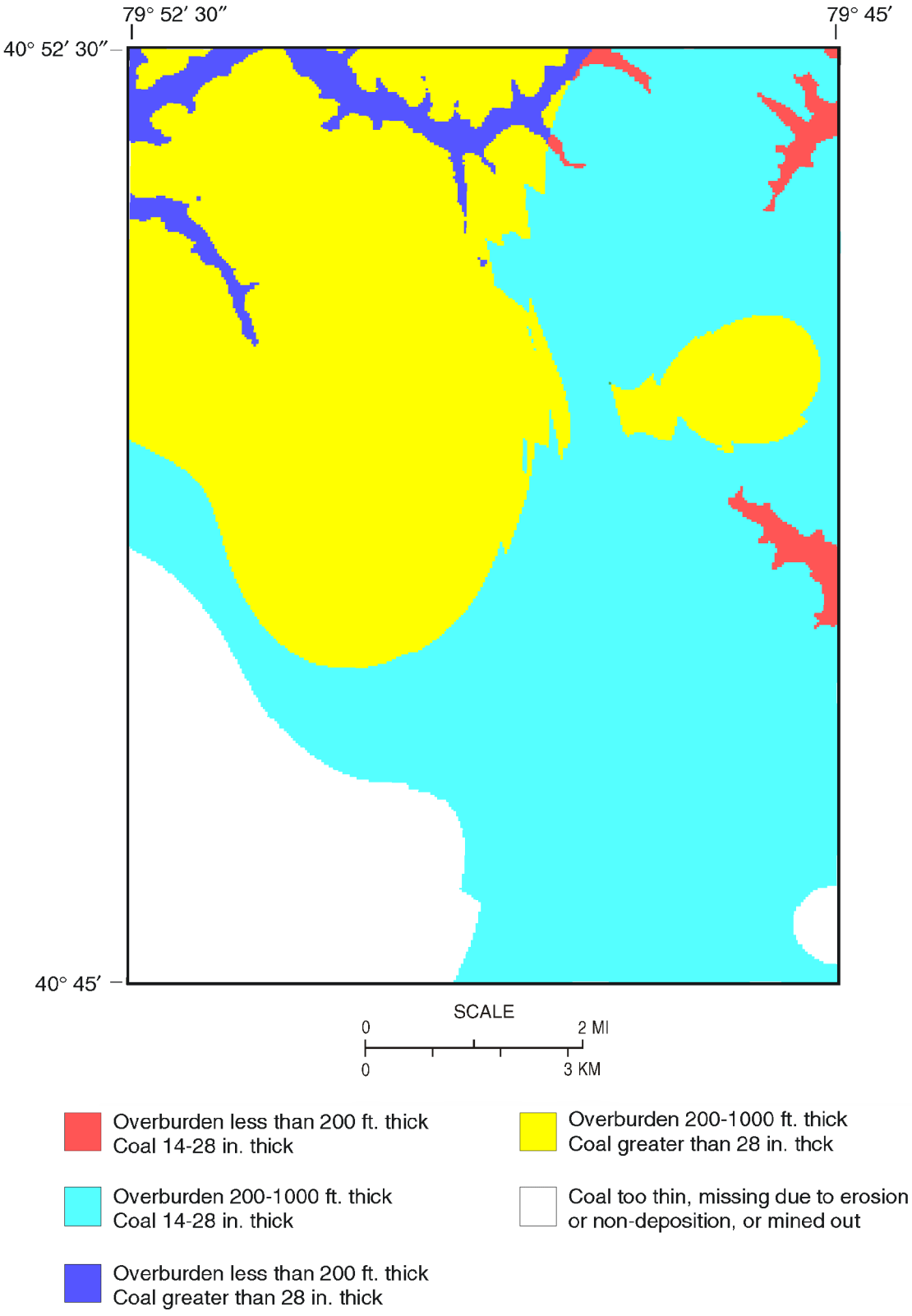

Figure 26. Remaining Lower Kittanning coal by coal-bed and overburden thickness categories.

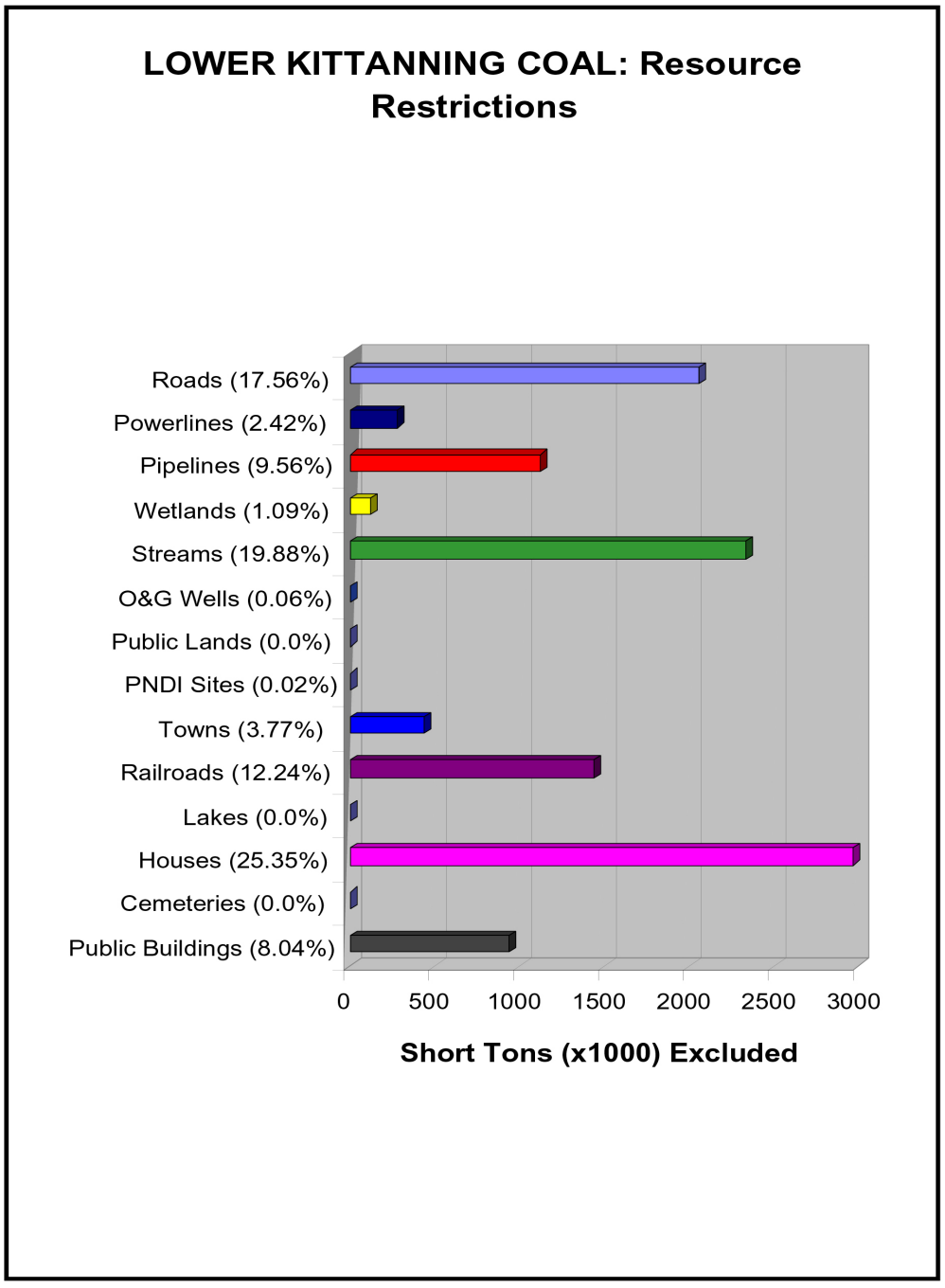

Figure 27. Impact of individual land-use restrictions on the Lower Kittanning coal bed.

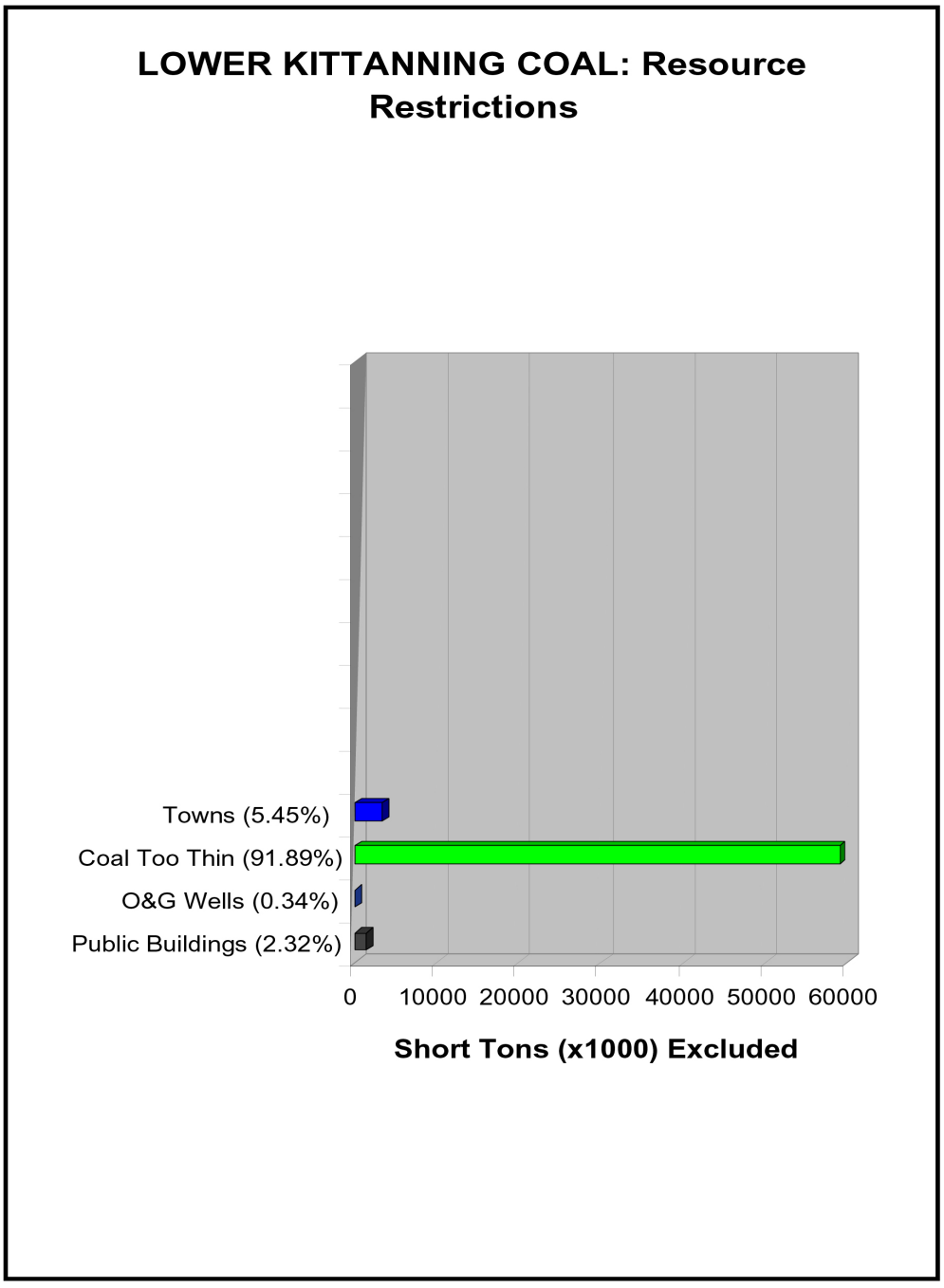

Figure 28. Impact of individual technological restrictions on the Lower Kittanning coal bed.

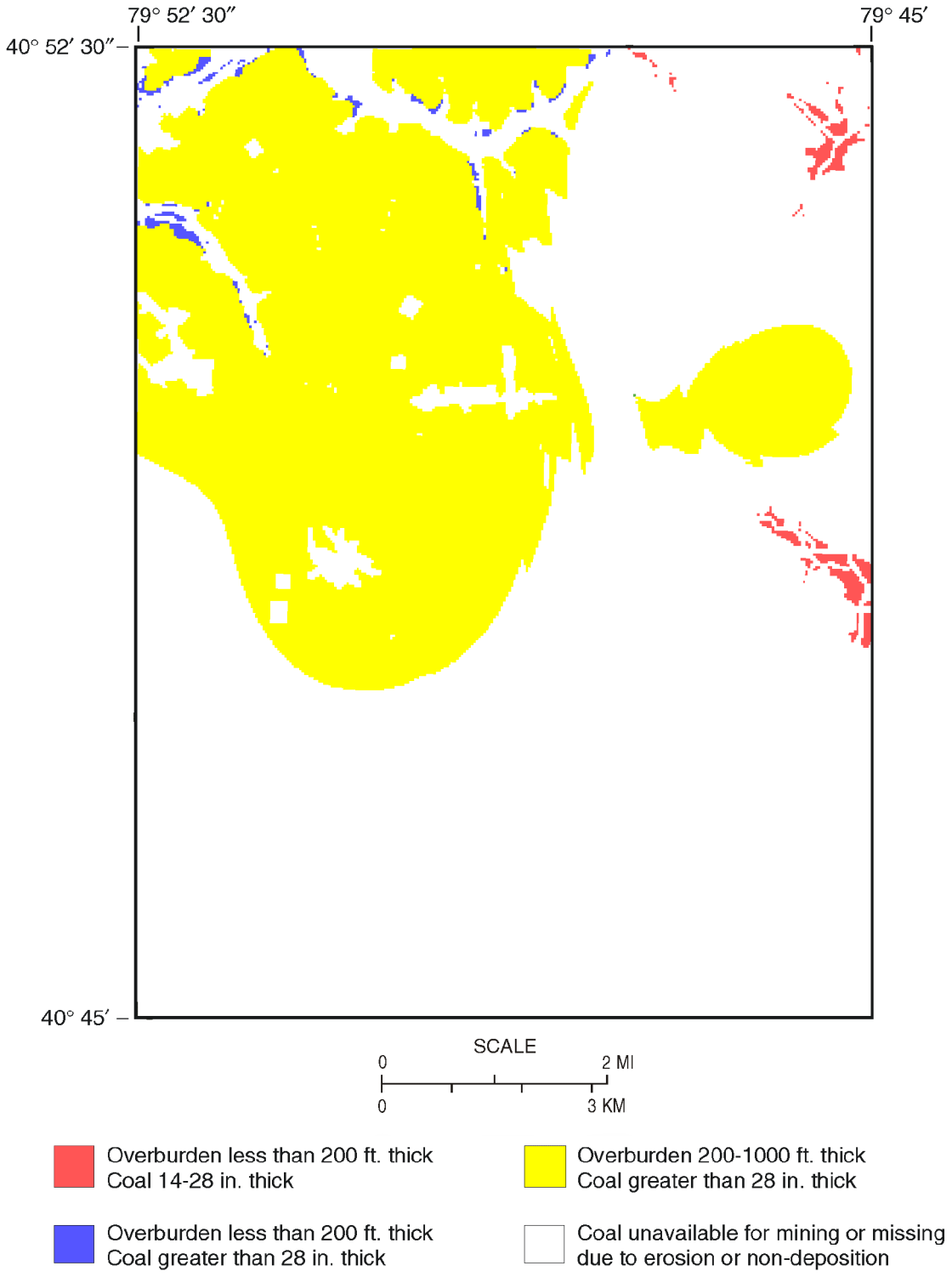

Figure 29. Available Lower Kittanning coal by coal-bed and overburden thickness categories.

short tons remaining (Figure 30). This is also summarized in the bar graphs given in Appendix A. The coal bed outcrops within the valleys of the northern and eastern parts of the quadrangle. The deep-mined areas are located off of crop in the northwestern corner of the quadrangle only as shown previously in Figure 14.

Ten of the land-use restrictions identified for the study area and all four technological restrictions in the study area impact upon the future mining of this coal bed. They remove nearly an additional 93 million short tons of coal from consideration, leaving approximately 6 million short tons, or about 6 percent of the original coal, available for mining (Figure 31). The impact of these restrictions on the Middle Kittanning coal is shown in Figures 32 and 33 and is tabulated in Table 1. Again, the category "bed too thin" is the primary factor limiting what can be mined in the study area.

Of the available coal, a little over 3.5 million short tons, or about 60 percent, has a thickness greater than or equal to 28 inches. Most of this coal is all in one area east of the existing deep mine in the northwest corner of the quadrangle; 2.5 million short tons is under 200 feet or more of overburden, and the remainder is generally close to outcrop in less than 200 feet of overburden. Nearly another 2.5 million short tons of coal is in less than 200 feet of cover, but it is thinner than 28 inches. This coal bed has further potential as both a surface and underground resource. Most of this coal is classified as either "indicated" or "inferred" meaning that this coal thickness was determined for data points that are between 0.75 mile and 3 miles apart. Only a small fraction of the coal resource is classified as "measured" (data points 0.25 mile apart). How all this is catalogued can be viewed in Appendix B. It is not known why the existing deep mine ceased production, or if it can be extended into the thicker pocket of coal found off to the east.

UPPER KITTANNING COAL BED SUMMARY

Original coal resources are estimated at 33 million short tons, or about 6 percent of the total original coal in the quadrangle (see Figure 15). Figure 34 indicates where the remaining coal is located.

Eleven of the 13 land-use restrictions and all four technological restrictions identified for the Saxonburg quadrangle intersect the Upper Kittanning coal bed. Their gross tonnages are presented in Table 1. Figures 35 and 36 provide a graphical companion to this table, further

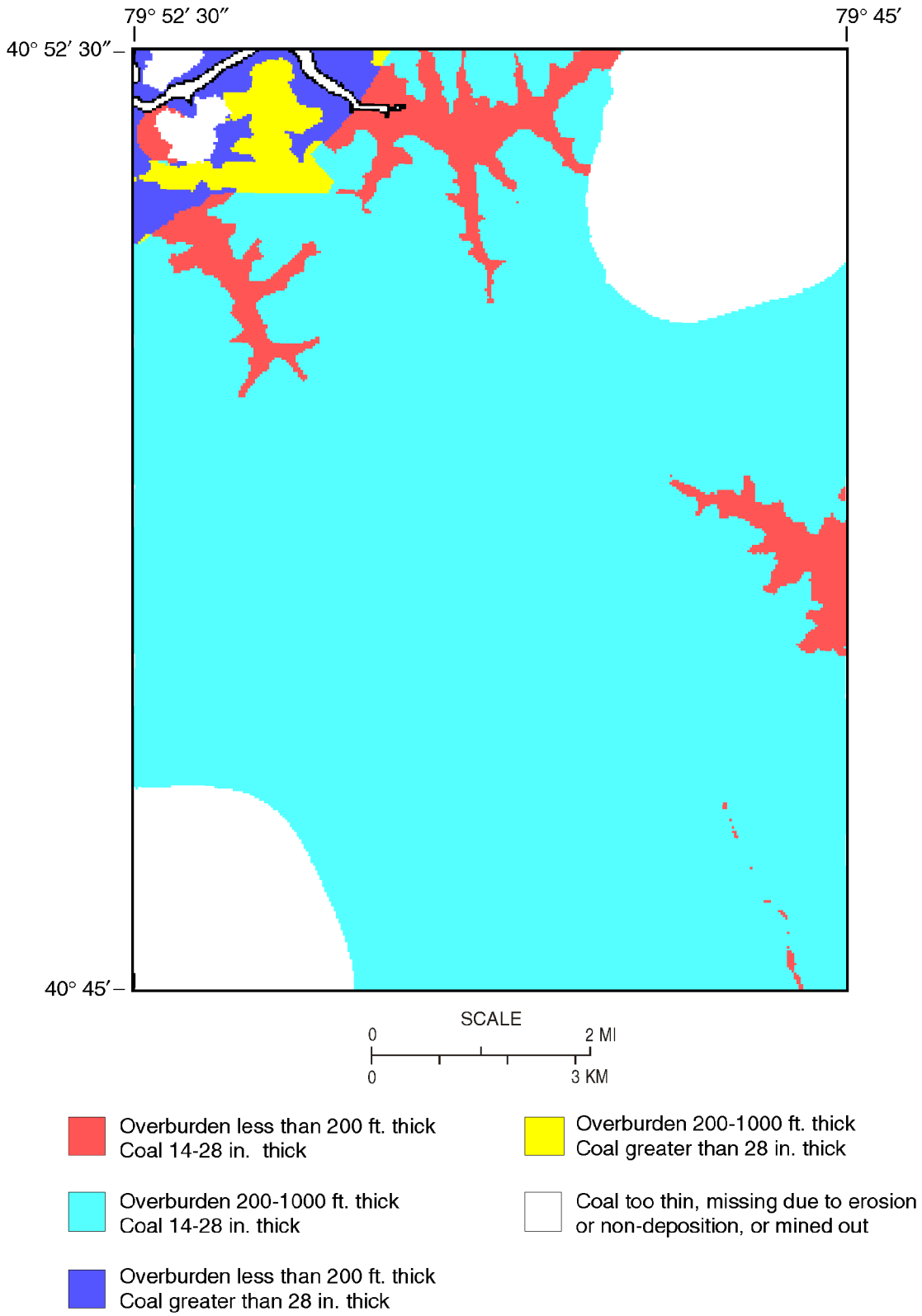

Figure 30. Remaining Middle Kittanning coal by coal-bed and overburden thickness categories.

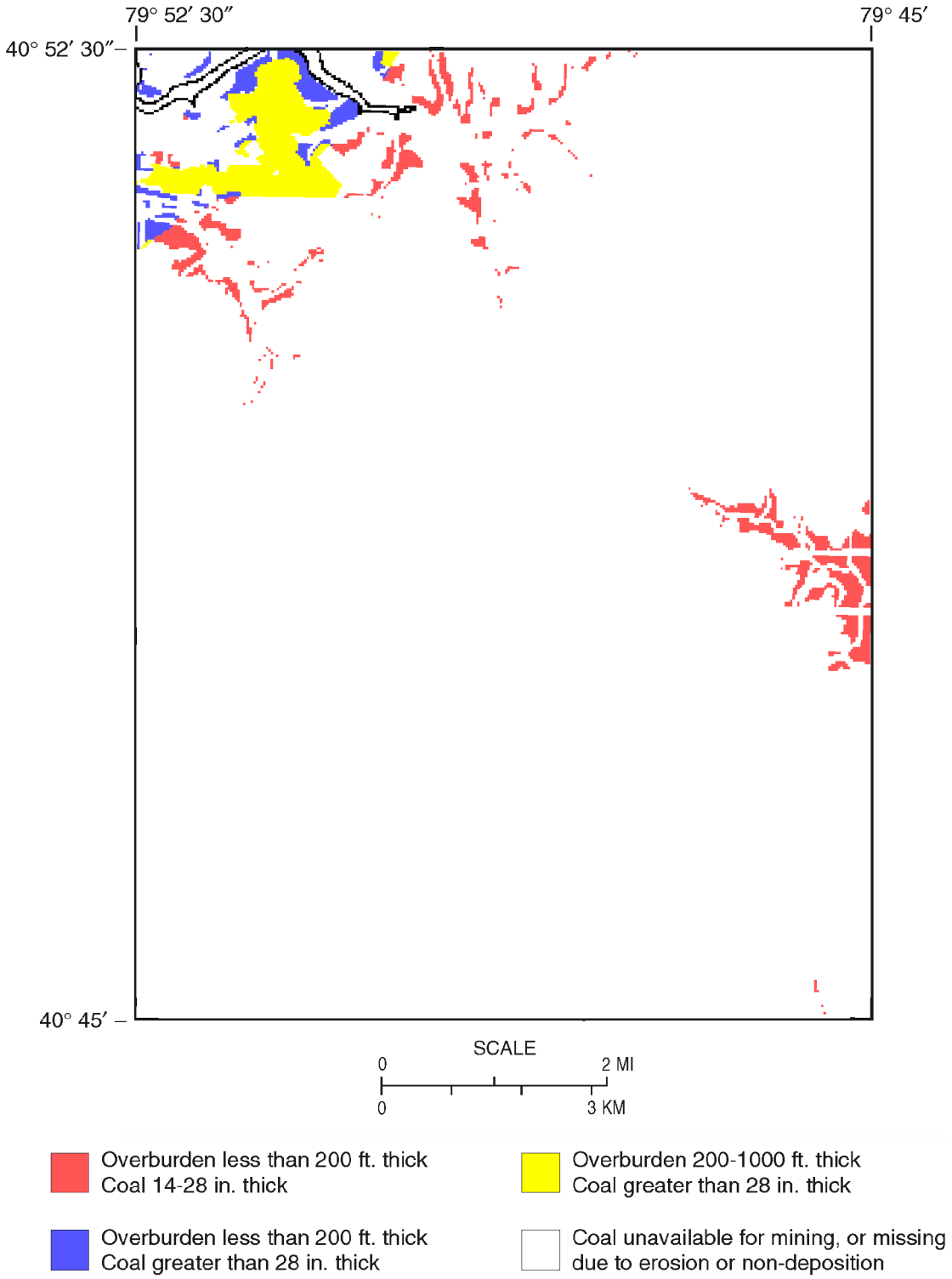

Figure 31. Available Middle Kittanning coal by coal-bed and overburden thickness categories.

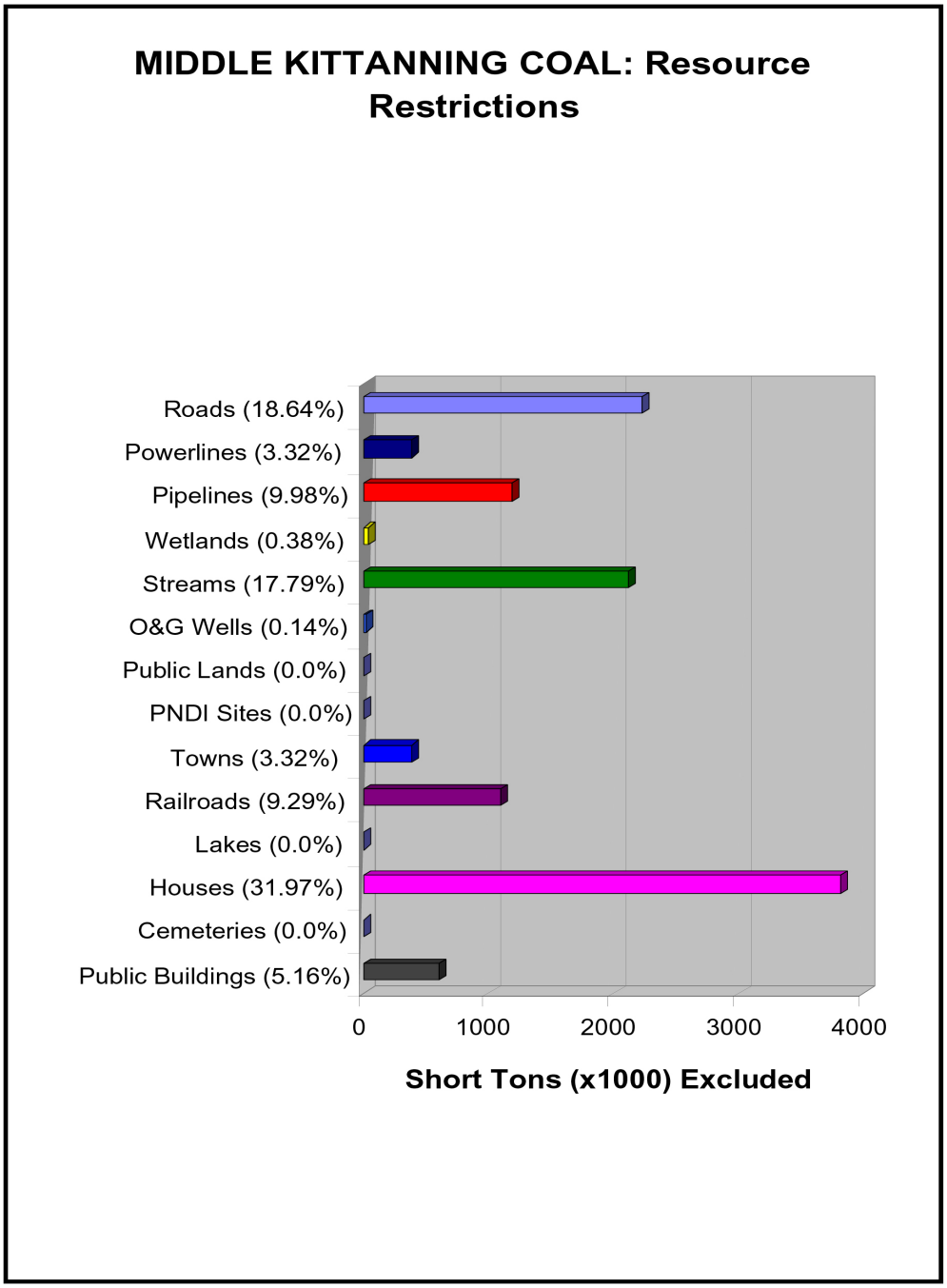

Figure 32. Impact of individual land-use restrictions on the Middle Kittanning coal bed.

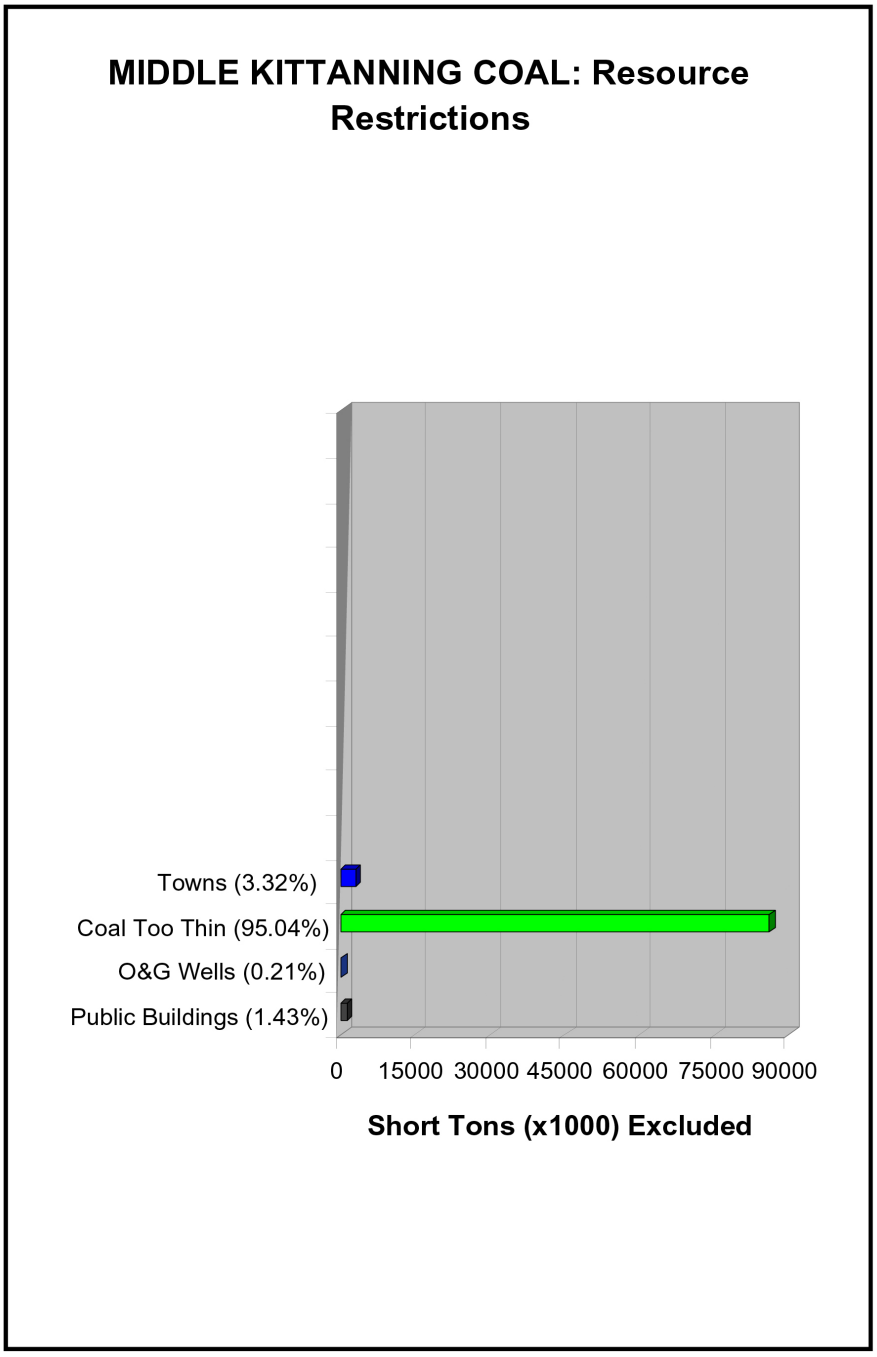

Figure 33. Impact of individual technological restrictions on the Middle Kittanning coal bed.

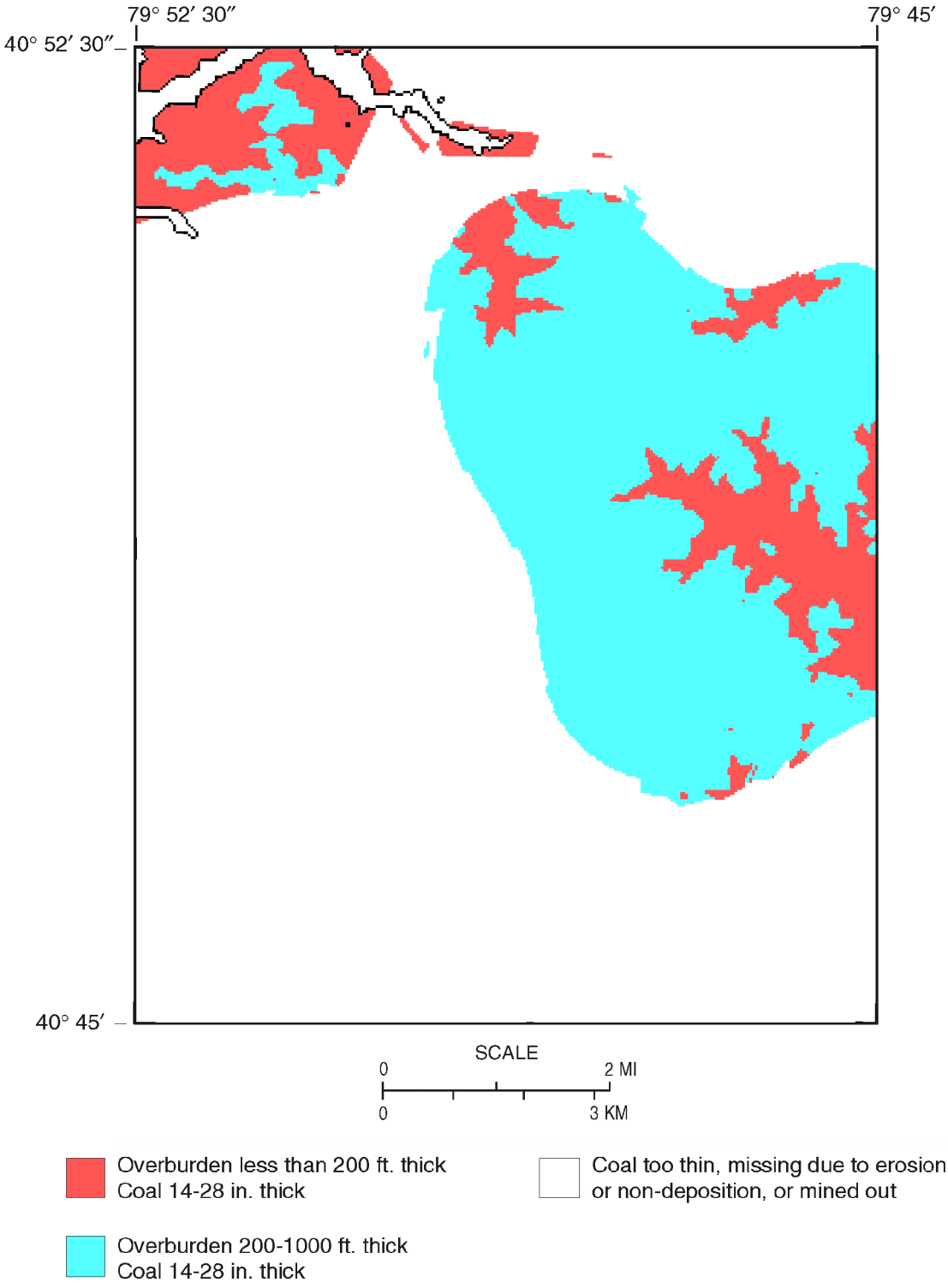

Figure 34. Remaining Upper Kittanning coal by coal-bed and overburden thickness categories.

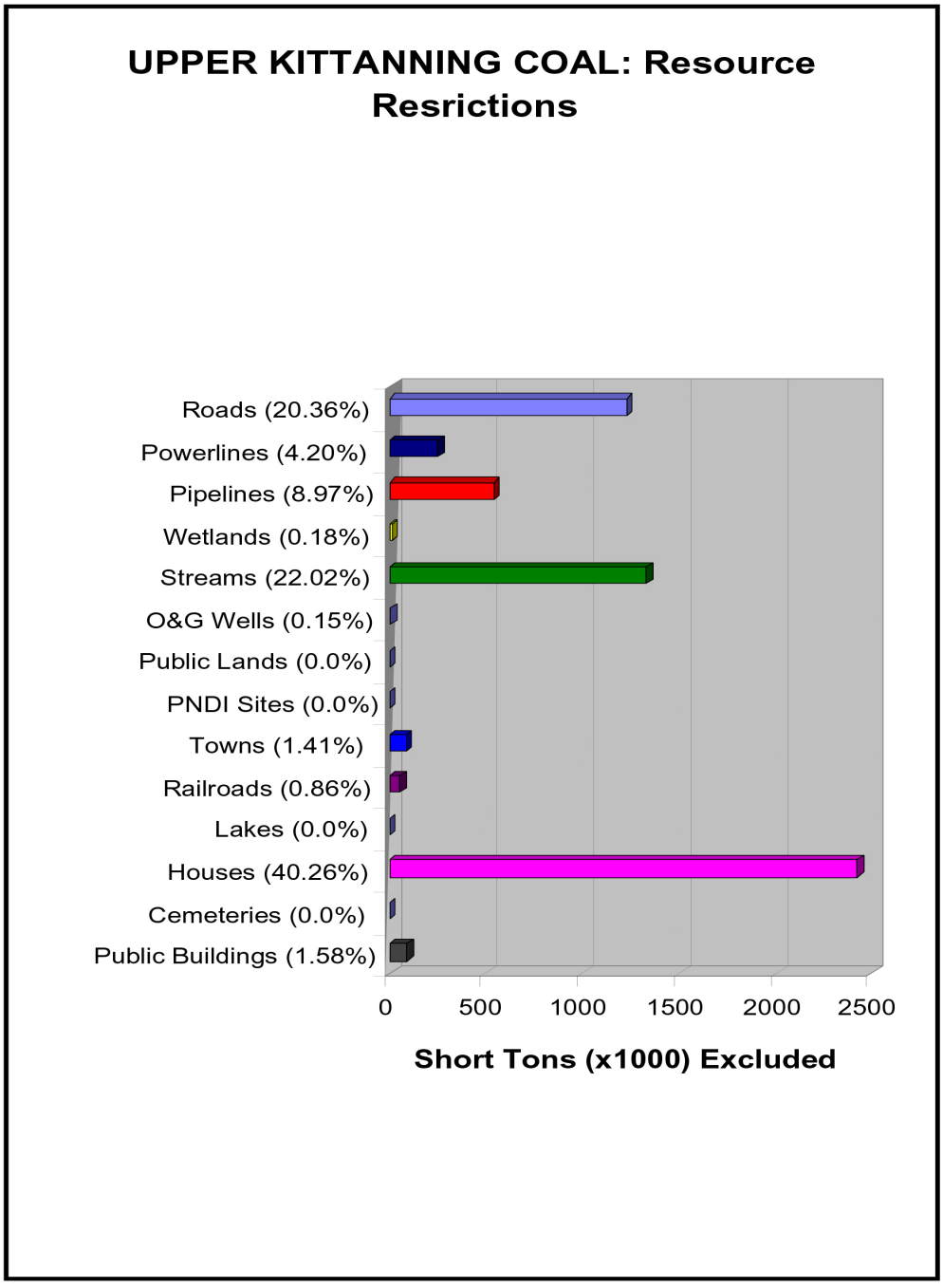

Figure 35. Impact of individual land-use restrictions on the Upper Kittanning coal bed.

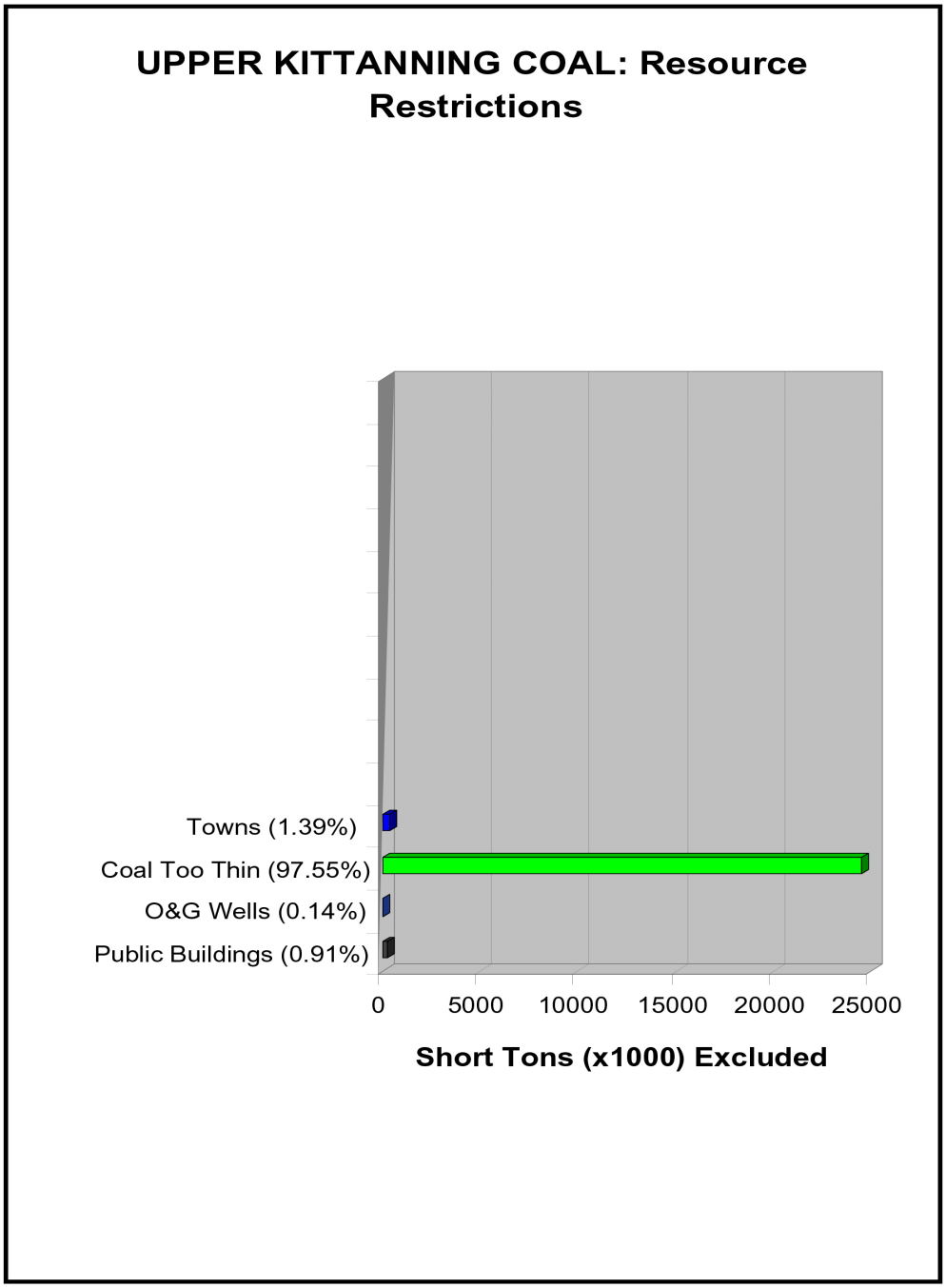

Figure 36. Impact of individual technological restrictions on the Upper Kittanning coal bed.

illustrating the effect of restrictions to mining on the resource. These restrictions remove nearly 29 million short tons of coal from development, leaving a little more than 4 million short tons, or approximately 13 percent of the original coal resource, available for mining. The relationship of original, remaining and available coal is given in Appendix A. Figure 37 indicates where the available coal occurs in the quadrangle.

Based upon the existing data, all of the Upper Kittanning coal is less than 28 inches thick and is unlikely to be a target for deep mining. However, of the more than 4 million short tons of available coal, all of it is in less than 200 feet of overburden, thus making it potentially surface minable along and away from its outcrop. The most likely area for surface mining would be in the northwestern corner of the quadrangle along Bonnie Brook. Approximately 81 percent of this coal falls into the "inferred " category, meaning many of the data points may be up to as much as 3 miles apart from each other. With that in mind, it is possible that between these data points coal greater than 28 inches thick may occur, as it does in the quadrangles which surround this quadrangle, and is just not identified here. Just as it was for the other coals, the category "bed too thin" accounts for the primary restriction type and removes all the remaining coal in overburden greater than 200 feet thick. The various classification totals are shown in Appendix B.

LOWER FREEPORT COAL BED SUMMARY

The Lower Freeport coal bed accounted for greater than 64 million short tons, or approximately 11 percent, of the total original coal found in the Saxonburg quadrangle (see Figure 15). About 286 thousand short tons has been mined out by contour surface mining, and by drift deep mining (refer to Figure 13), leaving just under 64 million short tons remaining for future development (Figure 38). The mapped deep mine is very small, perhaps a country bank mine, that removed only about 6 thousand short tons of coal from outcrop and a short distance into the hillside in coal that was 28 or less inches thick and in overburden less than 200 feet thick. The history of this small mine could not be readily determined by the authors.

Twelve of the 13 land-use and all four of the technologic restrictions identified for the study quadrangle intersect the coal bed. Their gross tonnages are given in Table 1. Figures 39 and 40 provide a graphical companion to this Table, by pictorially illustrating the amount of coal excluded by the various restrictions. These land-use and technological restrictions remove

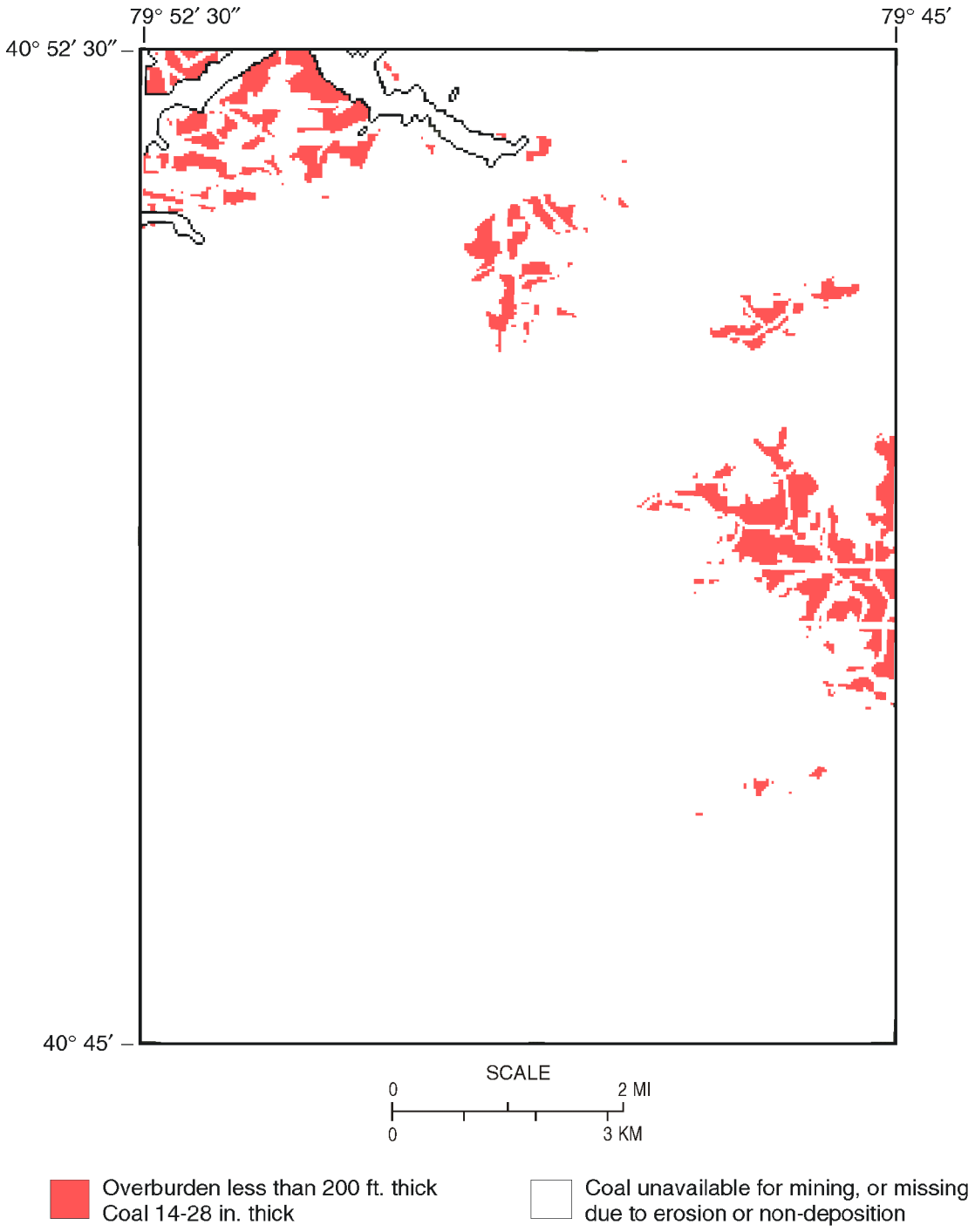

Figure 37. Available Upper Kittanning coal by coal-bed and overburden thickness categories.

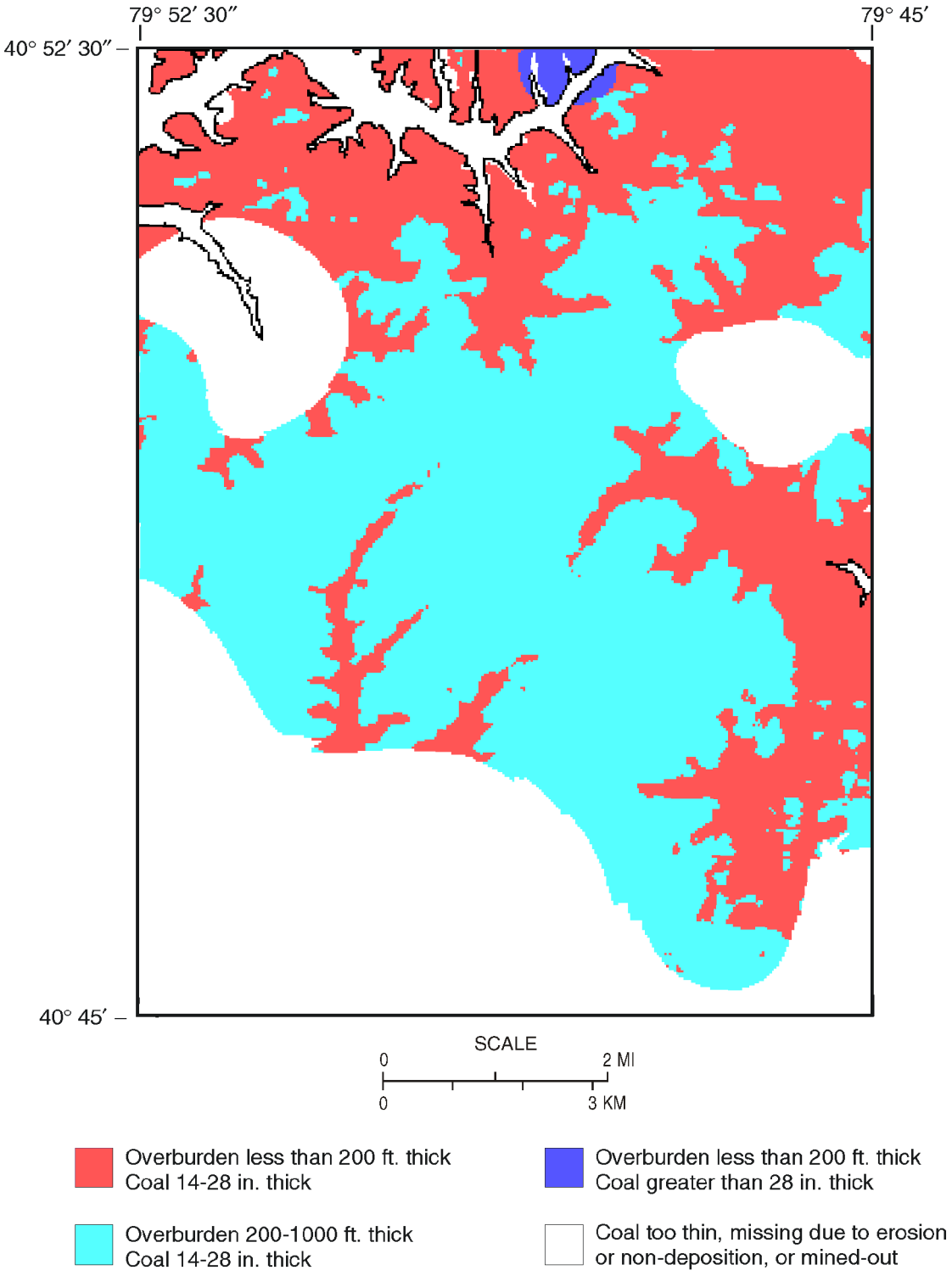

Figure 38. Remaining Lower Freeport coal by coal-bed and overburden thickness categories.

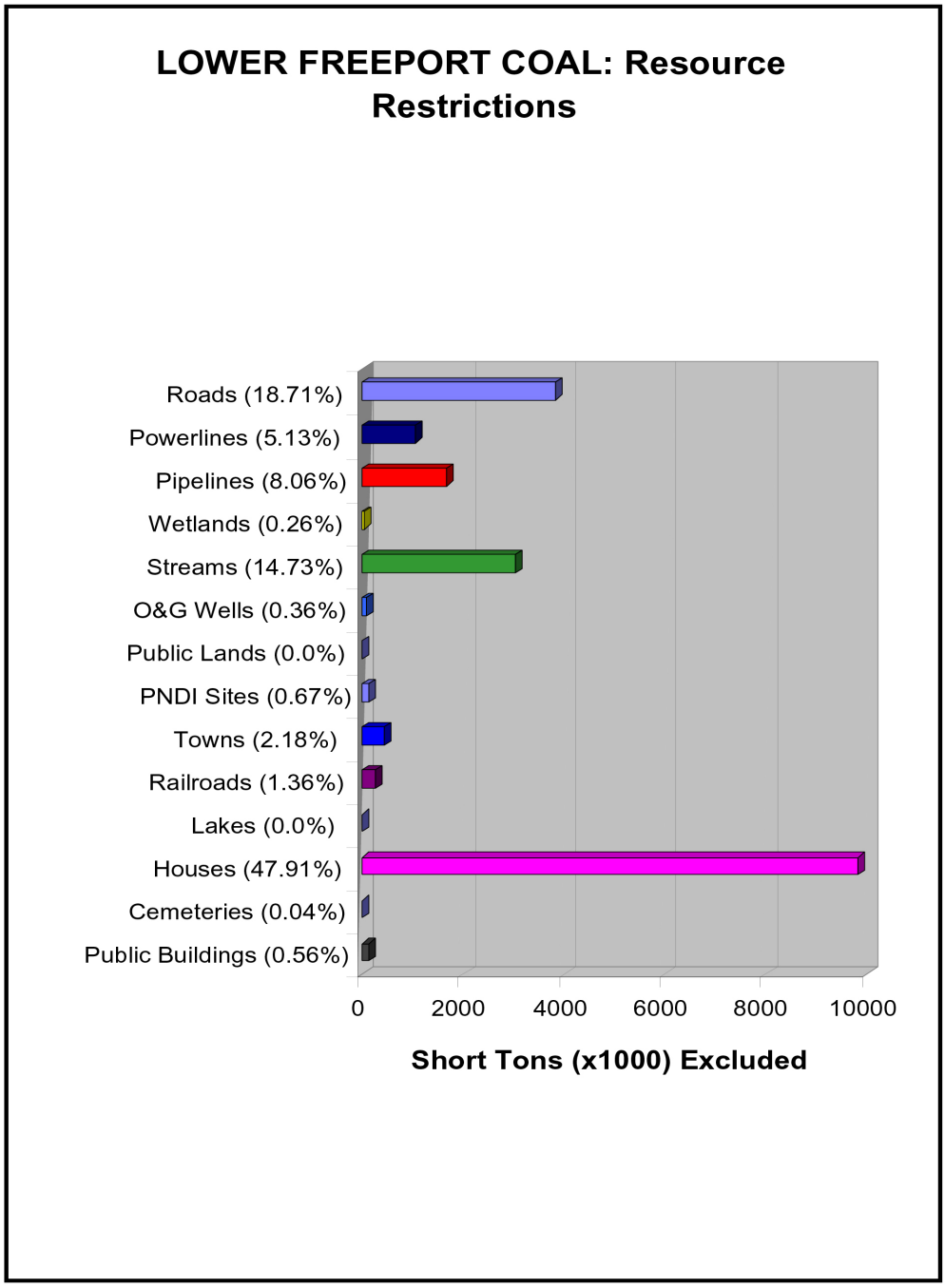

Figure 39. Impact of individual land-use restrictions on the Lower Freeport coal bed.

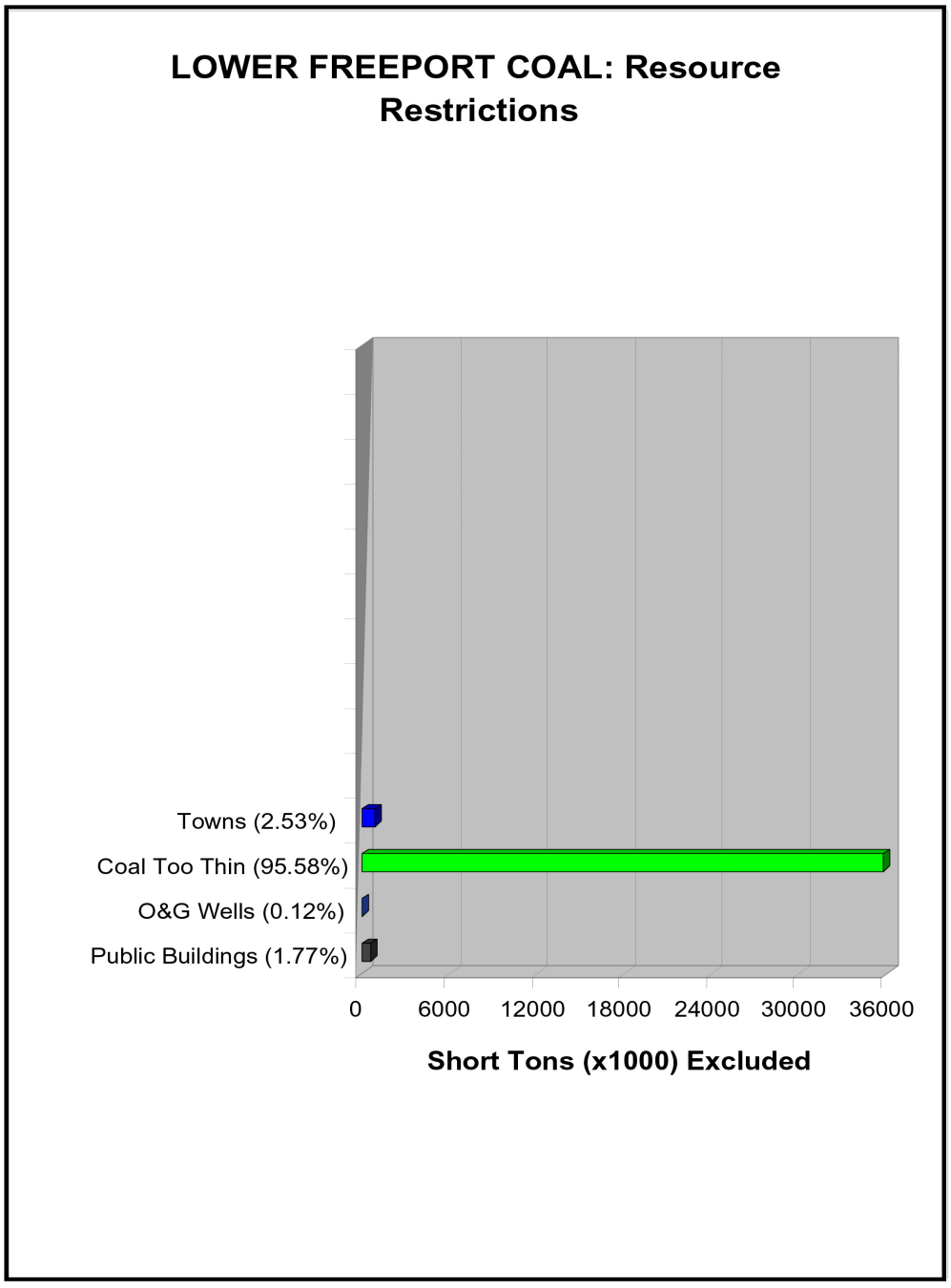

Figure 40. Impact of individual technological restrictions on the Lower Freeport coal bed.

nearly an additional 50 million short tons of coal from potential mining, leaving a little over 14 million short tons, or about 14 percent of the original resource available for surface or underground mining. The category "bed too thin" was the dominant restriction for this coal bed removing nearly 36 million short tons of coal from consideration for deep mining. Houses are the main restriction concern for surface mining of this coal bed. Appendix A gives a pictorial of the relative amounts of original, mined-out, remaining, and available coal. Figure 41 depicts the available coal in the quadrangle.

Of the available coal, 96 percent is less than 28 inches thick. Therefore, it is unlikely the remaining 4 percent of coal that is 28 or more inches thick will ever be deep mined in this quadrangle using current mining practices, because the resultant small block size is probably uneconomical. What is not known, though, is if this pocket of greater than 28 inch coal extends northward into the adjacent quadrangle for some distance to where a large enough block size could be assured and a deep mine could be developed somewhere along crop. However, since the greater than 28-inch coal is concentrated in one area along eastern Bonnie Brook northeast of the community of Wadsworth, and is in under 200 feet of cover, surface mining might be more practical instead. Further investigation is needed. Surface mining in other areas where the Lower Freeport coal outcrops is also possible, but the coal bed will be thinner (less than 28 inches thick). Approximately 89 percent of the coal falls into the "indicated" and "inferred" fields with data points generally from 0.75 mile to 3 miles apart used to define the resource. This spacing may not have as large of an impact when determining surface-minable coal, especially if the coal is not prone to discontinuities because thinner coal is better tolerated during surface mining, but it is important for deep-minable coal. Calculated tonnages of surface- and deep-minable coal for measured, indicated and inferred categories are given at the end of this study in Appendix B.

UPPER FREEPORT COAL BED SUMMARY

The Upper Freeport coal bed accounts for the largest percentage of coal present in the quadrangle. Over 152 million short tons of coal, or approximately 26 percent of the original coal found in the quadrangle, is Upper Freeport coal (see Figure 15). Of this amount, just under 10 million short tons of coal has been previously mined out by surface- and underground-mining methods (refer to Figure 12), leaving nearly 143 million short tons remaining for future mining

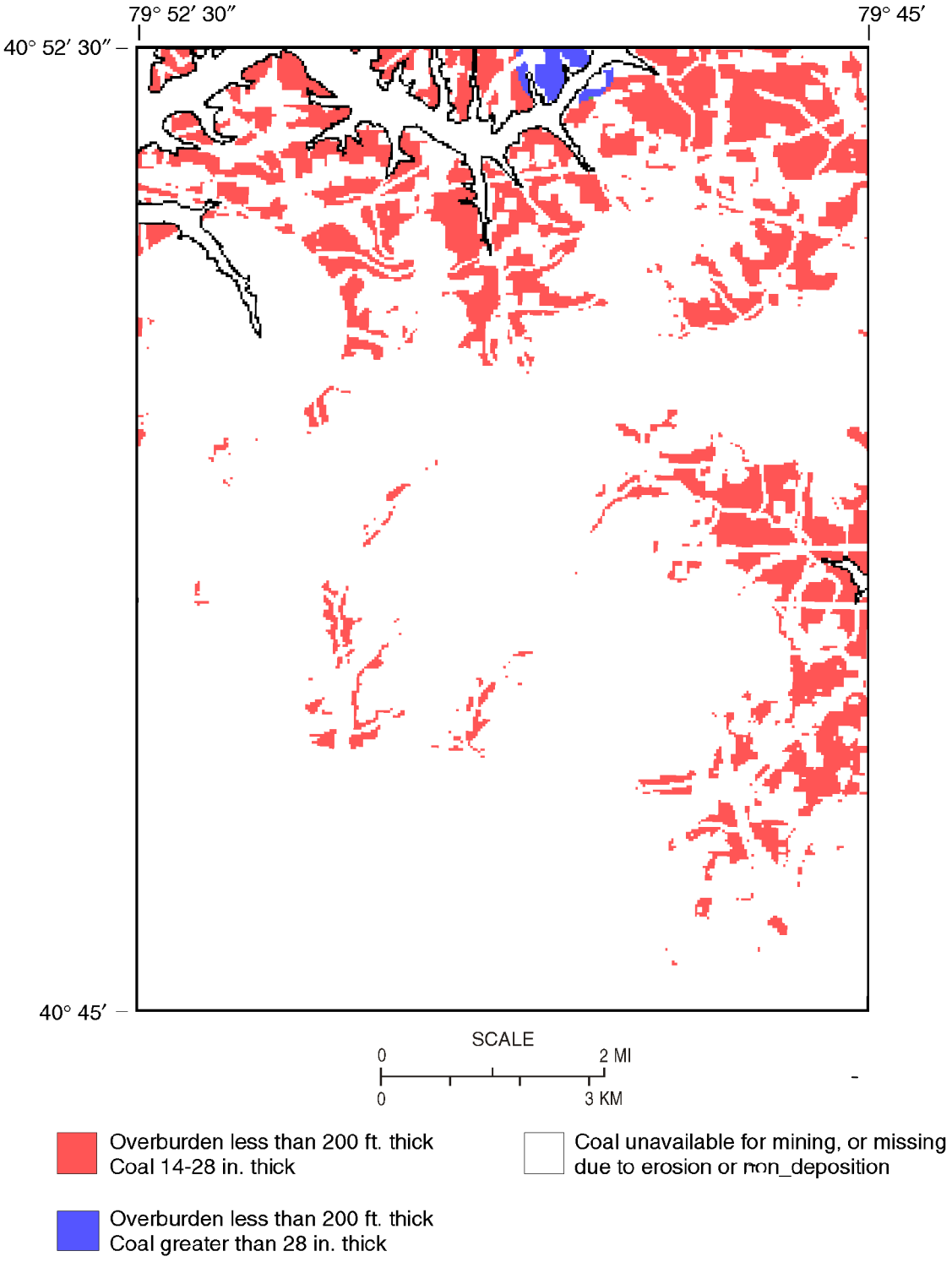

Figure 41. Available Lower Freeport coal by coal-bed and overburden thickness categories.

(Figure 42). Most of this mining has occurred along Bonnie Brook in the northern portion of the quadrangle, initially as contour-following surface mines and then finally taken from crop into the hillsides as drift deep mines. Largest deep mines are concentrated along Coal Run, with other smaller mines located along Little Buffalo Run, Rough Run and Thorn Creek. A single small shaft deep mine was opened in the southeastern corner of the quadrangle. The history of the shaft mine is not known. As of 1996 these mines were no longer in operation; most of the surface mines have since been reclaimed.

All 13 land-use and all four technological restrictions intersect this coal bed. Houses are the primary land-use restriction affecting surface mining, whereas the "bed too thin" category is the primary technological restriction affecting deep mining. Gross tonnages are given in Table 1. Figures 43 and 44 provide a companion set of graphs to this Table, illustrating the amount of coal excluded due to these individual land-use and technological restrictions. These land-use and technological restrictions remove another 60 to 61 million short tons of coal from potential mining in the Saxonburg quadrangle, leaving just under 82 million short tons, or about 54 percent of the original coal resource, available for surface or underground mining (Figure 45). The relative proportions of original, mined-out, remaining, and available coal are depicted as bar histograms in Appendix A.

A majority of the available coal falls in the "indicated" category of the resource estimate totals, meaning that the data point spread is more uniform and closer spaced—less than 0.75 mile apart. If one combines the "measured" and "indicated" categories, then about 88 percent of the coal resource is defined by data having a spacing of less than 0.25 to 0.75 mile between data points. Twenty-three percent of this resource is classed as measured, indicating that it is well defined by the data. Nearly 83 percent, or about 68 million short tons, of the available coal is greater than or equal to 28 inches thick. Of this amount, 32 million short tons is 28 inches or more thick and found in more than 200 feet of overburden, a future deep-minable resource. Past underground-mining practices have mined coal that was in less than 200 feet of cover, and even mined coal that was less than optimal ($\geq$ 28 inches) thickness for deep mining. This practice is reflected in the category "mined out"-"deep" in the tally for this coal in Appendix B, where almost all of the coal accounted for as deep mined is listed as 0-200 feet deep. The total amount of available coal in the quadrangle will not vary, but the ratio of surface-minable to deep-minable coal will be different from that calculated in this report if future mining were to continue

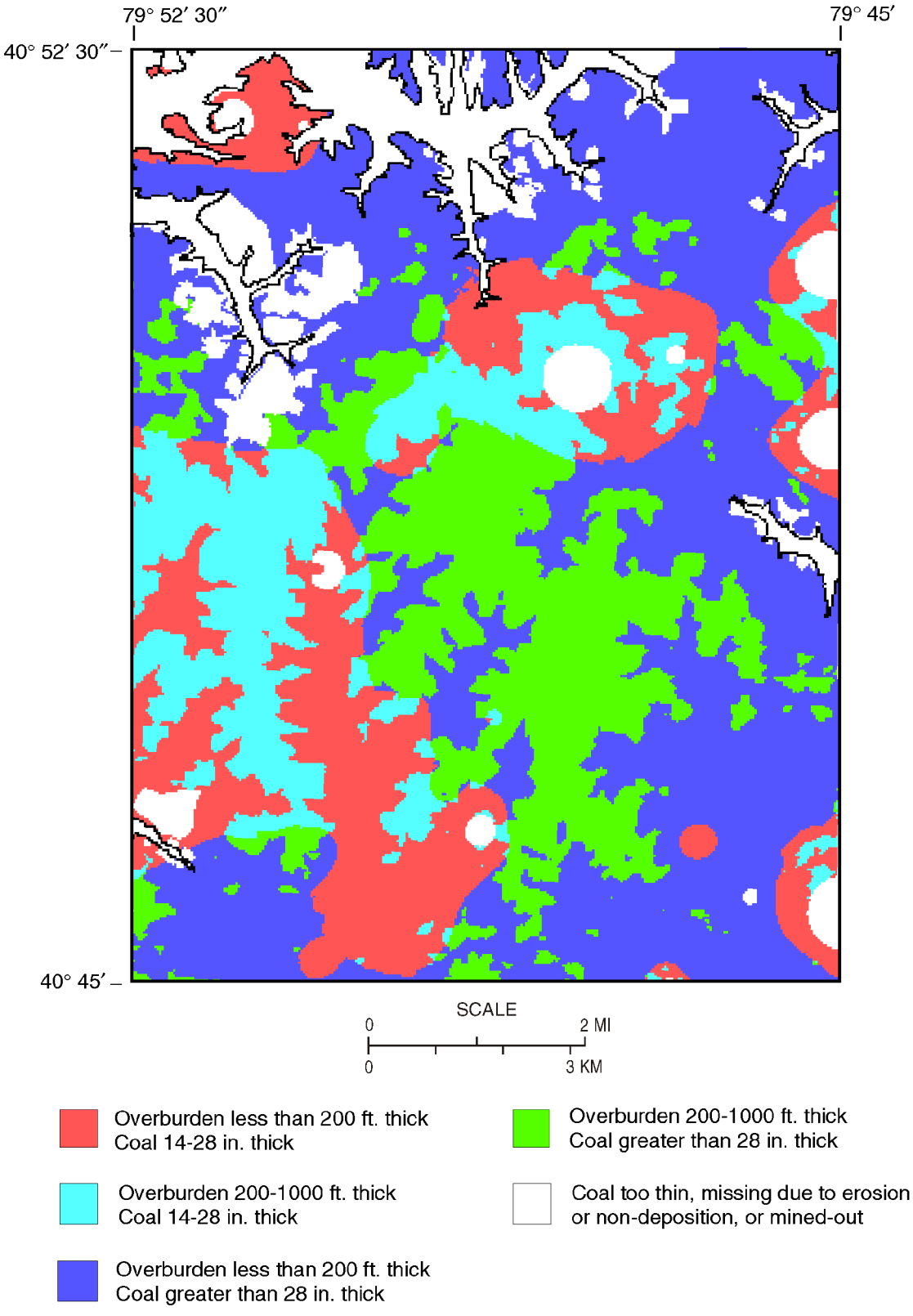

Figure 42. Remaining Upper Freeport coal by coal-bed and overburden thickness categories.

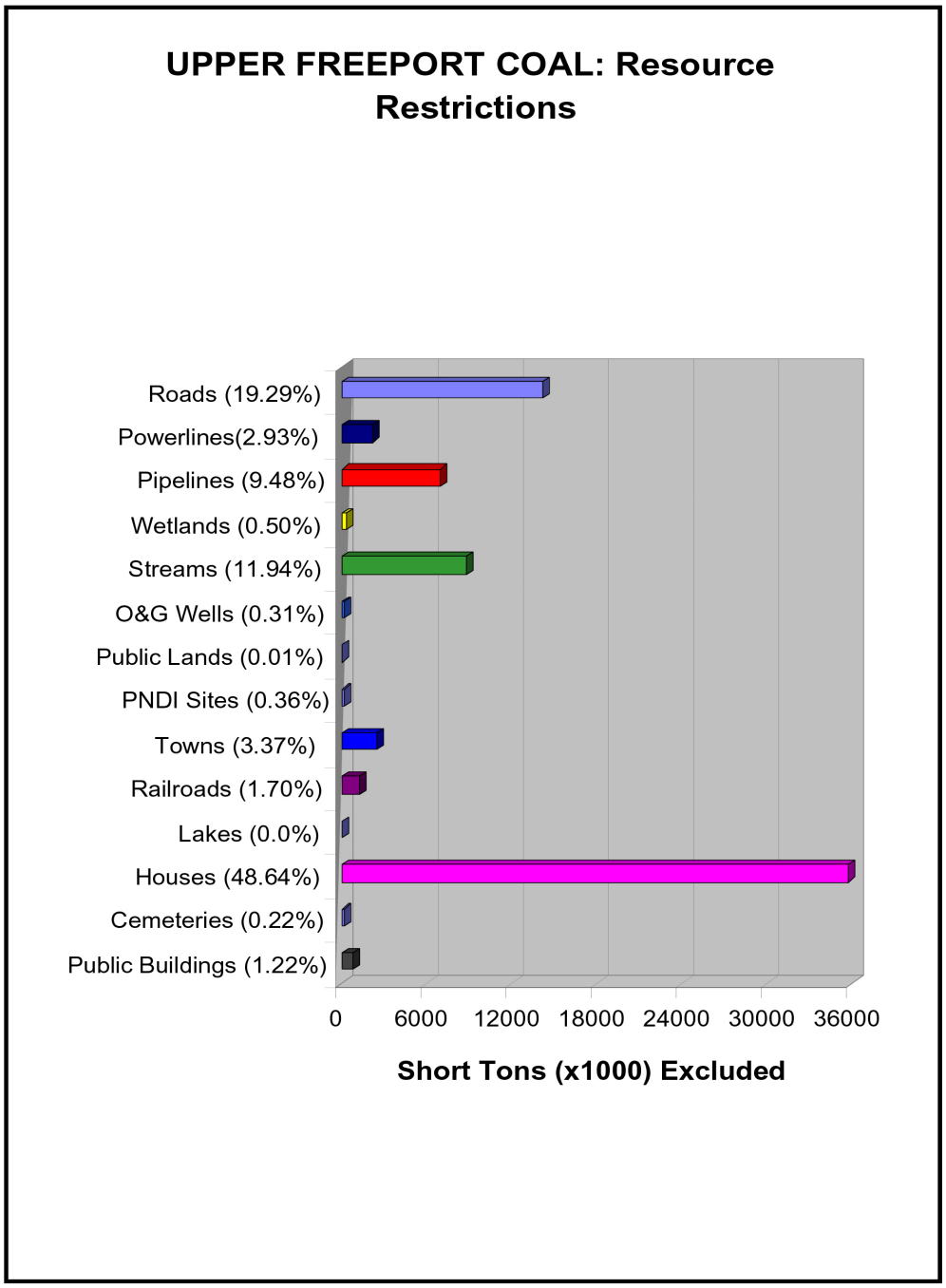

Figure 43. Impact of individual land-use restrictions on the Upper Freeport coal bed.

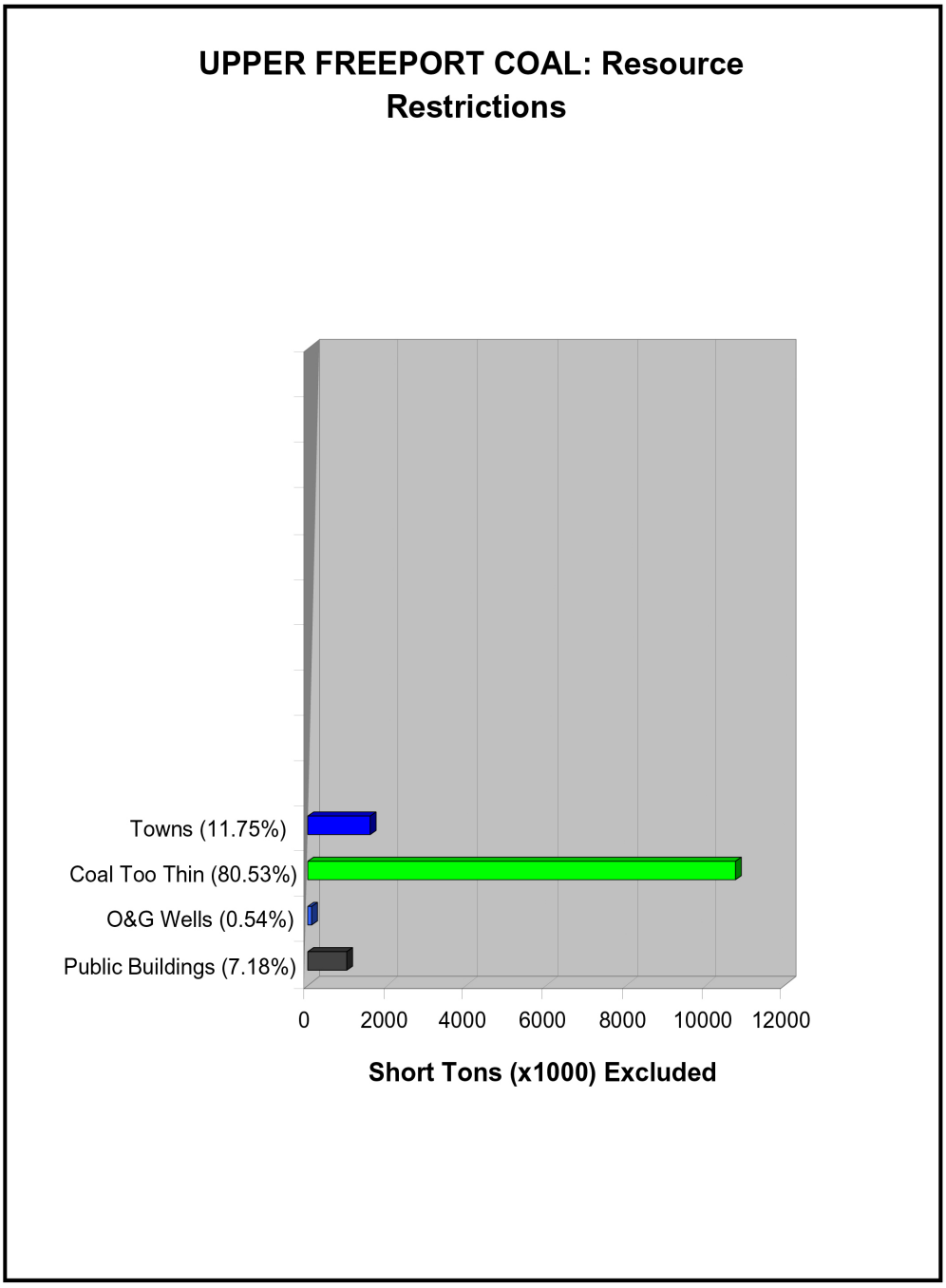

Figure 44. Impact of individual technological restrictions on the Upper Freeport coal bed.

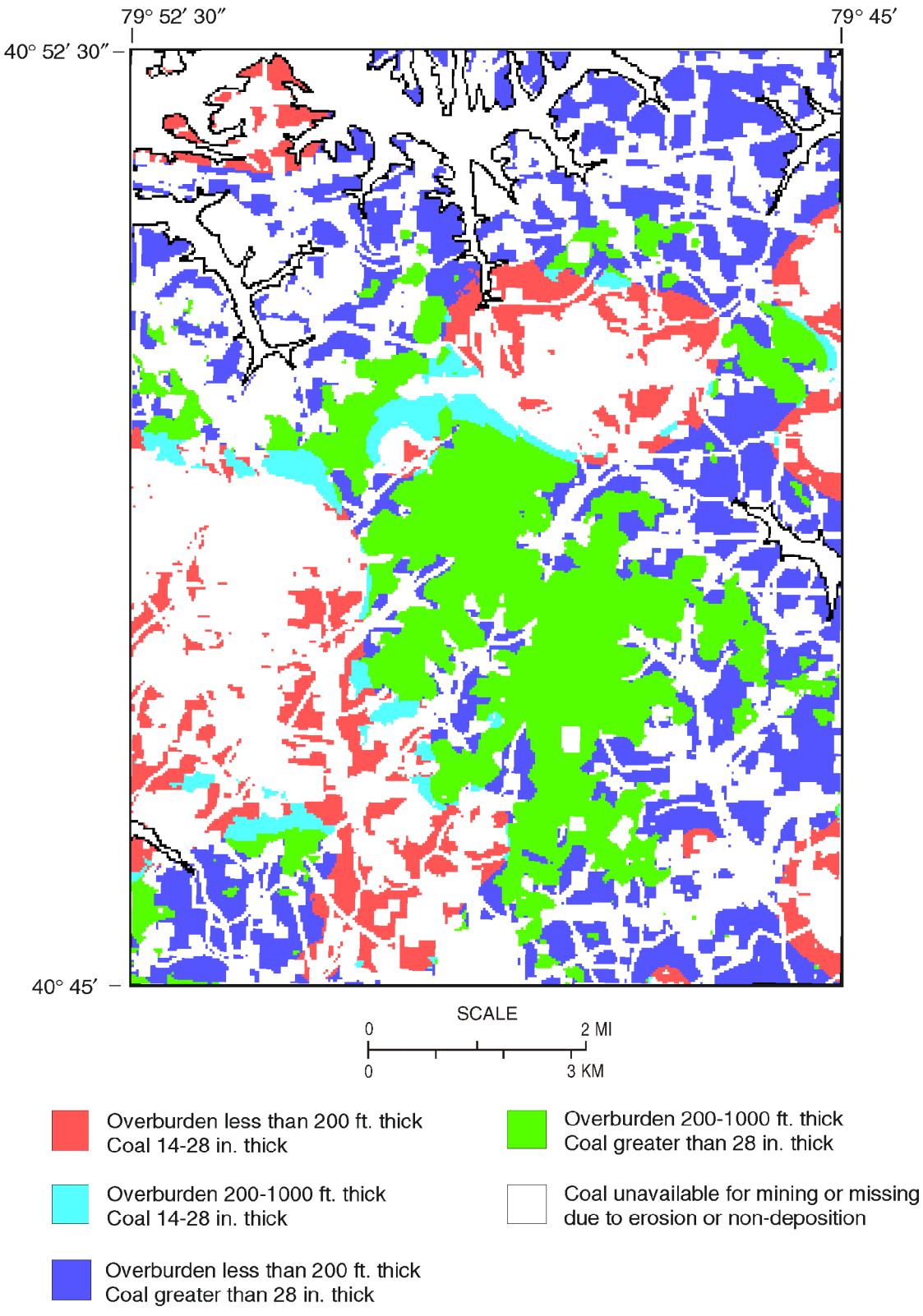

Figure 45. Available Upper Freeport coal by coal-bed and overburden thickness categories.

this past practice. The nature of the Upper Freeport coal bed with its abrupt thinning, erosion features, and other bed discontinuities dictates that additional drilling will have to be completed in this area to better define the resource (i. e. more of the resource defined as "measured") before additional mining, especially underground mining, is considered in this area. As Figure 45 illustrates, the coal in the center of the quadrangle would be a likely target for underground mining. It is deep and thick enough and not impacted by restrictions. Additional surface mining would appear to be feasible along crop at Bonnie Brook and Little Buffalo Run in the northern part of the quadrangle.

COAL QUALITY

A more rigorous look at the effect of coal quality on the resource is intended to be provided by the former U.S. Bureau of Mines personnel upon completion of this report (known as Coal Recoverability). However, due to downsizing in the Federal government in the 1990s, the ability to do such a follow-up study is now unlikely in the short term. Although data existed about the quality of the Upper Freeport and Lower Freeport seams, time did not permit the authors to do a most basic analysis of them for their inclusion into this report. These data will be given to the U.S.G.S., however, to hold on to until such time the follow-up Coal Recoverability study can be initiated for this quadrangle.

QUADRANGLE SUMMARY

Resources were calculated for seven coal seams: the Clarion, Scrubgrass, Lower Kittanning, Middle Kittanning, Upper Kittanning, Lower Freeport, and Upper Freeport. By associating two thickness categories (14 to 28 inches, and 28 inches or greater) with three overburden categories (less than 200 feet, representing surface-minable resources; and 200 feet to 1000 feet, and greater than 1000 feet, both representing deep-minable resources) for each seam, tonnages for original, mined-out, and remaining coal could be calculated. Since structure maps constructed for each of the study coal beds indicated that the beds were never under more than 1000 feet of overburden, the category for overburden "greater than 1000 feet" could therefore be dropped from the calculations. All land-use and technological restrictions to mining were identified for the quadrangle and their appropriate buffers were digitized, compiled, and the resultant areas subtracted from the remaining coal polygons (as tonnages), yielding the amount

of coal available for mining. The reliability of the resource estimate is expressed by the following categories: measured, indicated, inferred, and hypothetical. Each successive category defines a decreasing degree of assurance in the extrapolated thickness value of a known data point for incrementally greater (predefined) distances away from that point. They are measured (from point of measurement to 0.25 mile away); indicated (0.25 to 0.75 mile away); inferred (0.75 to 3 miles away); and hypothetical (3 miles or more away up to a predetermined upper distance limit). With the deeper coal beds, such as the Clarion, there were fewer data points from which to optimally define the resource; as a result more hypothetical coal was calculated as compared to the shallower coal beds.

Based on the criteria given above, the original, mined-out, remaining, restricted, and available coal resources for those seven coal seams in the Saxonburg quadrangle were calculated and have been placed in the accompanying tables, charts, and figures of this report. Table 2 provides a summary of this information. Of an estimated original coal resource of over 570 million short tons in the Saxonburg quadrangle, a little over 11 million short tons, or approximately 2 percent, has been mined out or lost in mining. Nearly an additional 373 million short tons, or about 65 percent, was restricted due to modern day regulatory statues or technological impediments which impact surface and underground mining, leaving a resource estimated at over 186 million short tons, or nearly 33 percent, available for future extraction. Of the seven coals, the Upper Freeport and the Lower Kittanning had the highest percentage of available coal to original coal, each had around 50 percent (53.8 percent and 47.4 percent, respectively) of their original tonnage still available for mining.

ACKNOWLEDGMENTS

The authors would like to thank M. Devereux Carter and Susan J. Tewalt of the U.S. Geological Survey for their help along the way as we assimilated the rudiments of the Coal Availability Study process and the many answers to questions that we posed. Also thanks to Donald Johnson of the U.S. Geological Survey for his assistance in helping us maintain the Pennsylvania Geological Survey's NCRDS database link.

Thanks goes to Jack Bergman (retired), Jim McKay, and Jim Welsh of the Pennsylvania Department of Environmental Protection's Bureau of Mining and Reclamation, McMurray District Office for providing us access to mine maps, to Fran Koch of the Commonwealth's

Table 2. Estimated Original, Mined, Remaining, Restricted, and Available Coal Resources in the Saxonburg Quadrangle (in thousands of short tons)[1]

COAL BED	ORIGINAL			MINED			REMAINING		
	0-200'	>200'	TOTAL	0-200'	>200'	TOTAL	0-200'	>200'	TOTAL
UPPER FREEPORT	103,566	48,926	**152,492**	9,533	275	**9,808**	94,034	48,650	**142,684**
LOWER FREEPORT	28,306	35,878	**64,184**	286	0	**286**	28,020	35,878	**63,898**
UPPER KITTANNING	8,738	24,538	**33,276**	0	0	**0**	8,738	24,538	**33,276**
MIDDLE KITTANNING	11,549	88,528	**100,077**	973	104	**1,077**	10,576	88,424	**99,000**
LOWER KITTANNING	7,457	122,346	**129,803**	0	0	**0**	7,457	122,346	**129,803**
SCRUBGRASS	123	18,828	**18,951**	0	0	**0**	123	18,828	**18,951**
CLARION	2,595	68,992	**71,587**	0	0	**0**	2,595	68,992	**71,587**
TOTAL	**162,334**	**408,036**	**570,370**	**10,792**	**379**	**11,171**	**151,543**	**407,656**	**559,199**

COAL BED	RESTRICTED			AVAILABLE		
	0-200'	>200'	TOTAL	0-200'	>200'	TOTAL
UPPER FREEPORT	48,085	12,603	**60,688**	45,949	36,047	**81,996**
LOWER FREEPORT	13,871	35,873	**49,744**	14,149	5	**14,154**
UPPER KITTANNING	4,315	24,538	**28,853**	4,423	0	**4,423**
MIDDLE KITTANNING	6,972	85,848	**92,820**	3,604	2,576	**6,180**
LOWER KITTANNING	6,010	62,230	**68,240**	1,447	60,116	**61,563**
SCRUBGRASS	99	18,828	**18,927**	24	0	**24**
CLARION	2,088	51,196	**53,284**	507	17,796	**18,303**
TOTAL	**81,440**	**291,116**	**372,556**	**70,103**	**116,540**	**186,643**

[1]Table composited from GRASS “tables” directory, v_*.tab files. Summation of these individual restrictions is greater than total shown on appendices tables.

Department of Environmental Protection, Bureau of Dams, Waterways, and Wetlands for providing information about wetland regulations and maps, and finally to Edward Dix and others within the Pennsylvania Department of Conservation and Natural Resources, Bureau of Forestry who provided us with assistance in accessing the PNDI database.

The work of Bradley Wolf, and Michael Cypcar, summer Scientific and Technical Interns for the Pennsylvania Geological Survey, was quite instrumental in shortening the compilation time required for the mine-out areas maps, the quadrangle restrictions map, and some of the illustrations used for this study. Their assistance is greatly appreciated.

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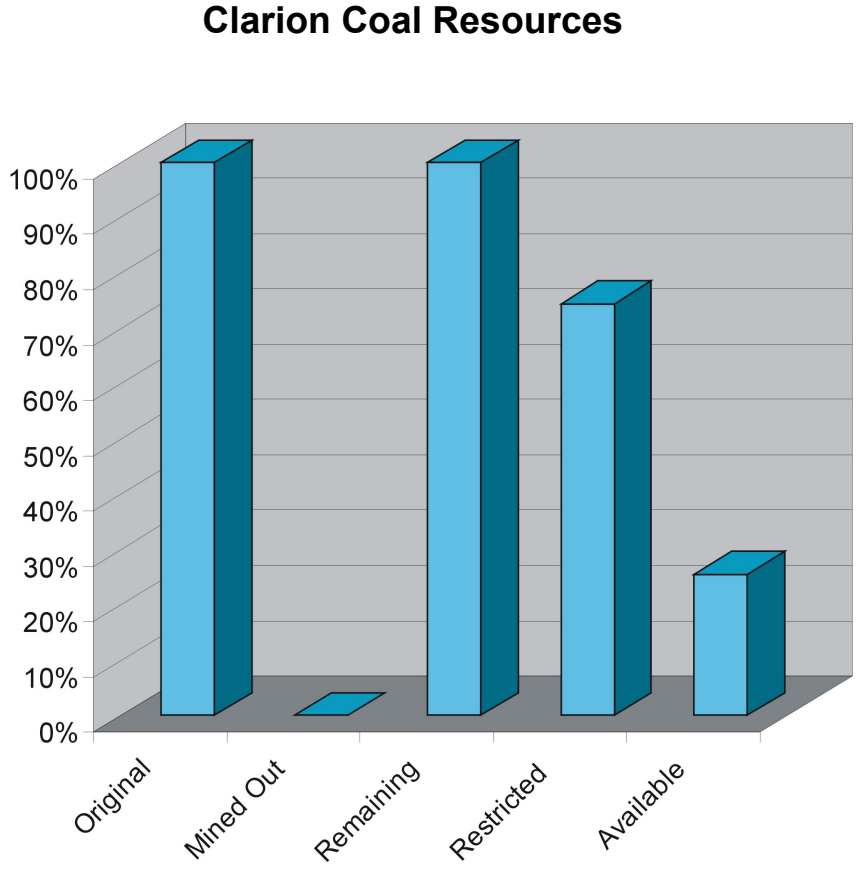
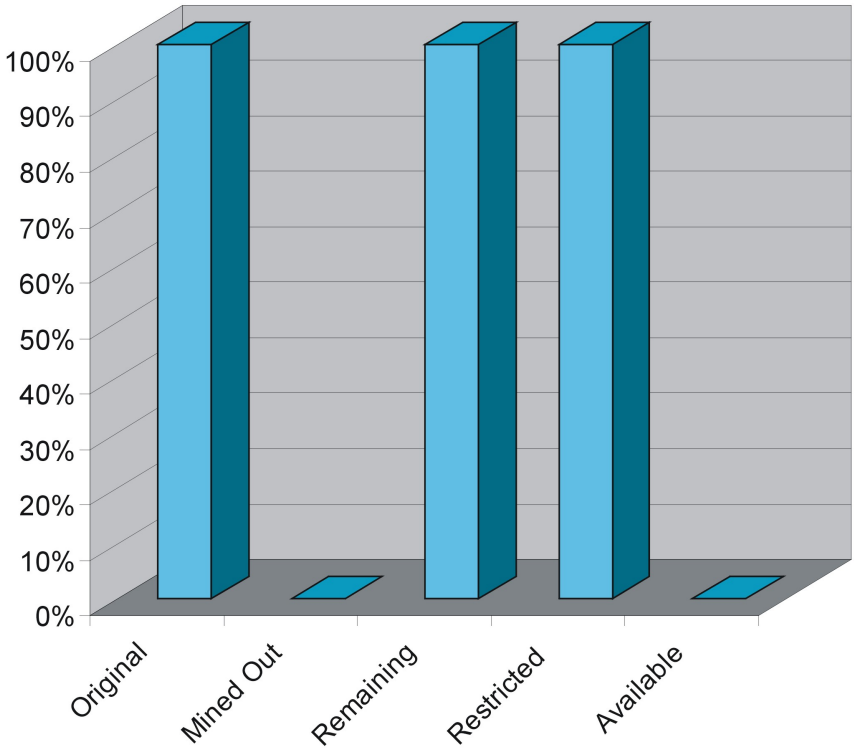
APPENDICES

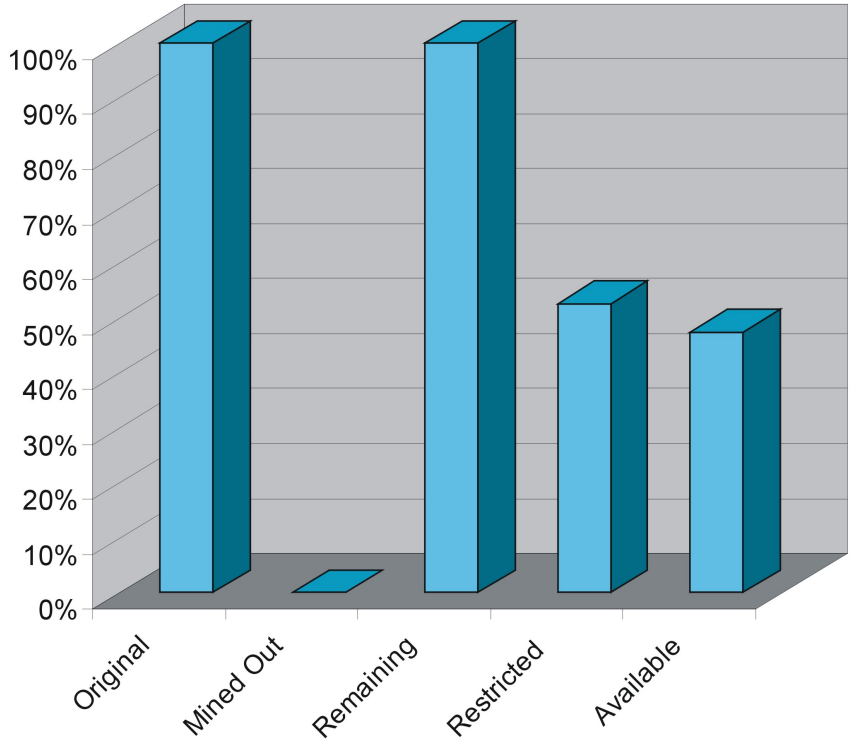
APPENDIX A. SAXONBURG COAL AVAILABILITY: BAR HISTOGRAMS OF THE CLARION, SCRUBGRASS, LOWER KITTANNING, MIDDLE KITTANNING, UPPER KITTANNING, LOWER FREEPORT, AND UPPER FREEPORT RESOURCES DEPICTING ORIGINAL, MINED-OUT, REMAINING, RESTRICTED, AND AVAILABLE COAL



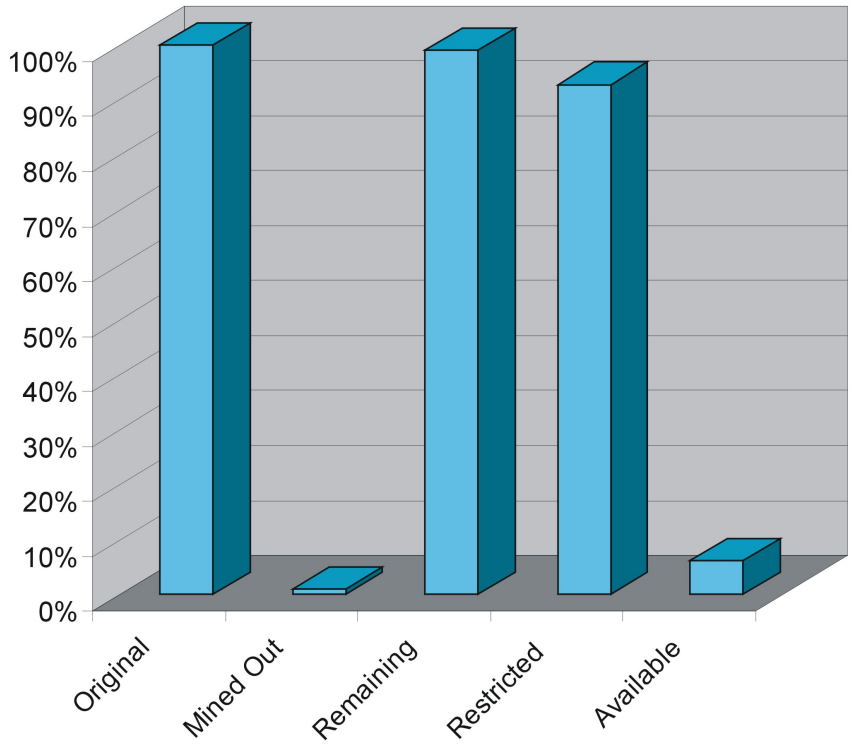
Scrubgrass Coal Resources



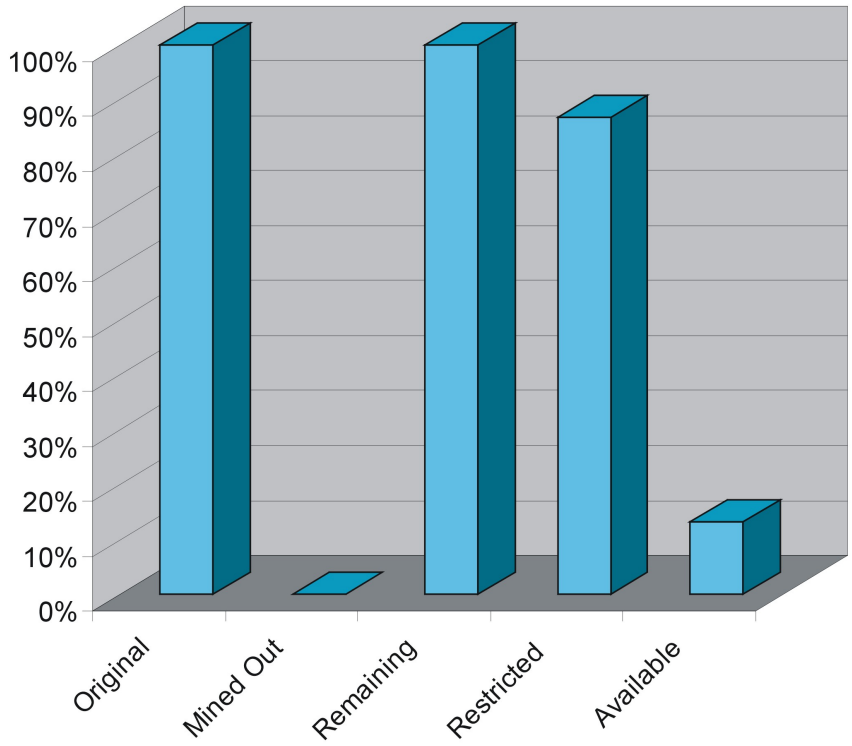
Lower Kittanning Coal Resources



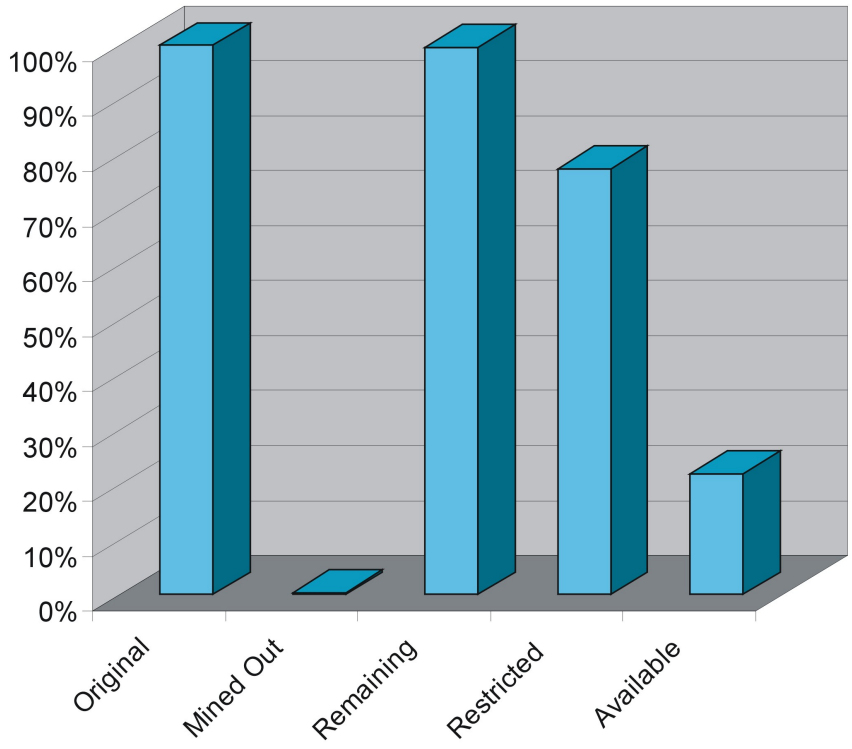
Middle Kittanning Coal Resources



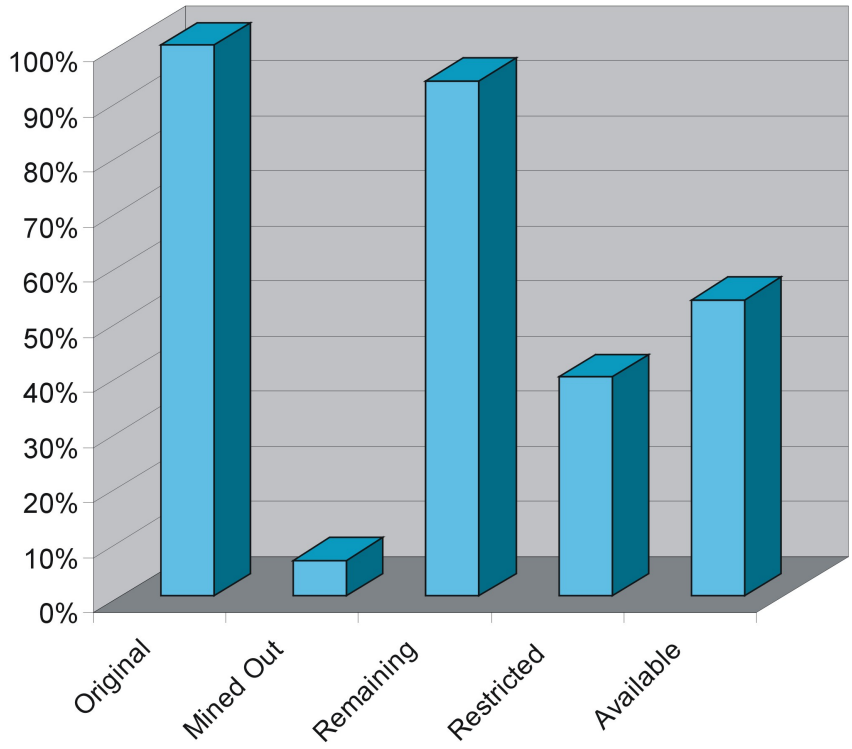
Upper Kittanning Coal Resources



Lower Freeport Coal Resources



Upper Freeport Coal Resources



APPENDIX B. RESOURCE SUMMARY TABLES FOR THE CLARION, SCRUBGRASS, LOWER KITTANNING, MIDDLE KITTANNING, UPPER KITTANNING, LOWER FREEPORT, AND UPPER FREEPORT COAL BEDS

Estimated coal resources of the Clarion coal bed
in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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	553	553	1,512	530	2,042	1,512	1,083	2,595
200-1000	216	0	216	1,608	0	1,608	22,538	6,303	28,841	26,705	11,622	38,327	51,067	17,925	68,992
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	216	0	216	1,608	0	1,608	22,538	6,856	29,394	28,217	12,152	40,369	52,579	19,008	71,587
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	553	553	1,512	530	2,042	1,512	1,083	2,595
200-1000	216	0	216	1,608	0	1,608	22,538	6,303	28,841	26,705	11,622	38,327	51,067	17,925	68,992
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	216	0	216	1,608	0	1,608	22,538	6,856	29,394	28,217	12,152	40,369	52,579	19,008	71,587
RESTRICTIONS															
LAND-USE															
0-200	0	0	0	0	0	0	0	316	316	1,437	335	1,772	1,437	651	2,088
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	316	316	1,437	335	1,772	1,437	651	2,088
TECHNOLOGIC															
200-1000	216	0	216	1,608	0	1,608	22,538	114	22,652	26,705	15	26,720	51,067	129	51,196
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	216	0	216	1,608	0	1,608	22,538	114	22,652	26,705	15	26,720	51,067	129	51,196
TOTAL															
0-200	0	0	0	0	0	0	0	316	316	1,437	335	1,772	1,437	651	2,088
200-1000	216	0	216	1,608	0	1,608	22,538	114	22,652	26,705	15	26,720	51,067	129	51,196
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	216	0	216	1,608	0	1,608	22,538	430	22,968	28,142	350	28,492	52,504	780	53,284
AVAILABLE															
0-200	0	0	0	0	0	0	0	237	237	76	195	270	75	432	507
200-1000	0	0	0	0	0	0	0	6,189	6,189	0	11,607	11,607	0	17,796	17,796
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	6,426	6,426	75	11,802	11,877	75	18,228	18,303

* Less than 1, not included in totals.
** Mined and lost-in-mining, by surface and deep mining methods.
Note: Totals may not equal sum of components because of independent rounding.

Estimated remaining coal resources of the Clarion coal bed
unavailable due to LAND-USE restrictions in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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
0-200															
Public Buildings	0	0	0	0	0	0	0	0	0	397	0	397	397	0	397
Houses	0	0	0	0	0	0	0	100	100	540	181	721	540	281	821
Oil and Gas Wells	0	0	0	0	0	0	0	0	0	0	5	5	0	5	5
Pipelines	0	0	0	0	0	0	0	42	42	320	0	320	320	42	362
PNDI Sites	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0
Powerlines	0	0	0	0	0	0	0	9	9	40	27	67	40	36	76
Railroads	0	0	0	0	0	0	0	0	0	605	0	605	605	0	605
Roads	0	0	0	0	0	0	0	32	32	481	49	530	481	81	562
Streams	0	0	0	0	0	0	0	221	221	539	209	748	539	430	969
Towns	0	0	0	0	0	0	0	0	0	191	0	191	191	0	191
Wetlands	0	0	0	0	0	0	0	0	0	56	0	56	56	0	56
Total**	0	0	0	0	0	0	0	316	316	1,437	335	1,772	1,437	651	2,088
200-1000															
Public Buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PNDI Sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powerlines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1000															
Public Buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PNDI Sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powerlines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL															
Houses	0	0	0	0	0	0	0	100	100	540	181	721	540	281	821
Oil and Gas Wells	0	0	0	0	0	0	0	0	0	0	5	5	0	5	5
PNDI Sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipelines	0	0	0	0	0	0	0	42	42	320	0	320	320	42	362
Powerlines	0	0	0	0	0	0	0	9	9	40	27	67	40	36	76
Public Buildings	0	0	0	0	0	0	0	0	0	397	0	397	397	0	397
Railroads	0	0	0	0	0	0	0	0	0	605	0	605	605	0	605
Roads	0	0	0	0	0	0	0	32	32	481	49	530	481	81	562
Streams	0	0	0	0	0	0	0	221	221	539	209	748	539	430	969
Towns	0	0	0	0	0	0	0	0	0	191	0	191	191	0	191
Wetlands	0	0	0	0	0	0	0	0	0	56	0	56	56	0	56
Total**	0	0	0	0	0	0	0	316	316	1,437	335	1,772	1,437	651	2,088

* Less than 1, not included in totals.
** Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Estimated remaining coal resources of the Clarion coal bed
unavailable due to TECHNOLOGIC restrictions in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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
0-200															
Public Buildings	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
Bed Too Thin	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
200-1000															
Public Buildings	0	0	0	2	0	2	537	0	537	319	0	319	858	0	858
Oil and Gas Wells	0	0	0	9	0	9	74	25	99	32	15	47	115	40	155
Bed Too Thin	216	0	216	1,608	0	1,608	22,538	0	22,538	26,705	0	26,705	51,067	0	51,067
Towns	0	0	0	2	0	2	846	88	934	121	0	121	969	88	1,057
Total**	216	0	216	1,608	0	1,608	22,538	114	22,652	26,705	15	26,720	51,067	129	51,196
>1000															
Public Buildings	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
Bed Too Thin	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	216	0	216	1,608	0	1,608	22,538	0	22,538	26,705	0	26,705	51,067	0	51,067
Oil and Gas Wells	0	0	0	9	0	9	74	25	99	32	15	47	115	40	155
Public Buildings	0	0	0	2	0	2	537	0	537	319	0	319	858	0	858
Towns	0	0	0	2	0	2	846	88	934	121	0	121	969	88	1,057
Total**	216	0	216	1,608	0	1,608	22,538	114	22,652	26,705	15	26,720	51,067	129	51,196

* Less than 1, not included in totals.
** Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Estimated coal resources of the Scrubgrass coal bed
in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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	21	0	21	102	0	102	0	0	0	123	0	123
200-1000	799	0	799	5,903	0	5,903	12,126	0	12,126	0	0	0	18,828	0	18,828
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	799	0	799	5,924	0	5,924	12,228	0	12,228	0	0	0	18,951	0	18,951
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	21	0	21	102	0	102	0	0	0	123	0	123
200-1000	799	0	799	5,903	0	5,903	12,126	0	12,126	0	0	0	18,828	0	18,828
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	799	0	799	5,924	0	5,924	12,228	0	12,228	0	0	0	18,951	0	18,951
RESTRICTIONS															
LAND-USE															
0-200	0	0	0	16	0	16	83	0	83	0	0	0	99	0	99
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	16	0	16	83	0	83	0	0	0	99	0	99
TECHNOLOGIC															
0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200-1000	799	0	799	5,903	0	5,903	12,126	0	12,126	0	0	0	18,828	0	18,828
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	799	0	799	5,903	0	5,903	12,126	0	12,126	0	0	0	18,828	0	18,828
TOTAL															
0-200	0	0	0	16	0	16	83	0	83	0	0	0	99	0	99
200-1000	799	0	799	5,903	0	5,903	12,126	0	12,126	0	0	0	18,828	0	18,828
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	799	0	799	5,919	0	5,919	12,209	0	12,209	0	0	0	18,927	0	18,927
AVAILABLE															
0-200	0	0	0	5	0	5	19	0	19	0	0	0	24	0	24
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	5	0	5	19	0	19	0	0	0	24	0	24

* Less than 1, not included in totals.
** Mined and lost-in-mining, by surface and deep mining methods.
Note: Totals may not equal sum of components because of independent rounding.

Estimated remaining coal resources of the Scrubgrass coal bed
unavailable due to LAND-USE restrictions in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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
0-200															
Public Buildings	0	0	0	0	0	0	39	0	39	0	0	0	39	0	39
Houses	0	0	0	3	0	3	14	0	14	0	0	0	17	0	17
Pipelines	0	0	0	0	0	0	20	0	20	0	0	0	20	0	20
Powerlines	0	0	0	0	0	0	3	0	3	0	0	0	3	0	3
Railroads	0	0	0	4	0	4	18	0	18	0	0	0	22	0	22
Roads	0	0	0	5	0	5	25	0	25	0	0	0	30	0	30
Streams	0	0	0	12	0	12	31	0	31	0	0	0	43	0	43
Total**	0	0	0	16	0	16	83	0	83	0	0	0	99	0	99
200-1000															
Public Buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powerlines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1000															
Public Buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powerlines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL															
Houses	0	0	0	3	0	3	14	0	14	0	0	0	17	0	17
Pipelines	0	0	0	0	0	0	20	0	20	0	0	0	20	0	20
Powerlines	0	0	0	0	0	0	3	0	3	0	0	0	3	0	3
Public Buildings	0	0	0	0	0	0	39	0	39	0	0	0	39	0	39
Railroads	0	0	0	4	0	4	18	0	18	0	0	0	22	0	22
Roads	0	0	0	5	0	5	25	0	25	0	0	0	30	0	30
Streams	0	0	0	12	0	12	31	0	31	0	0	0	43	0	43
Total**	0	0	0	16	0	16	83	0	83	0	0	0	99	0	99

* Less than 1, not included in totals.
** Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Estimated remaining coal resources of the Scrubgrass coal bed
unavailable due to TECHNOLOGIC restrictions in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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
0-200															
Public Buildings	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
Bed Too Thin	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
200-1000															
Public Buildings	0	0	0	122	0	122	172	0	172	0	0	0	294	0	294
Oil and Gas Wells	0	0	0	8	0	8	31	0	31	0	0	0	39	0	39
Bed Too Thin	799	0	799	5,903	0	5,903	12,126	0	12,126	0	0	0	18,828	0	18,828
Towns	112	0	112	512	0	512	342	0	342	0	0	0	966	0	966
Total**	799	0	799	5,903	0	5,903	12,126	0	12,126	0	0	0	18,828	0	18,828
>1000															
Public Buildings	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
Bed Too Thin	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	799	0	799	5,903	0	5,903	12,126	0	12,126	0	0	0	18,828	0	18,828
Oil and Gas Wells	0	0	0	8	0	8	31	0	31	0	0	0	39	0	39
Public Buildings	0	0	0	122	0	122	172	0	172	0	0	0	294	0	294
Towns	112	0	112	512	0	512	342	0	342	0	0	0	966	0	966
Total**	799	0	799	5,903	0	5,903	12,126	0	12,126	0	0	0	18,828	0	18,828

* Less than 1, not included in totals.
** Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Estimated coal resources of the Lower Kittanning coal bed
in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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	40	40	58	777	835	1,850	4,732	6,582	0	0	0	1,908	5,549	7,457
200-1000	857	2,417	3,274	9,950	15,168	25,118	48,129	45,776	93,905	0	49	49	58,936	63,410	122,346
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	857	2,457	3,314	10,008	15,945	25,953	49,979	50,508	100,487	0	49	49	60,844	68,959	129,803
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	40	40	58	777	835	1,850	4,732	6,582	0	0	0	1,908	5,549	7,457
200-1000	857	2,417	3,274	9,950	15,168	25,118	48,129	45,776	93,905	0	49	49	58,936	63,410	122,346
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	857	2,457	3,314	10,008	15,945	25,953	49,979	50,508	100,487	0	49	49	60,844	68,959	129,803
RESTRICTIONS															
LAND-USE															
0-200	0	26	26	51	681	732	1,091	4,161	5,252	0	0	0	1,142	4,868	6,010
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	26	26	51	681	732	1,091	4,161	5,252	0	0	0	1,142	4,868	6,010
TECHNOLOGIC															
0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200-1000	857	311	1,168	9,950	1,690	11,640	48,129	1,293	49,422	0	0	0	58,936	3,294	62,230
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	857	311	1,168	9,950	1,690	11,640	48,129	1,293	49,422	0	0	0	58,936	3,294	62,230
TOTAL															
0-200	0	26	26	51	681	732	1,091	4,161	5,252	0	0	0	1,142	4,868	6,010
200-1000	857	311	1,168	9,950	1,690	11,640	48,129	1,293	49,422	0	0	0	58,936	3,294	62,230
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	857	337	1,194	10,001	2,371	12,372	49,220	5,454	54,674	0	0	0	60,078	8,162	68,240
AVAILABLE															
0-200	0	14	14	7	95	102	758	571	1,329	0	0	0	766	681	1,447
200-1000	0	2,105	2,105	0	13,478	13,478	0	44,483	44,483	0	49	49	0	60,116	60,116
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	2,119	2,119	7	13,573	13,580	758	45,054	45,812	0	49	49	766	60,797	61,563

* Less than 1, not included in totals.
** Mined and lost-in-mining, by surface and deep mining methods.
Note: Totals may not equal sum of components because of independent rounding.

Estimated remaining coal resources of the Lower Kittanning coal bed
unavailable due to LAND-USE restrictions in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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
0-200															
Public Buildings	0	0	0	0	0	0	0	943	943	0	0	0	0	943	943
Houses	0	25	25	38	490	528	559	1,863	2,422	0	0	0	597	2,378	2,975
Oil and Gas Wells	0	0	0	0	0	0	7	*	7	0	0	0	7	0	7
Pipelines	0	0	0	0	80	80	144	898	1,042	0	0	0	144	978	1,122
PNDI Sites	0	0	0	0	0	0	3	0	3	0	0	0	3	0	3
Powerlines	0	0	0	0	0	0	79	205	284	0	0	0	79	205	284
Railroads	0	0	0	0	190	190	40	1,206	1,246	0	0	0	40	1,396	1,436
Roads	0	0	0	18	251	269	263	1,529	1,792	0	0	0	281	1,780	2,061
Streams	0	17	17	32	337	369	564	1,383	1,947	0	0	0	596	1,737	2,333
Towns	0	0	0	0	0	0	0	443	443	0	0	0	0	443	443
Wetlands	0	0	0	0	4	4	0	125	125	0	0	0	0	129	129
Total**	0	26	26	51	681	732	1,091	4,161	5,252	0	0	0	1,142	4,868	6,010
200-1000															
Public Buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PNDI Sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powerlines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1000															
Public Buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PNDI Sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powerlines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL															
Houses	0	25	25	38	490	528	559	1,863	2,422	0	0	0	597	2,378	2,975
Oil and Gas Wells	0	0	0	0	0	0	7	0	7	0	0	0	7	0	7
PNDI Sites	0	0	0	0	0	0	3	0	3	0	0	0	3	0	3
Pipelines	0	0	0	0	80	80	144	898	1,042	0	0	0	144	978	1,122
Powerlines	0	0	0	0	0	0	79	205	284	0	0	0	79	205	284
Public Buildings	0	0	0	0	0	0	0	943	943	0	0	0	0	943	943
Railroads	0	0	0	0	190	190	40	1,206	1,246	0	0	0	40	1,396	1,436
Roads	0	0	0	18	251	269	263	1,529	1,792	0	0	0	281	1,780	2,061
Streams	0	17	17	32	337	369	564	1,383	1,947	0	0	0	596	1,737	2,333
Towns	0	0	0	0	0	0	0	443	443	0	0	0	0	443	443
Wetlands	0	0	0	0	4	4	0	125	125	0	0	0	0	129	129
Total**	0	26	26	51	681	732	1,091	4,161	5,252	0	0	0	1,142	4,868	6,010

* Less than 1, not included in totals.
** Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Estimated remaining coal resources of the Lower Kittanning coal bed
unavailable due to TECHNOLOGIC restrictions in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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
0-200															
Public Buildings	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
Bed Too Thin	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
200-1000															
Public Buildings	0	0	0	1	311	312	745	433	1,178	0	0	0	746	744	1,490
Oil and Gas Wells	0	0	0	8	4	12	132	72	204	0	0	0	140	76	216
Bed Too Thin	857	0	857	9,950	0	9,950	48,129	0	48,129	0	0	0	58,936	0	58,936
Towns	0	311	311	13	1,438	1,451	886	850	1,736	0	0	0	899	2,599	3,498
Total**	857	311	1,168	9,950	1,690	11,640	48,129	1,293	49,422	0	0	0	58,936	3,294	62,230
>1000															
Public Buildings	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
Bed Too Thin	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	857	0	857	9,950	0	9,950	48,129	0	48,129	0	0	0	58,936	0	58,936
Oil and Gas Wells	0	0	0	8	4	12	132	72	204	0	0	0	140	76	216
Public Buildings	0	0	0	1	311	312	745	433	1,178	0	0	0	746	744	1,490
Towns	0	311	311	13	1,438	1,451	886	850	1,736	0	0	0	899	2,599	3,498
Total**	857	311	1,168	9,950	1,690	11,640	48,129	1,293	49,422	0	0	0	58,936	3,294	62,230

* Less than 1, not included in totals.
** Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Estimated coal resources of the Middle Kittanning coal bed
in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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	512	106	618	1,412	1,944	3,356	5,747	1,828	7,575	0	0	0	7,671	3,878	11,549
200-1000	3,065	0	3,065	21,605	611	22,216	61,162	2,085	63,247	0	0	0	85,832	2,696	88,528
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3,577	106	3,683	23,017	2,555	25,572	66,909	3,913	70,822	0	0	0	93,503	6,574	100,077
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	182	5	187	57	729	786	0	0	0	0	0	0	239	734	973
200-1000	27	0	27	5	72	77	0	0	0	0	0	0	32	72	104
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	209	5	214	62	801	863	0	0	0	0	0	0	271	806	1,077
TOTAL															
0-200	182	5	187	57	729	786	0	0	0	0	0	0	239	734	973
200-1000	27	0	27	5	72	77	0	0	0	0	0	0	32	72	104
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	209	5	214	62	801	863	0	0	0	0	0	0	271	806	1,077
REMAINING															
0-200	330	101	431	1,355	1,215	2,570	5,747	1,828	7,575	0	0	0	7,432	3,144	10,576
200-1000	3,038	0	3,038	21,600	539	22,139	61,162	2,085	63,247	0	0	0	85,800	2,624	88,424
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3,368	101	3,469	22,955	1,754	24,709	66,909	3,913	70,822	0	0	0	93,232	5,768	99,000
RESTRICTIONS															
LAND-USE															
0-200	267	95	362	968	910	1,878	3,715	1,017	4,732	0	0	0	4,950	2,022	6,972
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	267	95	362	968	910	1,878	3,715	1,017	4,732	0	0	0	4,950	2,022	6,972
TECHNOLOGIC															
0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200-1000	3,038	0	3,038	21,600	1	21,601	61,162	47	61,209	0	0	0	85,800	48	85,848
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3,038	0	3,038	21,600	1	21,601	61,162	47	61,209	0	0	0	85,800	48	85,848
TOTAL															
0-200	267	95	362	968	910	1,878	3,715	1,017	4,732	0	0	0	4,950	2,022	6,972
200-1000	3,038	0	3,038	21,600	1	21,601	61,162	47	61,209	0	0	0	85,800	48	85,848
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3,305	95	3,400	22,568	911	23,479	64,877	1,064	65,941	0	0	0	90,750	2,070	92,820
AVAILABLE															
0-200	63	6	69	387	305	692	2,032	811	2,843	0	0	0	2,482	1,122	3,604
200-1000	0	0	0	0	538	538	0	2,038	2,038	0	0	0	0	2,576	2,576
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	63	6	69	387	843	1,230	2,032	2,849	4,881	0	0	0	2,482	3,698	6,180

* Less than 1, not included in totals.
** Mined and lost-in-mining, by surface and deep mining methods.
Note: Totals may not equal sum of components because of independent rounding.

Estimated remaining coal resources of the Middle Kittanning coal bed
unavailable due to LAND-USE restrictions in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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
0-200															
Public Buildings	167	43	210	2	60	62	112	231	343	0	0	0	281	334	615
Houses	97	0	97	639	555	1,194	2,120	397	2,517	0	0	0	2,856	952	3,808
Oil and Gas Wells	0	0	0	0	0	0	17	0	17	0	0	0	17	0	17
Pipelines	126	11	137	114	171	285	626	141	767	0	0	0	866	323	1,189
Powerlines	21	5	26	4	103	107	216	46	262	0	0	0	241	154	395
Railroads	0	*	0	218	170	388	558	161	719	0	0	0	776	331	1,107
Roads	95	55	150	262	166	428	1,323	319	1,642	0	0	0	1,680	540	2,220
Streams	66	3	69	344	96	440	1,414	197	1,611	0	0	0	1,824	296	2,120
Towns	0	0	0	0	14	14	19	362	381	0	0	0	19	376	395
Wetlands	0	0	0	5	2	7	31	8	39	0	0	0	36	10	46
Total**	267	95	362	968	910	1,878	3,715	1,017	4,732	0	0	0	4,950	2,022	6,972
200-1000															
Public Buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powerlines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1000															
Public Buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powerlines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL															
Houses	97	0	97	639	555	1,194	2,120	397	2,517	0	0	0	2,856	952	3,808
Oil and Gas Wells	0	0	0	0	0	0	17	0	17	0	0	0	17	0	17
Pipelines	126	11	137	114	171	285	626	141	767	0	0	0	866	323	1,189
Powerlines	21	5	26	4	103	107	216	46	262	0	0	0	241	154	395
Public Buildings	167	43	210	2	60	62	112	231	343	0	0	0	281	334	615
Railroads	0	0	0	218	170	388	558	161	719	0	0	0	776	331	1,107
Roads	95	55	150	262	166	428	1,323	319	1,642	0	0	0	1,680	540	2,220
Streams	66	3	69	344	96	440	1,414	197	1,611	0	0	0	1,824	296	2,120
Towns	0	0	0	0	14	14	19	362	381	0	0	0	19	376	395
Wetlands	0	0	0	5	2	7	31	8	39	0	0	0	36	10	46
Total**	267	95	362	968	910	1,878	3,715	1,017	4,732	0	0	0	4,950	2,022	6,972

* Less than 1, not included in totals.
** Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Estimated remaining coal resources of the Middle Kittanning coal bed
unavailable due to TECHNOLOGIC restrictions in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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
0-200															
Public Buildings	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
Bed Too Thin	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
200-1000															
Public Buildings	0	0	0	227	1	228	1,019	44	1,063	0	0	0	1,246	45	1,291
Oil and Gas Wells	0	0	0	29	0	29	155	3	158	0	0	0	184	3	187
Bed Too Thin	3,038	0	3,038	21,600	0	21,600	61,162	0	61,162	0	0	0	85,800	0	85,800
Towns	157	0	157	1,005	0	1,005	1,833	0	1,833	0	0	0	2,995	0	2,995
Total**	3,038	0	3,038	21,600	1	21,601	61,162	47	61,209	0	0	0	85,800	48	85,848
>1000															
Public Buildings	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
Bed Too Thin	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	3,038	0	3,038	21,600	0	21,600	61,162	0	61,162	0	0	0	85,800	0	85,800
Oil and Gas Wells	0	0	0	29	0	29	155	3	158	0	0	0	184	3	187
Public Buildings	0	0	0	227	1	228	1,019	44	1,063	0	0	0	1,246	45	1,291
Towns	157	0	157	1,005	0	1,005	1,833	0	1,833	0	0	0	2,995	0	2,995
Total**	3,038	0	3,038	21,600	1	21,601	61,162	47	61,209	0	0	0	85,800	48	85,848

* Less than 1, not included in totals.
** Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Estimated coal resources of the Upper Kittanning coal bed
in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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	185	0	185	1,784	0	1,784	6,769	0	6,769	0	0	0	8,738	0	8,738
200-1000	1,300	0	1,300	9,342	0	9,342	13,896	0	13,896	0	0	0	24,538	0	24,538
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1,485	0	1,485	11,126	0	11,126	20,665	0	20,665	0	0	0	33,276	0	33,276
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	185	0	185	1,784	0	1,784	6,769	0	6,769	0	0	0	8,738	0	8,738
200-1000	1,300	0	1,300	9,342	0	9,342	13,896	0	13,896	0	0	0	24,538	0	24,538
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1,485	0	1,485	11,126	0	11,126	20,665	0	20,665	0	0	0	33,276	0	33,276
RESTRICTIONS															
LAND-USE															
0-200	142	0	142	967	0	967	3,206	0	3,206	0	0	0	4,315	0	4,315
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	142	0	142	967	0	967	3,206	0	3,206	0	0	0	4,315	0	4,315
TECHNOLOGIC															
0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200-1000	1,300	0	1,300	9,342	0	9,342	13,896	0	13,896	0	0	0	24,538	0	24,538
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1,300	0	1,300	9,342	0	9,342	13,896	0	13,896	0	0	0	24,538	0	24,538
TOTAL															
0-200	142	0	142	967	0	967	3,206	0	3,206	0	0	0	4,315	0	4,315
200-1000	1,300	0	1,300	9,342	0	9,342	13,896	0	13,896	0	0	0	24,538	0	24,538
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1,442	0	1,442	10,309	0	10,309	17,102	0	17,102	0	0	0	28,853	0	28,853
AVAILABLE															
0-200	43	0	43	816	0	816	3,562	0	3,562	0	0	0	4,423	0	4,423
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	43	0	43	816	0	816	3,562	0	3,562	0	0	0	4,423	0	4,423

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** Mined and lost-in-mining, by surface and deep mining methods.
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coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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
0-200															
Public Buildings	32	0	32	28	0	28	35	0	35	0	0	0	95	0	95
Cemeteries	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0
Houses	86	0	86	459	0	459	1,879	0	1,879	0	0	0	2,424	0	2,424
Oil and Gas Wells	0	0	0	0	0	0	9	0	9	0	0	0	9	0	9
Pipelines	43	0	43	202	0	202	295	0	295	0	0	0	540	0	540
Powerlines	35	0	35	134	0	134	84	0	84	0	0	0	253	0	253
Railroads	0	0	0	9	0	9	43	0	43	0	0	0	52	0	52
Roads	42	0	42	216	0	216	968	0	968	0	0	0	1,226	0	1,226
Streams	9	0	9	174	0	174	1,143	0	1,143	0	0	0	1,326	0	1,326
Towns	0	0	0	23	0	23	62	0	62	0	0	0	85	0	85
Wetlands	0	0	0	3	0	3	8	0	8	0	0	0	11	0	11
Total**	142	0	142	967	0	967	3,206	0	3,206	0	0	0	4,315	0	4,315
200-1000															
Public Buildings	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
Houses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powerlines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1000															
Public Buildings	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
Houses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powerlines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL															
Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Houses	86	0	86	459	0	459	1,879	0	1,879	0	0	0	2,424	0	2,424
Oil and Gas Wells	0	0	0	0	0	0	9	0	9	0	0	0	9	0	9
Pipelines	43	0	43	202	0	202	295	0	295	0	0	0	540	0	540
Powerlines	35	0	35	134	0	134	84	0	84	0	0	0	253	0	253
Public Buildings	32	0	32	28	0	28	35	0	35	0	0	0	95	0	95
Railroads	0	0	0	9	0	9	43	0	43	0	0	0	52	0	52
Roads	42	0	42	216	0	216	968	0	968	0	0	0	1,226	0	1,226
Streams	9	0	9	174	0	174	1,143	0	1,143	0	0	0	1,326	0	1,326
Towns	0	0	0	23	0	23	62	0	62	0	0	0	85	0	85
Wetlands	0	0	0	3	0	3	8	0	8	0	0	0	11	0	11
Total**	142	0	142	967	0	967	3,206	0	3,206	0	0	0	4,315	0	4,315

* Less than 1, not included in totals.
** Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
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	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
0-200															
Public Buildings	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
Bed Too Thin	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
200-1000															
Public Buildings	0	0	0	0	0	0	228	0	228	0	0	0	228	0	228
Oil and Gas Wells	0	0	0	9	0	9	26	0	26	0	0	0	35	0	35
Bed Too Thin	1,300	0	1,300	9,342	0	9,342	13,896	0	13,896	0	0	0	24,538	0	24,538
Towns	0	0	0	77	0	77	275	0	275	0	0	0	352	0	352
Total**	1,300	0	1,300	9,342	0	9,342	13,896	0	13,896	0	0	0	24,538	0	24,538
>1000															
Public Buildings	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
Bed Too Thin	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	1,300	0	1,300	9,342	0	9,342	13,896	0	13,896	0	0	0	24,538	0	24,538
Oil and Gas Wells	0	0	0	9	0	9	26	0	26	0	0	0	35	0	35
Public Buildings	0	0	0	0	0	0	228	0	228	0	0	0	228	0	228
Towns	0	0	0	77	0	77	275	0	275	0	0	0	352	0	352
Total**	1,300	0	1,300	9,342	0	9,342	13,896	0	13,896	0	0	0	24,538	0	24,538

* Less than 1, not included in totals.
** Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Estimated coal resources of the Lower Freeport coal bed
in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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	2,149	443	2,592	13,688	417	14,105	11,609	0	11,609	0	0	0	27,446	860	28,306
200-1000	2,433	0	2,433	13,609	5	13,614	19,831	0	19,831	0	0	0	35,873	5	35,878
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	4,582	443	5,025	27,297	422	27,719	31,440	0	31,440	0	0	0	63,319	865	64,184
MINED OUT**															
SURFACE															
0-200	20	14	34	171	51	222	24	0	24	0	0	0	215	65	280
200-1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	20	14	34	171	51	222	24	0	24	0	0	0	215	65	280
DEEP															
0-200	6	0	6	0	0	0	0	0	0	0	0	0	6	0	6
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	6	0	6	0	0	0	0	0	0	0	0	0	6	0	6
TOTAL															
0-200	26	14	40	171	51	222	24	0	24	0	0	0	221	65	286
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	26	14	40	171	51	222	24	0	24	0	0	0	221	65	286
REMAINING															
0-200	2,123	429	2,552	13,517	366	13,883	11,585	0	11,585	0	0	0	27,225	795	28,020
200-1000	2,433	0	2,433	13,609	5	13,614	19,831	0	19,831	0	0	0	35,873	5	35,878
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	4,556	429	4,985	27,126	371	27,497	31,416	0	31,416	0	0	0	63,098	800	63,898
RESTRICTIONS															
LAND-USE															
0-200	938	76	1,014	6,835	168	7,003	5,854	0	5,854	0	0	0	13,627	244	13,871
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	938	76	1,014	6,835	168	7,003	5,854	0	5,854	0	0	0	13,627	244	13,871
TECHNOLOGIC															
0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200-1000	2,433	0	2,433	13,609	0	13,609	19,831	0	19,831	0	0	0	35,873	0	35,873
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2,433	0	2,433	13,609	0	13,609	19,831	0	19,831	0	0	0	35,873	0	35,873
TOTAL															
0-200	938	76	1,014	6,835	168	7,003	5,854	0	5,854	0	0	0	13,627	244	13,871
200-1000	2,433	0	2,433	13,609	0	13,609	19,831	0	19,831	0	0	0	35,873	0	35,873
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3,371	76	3,447	20,444	168	20,612	25,685	0	25,685	0	0	0	49,500	244	49,744
AVAILABLE															
0-200	1,185	353	1,538	6,683	198	6,880	5,731	0	5,731	0	0	0	13,598	551	14,149
200-1000	0	0	0	0	5	5	0	0	0	0	0	0	0	5	5
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1,185	353	1,538	6,683	203	6,885	5,731	0	5,731	0	0	0	13,598	556	14,154

* Less than 1, not included in totals.
** Mined and lost-in-mining, by surface and deep mining methods.
Note: Totals may not equal sum of components because of independent rounding.

Estimated remaining coal resources of the Lower Freeport coal bed
unavailable due to LAND-USE restrictions in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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
0-200															
Public Buildings	12	*	12	54	*	54	50	0	50	0	0	0	116	0	116
Cemeteries	0	0	0	8	0	8	0	0	0	0	0	0	8	0	8
Houses	794	58	852	4,764	109	4,873	4,101	0	4,101	0	0	0	9,659	167	9,826
Oil and Gas Wells	*	0	0	15	0	15	60	0	60	0	0	0	75	0	75
Pipelines	65	4	69	874	4	878	707	0	707	0	0	0	1,646	8	1,654
PNDI Sites	0	0	0	138	0	138	0	0	0	0	0	0	138	0	138
Powerlines	55	0	55	754	35	789	209	0	209	0	0	0	1,018	35	1,053
Railroads	0	17	17	80	26	106	156	0	156	0	0	0	236	43	279
Roads	283	36	319	1,836	16	1,852	1,667	0	1,667	0	0	0	3,786	52	3,838
Streams	133	*	133	1,175	22	1,197	1,692	0	1,692	0	0	0	3,000	22	3,022
Towns	88	0	88	239	0	239	121	0	121	0	0	0	448	0	448
Wetlands	11	0	11	18	3	21	21	0	21	0	0	0	50	3	53
Total**	938	76	1,014	6,835	168	7,003	5,854	0	5,854	0	0	0	13,627	244	13,871
200-1000															
Public Buildings	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
Houses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PNDI Sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powerlines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1000															
Public Buildings	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
Houses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and Gas Wells	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PNDI Sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powerlines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL															
Cemeteries	0	0	0	8	0	8	0	0	0	0	0	0	8	0	8
Houses	794	58	852	4,764	109	4,873	4,101	0	4,101	0	0	0	9,659	167	9,826
Oil and Gas Wells	0	0	0	15	0	15	60	0	60	0	0	0	75	0	75
PNDI Sites	0	0	0	138	0	138	0	0	0	0	0	0	138	0	138
Pipelines	65	4	69	874	4	878	707	0	707	0	0	0	1,646	8	1,654
Powerlines	55	0	55	754	35	789	209	0	209	0	0	0	1,018	35	1,053
Public Buildings	12	0	12	54	0	54	50	0	50	0	0	0	116	0	116
Railroads	0	17	17	80	26	106	156	0	156	0	0	0	236	43	279
Roads	283	36	319	1,836	16	1,852	1,667	0	1,667	0	0	0	3,786	52	3,838
Streams	133	0	133	1,175	22	1,197	1,692	0	1,692	0	0	0	3,000	22	3,022
Towns	88	0	88	239	0	239	121	0	121	0	0	0	448	0	448
Wetlands	11	0	11	18	3	21	21	0	21	0	0	0	50	3	53
Total**	938	76	1,014	6,835	168	7,003	5,854	0	5,854	0	0	0	13,627	244	13,871

* Less than 1, not included in totals.
** Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Estimated remaining coal resources of the Lower Freeport coal bed
unavailable due to TECHNOLOGIC restrictions in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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
0-200															
Public Buildings	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
Bed Too Thin	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
200-1000															
Public Buildings	26	0	26	199	0	199	438	0	438	0	0	0	663	0	663
Oil and Gas Wells	9	0	9	16	0	16	21	0	21	0	0	0	46	0	46
Bed Too Thin	2,433	0	2,433	13,609	0	13,609	19,831	0	19,831	0	0	0	35,873	0	35,873
Towns	335	0	335	329	0	329	286	0	286	0	0	0	950	0	950
Total**	2,433	0	2,433	13,609	0	13,609	19,831	0	19,831	0	0	0	35,873	0	35,873
>1000															
Public Buildings	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
Bed Too Thin	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	2,433	0	2,433	13,609	0	13,609	19,831	0	19,831	0	0	0	35,873	0	35,873
Oil and Gas Wells	9	0	9	16	0	16	21	0	21	0	0	0	46	0	46
Public Buildings	26	0	26	199	0	199	438	0	438	0	0	0	663	0	663
Towns	335	0	335	329	0	329	286	0	286	0	0	0	950	0	950
Total**	2,433	0	2,433	13,609	0	13,609	19,831	0	19,831	0	0	0	35,873	0	35,873

* Less than 1, not included in totals.
** Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Estimated coal resources of the Upper Freeport coal bed
in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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	3,324	19,064	22,388	15,801	51,981	67,782	3,088	10,308	13,396	0	0	0	22,213	81,353	103,566
200-1000	1,920	9,932	11,852	9,691	21,099	30,790	3,085	3,199	6,284	0	0	0	14,696	34,230	48,926
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	5,244	28,996	34,240	25,492	73,080	98,572	6,173	13,507	19,680	0	0	0	36,909	115,583	152,492
MINED OUT**															
SURFACE															
0-200	0	1,542	1,542	51	1,549	1,600	0	302	302	0	0	0	51	3,393	3,444
200-1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	1,542	1,542	51	1,549	1,600	0	302	302	0	0	0	51	3,393	3,444
DEEP															
0-200	193	1,757	1,950	360	2,639	2,999	*	1,138	1,138	0	0	0	553	5,534	6,087
200-1000	0	61	61	3	78	81	1	132	133	0	0	0	4	271	275
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	193	1,818	2,011	363	2,717	3,080	1	1,270	1,271	0	0	0	557	5,805	6,362
TOTAL															
0-200	193	3,299	3,492	411	4,188	4,600	0	1,440	1,440	0	0	0	604	8,927	9,531
200-1000	0	61	61	3	78	81	1	132	133	0	0	0	4	271	275
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	193	3,360	3,553	414	4,266	4,681	1	1,572	1,573	0	0	0	608	9,198	9,806
REMAINING															
0-200	3,130	15,765	18,896	15,390	47,793	63,182	3,088	8,868	11,956	0	0	0	21,609	72,426	94,035
200-1000	1,920	9,871	11,791	9,688	21,021	30,709	3,084	3,067	6,151	0	0	0	14,692	33,959	48,651
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	5,050	25,636	30,687	25,078	68,814	93,891	6,172	11,935	18,107	0	0	0	36,301	106,385	142,686
RESTRICTIONS															
LAND-USE															
0-200	1,816	7,895	9,711	7,885	24,324	32,209	1,445	4,720	6,165	0	0	0	11,146	36,939	48,085
200-1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1,816	7,895	9,711	7,885	24,324	32,209	1,445	4,720	6,165	0	0	0	11,146	36,939	48,085
TECHNOLOGIC															
0-200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200-1000	1,602	330	1,932	7,658	876	8,534	1,817	320	2,137	0	0	0	11,077	1,526	12,603
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1,602	330	1,932	7,658	876	8,534	1,817	320	2,137	0	0	0	11,077	1,526	12,603
TOTAL															
0-200	1,816	7,895	9,711	7,885	24,324	32,209	1,445	4,720	6,165	0	0	0	11,146	36,939	48,085
200-1000	1,602	330	1,932	7,658	876	8,534	1,817	320	2,137	0	0	0	11,077	1,526	12,603
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3,418	8,225	11,643	15,543	25,200	40,743	3,262	5,040	8,302	0	0	0	22,223	38,465	60,688
AVAILABLE															
0-200	1,314	7,870	9,185	7,505	23,469	30,973	1,643	4,148	5,791	0	0	0	10,463	35,487	45,950
200-1000	318	9,541	9,859	2,030	20,145	22,175	1,267	2,747	4,014	0	0	0	3,615	32,433	36,048
>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1,632	17,411	19,044	9,535	43,614	53,148	2,910	6,895	9,805	0	0	0	14,078	67,920	81,998

* Less than 1, not included in totals.
** Mined and lost-in-mining, by surface and deep mining methods.
Note: Totals may not equal sum of components because of independent rounding.

Estimated remaining coal resources of the Upper Freeport coal bed
unavailable due to LAND-USE restrictions in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

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coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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
0-200															
Public Buildings	40	135	175	92	499	591	5	123	128	0	0	0	137	757	894
Cemeteries	0	0	0	0	161	161	0	4	4	0	0	0	0	165	165
Houses	1,323	5,800	7,123	5,905	17,883	23,788	1,050	3,762	4,812	0	0	0	8,278	27,445	35,723
Oil and Gas Wells	1	40	41	19	150	169	0	19	19	0	0	0	20	209	229
County Park	0	0	0	0	7	7	0	0	0	0	0	0	0	7	7
Pipelines	421	829	1,250	1,660	3,124	4,784	153	778	931	0	0	0	2,234	4,731	6,965
PNDI Sites	0	166	166	0	100	100	0	0	0	0	0	0	0	266	266
Powerlines	59	251	310	143	1,495	1,638	93	113	206	0	0	0	295	1,859	2,154
Railroads	14	269	283	51	687	738	40	191	231	0	0	0	105	1,147	1,252
Roads	536	2,294	2,830	2,257	7,406	9,663	317	1,363	1,680	0	0	0	3,110	11,063	14,173
Streams	227	1,571	1,798	1,916	3,913	5,829	403	740	1,143	0	0	0	2,546	6,224	8,770
Towns	68	411	479	401	1,460	1,861	68	70	138	0	0	0	537	1,941	2,478
Wetlands	9	73	82	59	206	265	13	9	22	0	0	0	81	288	369
Total**	1,816	7,895	9,711	7,885	24,324	32,209	1,445	4,720	6,165	0	0	0	11,146	36,939	48,085
200-1000															
Public Buildings	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
Houses	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
County Park	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PNDI Sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powerlines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1000															
Public Buildings	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
Houses	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
County Park	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PNDI Sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powerlines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL															
Cemeteries	0	0	0	0	161	161	0	4	4	0	0	0	0	165	165
County Park	0	0	0	0	7	7	0	0	0	0	0	0	0	7	7
Houses	1,323	5,800	7,123	5,905	17,883	23,788	1,050	3,762	4,812	0	0	0	8,278	27,445	35,723
Oil and Gas Wells	1	40	41	19	150	169	0	19	19	0	0	0	20	209	229
PNDI Sites	0	166	166	0	100	100	0	0	0	0	0	0	0	266	266
Pipelines	421	829	1,250	1,660	3,124	4,784	153	778	931	0	0	0	2,234	4,731	6,965
Powerlines	59	251	310	143	1,495	1,638	93	113	206	0	0	0	295	1,859	2,154
Public Buildings	40	135	175	92	499	591	5	123	128	0	0	0	137	757	894
Railroads	14	269	283	51	687	738	40	191	231	0	0	0	105	1,147	1,252
Roads	536	2,294	2,830	2,257	7,406	9,663	317	1,363	1,680	0	0	0	3,110	11,063	14,173
Streams	227	1,571	1,798	1,916	3,913	5,829	403	740	1,143	0	0	0	2,546	6,224	8,770
Towns	68	411	479	401	1,460	1,861	68	70	138	0	0	0	537	1,941	2,478
Wetlands	9	73	82	59	206	265	13	9	22	0	0	0	81	288	369
Total**	1,816	7,895	9,711	7,885	24,324	32,209	1,445	4,720	6,165	0	0	0	11,146	36,939	48,085

* Less than 1, not included in totals.
** Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Estimated remaining coal resources of the Upper Freeport coal bed
unavailable due to TECHNOLOGIC restrictions in the Saxonburg 7.5-minute quadrangle, Butler County, Pa
(in thousands of short tons)

Resources are subdivided into categories of overburden thickness (0-200 ft, 200-1000 ft, and >1000 ft),
coal thickness (14-28 in and >28 in), and reliability of estimate (measured, indicated, inferred, and hypothetical).

	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
0-200															
Public Buildings	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
Bed Too Thin	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
200-1000															
Public Buildings	64	88	152	139	407	546	106	153	259	0	0	0	309	648	957
Oil and Gas Wells	6	22	28	13	31	44	0	0	0	0	0	0	19	53	72
Bed Too Thin	1,592	0	1,592	7,455	0	7,455	1,690	0	1,690	0	0	0	10,737	0	10,737
Towns	19	224	243	405	526	931	203	190	393	0	0	0	627	940	1,567
Total**	1,602	330	1,932	7,658	876	8,534	1,817	320	2,137	0	0	0	11,077	1,526	12,603
>1000															
Public Buildings	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
Bed Too Thin	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	1,592	0	1,592	7,455	0	7,455	1,690	0	1,690	0	0	0	10,737	0	10,737
Oil and Gas Wells	6	22	28	13	31	44	0	0	0	0	0	0	19	53	72
Public Buildings	64	88	152	139	407	546	106	153	259	0	0	0	309	648	957
Towns	19	224	243	405	526	931	203	190	393	0	0	0	627	940	1,567
Total**	1,602	330	1,932	7,658	876	8,534	1,817	320	2,137	0	0	0	11,077	1,526	12,603

* Less than 1, not included in totals.
** Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

APPENDIX C. SAXONBURG COAL AVAILABILITY STUDY METHODOLOGY

Introduction

Of all the tasks which Federal and State geological surveys do, the estimation of natural resources has always been of major importance. It is important not just to provide an estimate of how much of that resource remains, but also to provide a mechanism whereby planners and economists can determine potential employment displacements or employment opportunities within a geographical region by knowing the location of remaining resources. Coal is one of the resources in the United States currently being scrutinized by the U.S. Geological Survey as it looks to define those sources of energy to be used in the future. But how much coal remains and what is its quality? That is what the federally-funded Coal Availability Study program hopes to do, provide some idea of the remaining *available* coal resources on a basin by basin basis.

One of the most important natural resources in Pennsylvania is coal. Its value as an energy source was acknowledged early on and it has maintained the economic health of the Commonwealth for nearly two centuries. Yet, how much remains? Through the Coal Availability Study program for Pennsylvania a glimpse of the answer to that question is possible.

Past resource estimates of coal in Pennsylvania have relied upon geologic understanding and interpretation of data gathered from strip mines and deep mines. Often these sites were few and far between. Coal resources were calculated by the geologist or engineer using one of several different methods, with each subsequent author tending to use some variation of the previous worker's method (e.g., Ashley, 1944), each yielding different results. Today, after decades of drilling for coal by energy companies, a more complete understanding of the geology and occurrence of coal is possible. Basic resource analysis methodologies have improved and have become standardized through time, too, like those developed in U.S. Geological Survey Circular 891 (Wood and others, 1983). However, there has yet to be a detailed study of the coal resources in Pennsylvania based upon this increase in data and improved methodology since the last full Demonstrated Reserve Base was completed by the U.S. Department of Energy in 1979.

The first Pennsylvania Geological Survey was formed in 1836 by act of the State Legislature for the expressed purpose of gathering and disseminating geologic information about coal and other natural resources within its borders, powering the Commonwealth into the industrial age. Today, in its fourth incarnation, the Pennsylvania Geological Survey (presently

known as the Bureau of Topographic and Geologic Survey) continues to provide information about the nature of the coal resources remaining in the Commonwealth.

The last coal resource estimate completed by the Pennsylvania Geological Survey reported that about 14 billion short tons of coal has been mined (underground and surface mines) in the bituminous region of Pennsylvania since the early 1800s and that the amount of bituminous coal remaining in the Commonwealth was estimated at 65 billion short tons. Of that amount, 10 billion short tons is estimated to be recoverable (Edmunds, 1972).

It would seem that there are ample reserves of coal left looking at those numbers. Yet additional factors, such as regulatory statutes and adverse geologic or engineering-related conditions could exist which might impact on that total and further limit the amount of coal available for mining, and therefore should be factored into any resource evaluation.

It should also be pointed out that for this study, in order to quantify available coal, only total coal is considered. Partings were left out on purpose, because their impact on the resource is beyond the scope of this study. However, personnel from the former U.S. Bureau of Mines in a follow-up study to Coal Availability, called Coal Recoverability, do consider the economic implications of partings in the coal, as well as also look at other economic indicators (e.g., coal chemistry), and their impact on coal minability. Towards that end, two datasets are provided to the U.S. Geological Survey upon completion of this study: coal without partings, and coal with partings.

Historical Background of Study

The U.S. Geological Survey (USGS) by the late 1970s was developing an in-house, electronic version of the file cabinet to hold coal information from a number of states that they called the National Coal Resources Data System (NCRDS). It was built upon the Multics, and later, the PRIME operating system. In addition the USGS developed two software programs to augment the database application. They were known as the Program to Analyze Coal Energy Resources (PACER) and Graphics Analysis of Resources using Numerical Evaluation Techniques (GARNET) and could be used to determine coal resources. This computer technology worked well for a number of years, but in 1987 the U.S. Geological Survey decided to expand and update this simple coal resource program and to replace PACER and GARNET with a more robust system of computers and software based on the Unix operating system. Their

objective was to put together a database manager and analysis software comparable in function to the old system, plus add those elements found in the newly evolving Geographic Information System (GIS) technology which might provide for further refinement of the coal resource, for example, the addition of data layers that represent the various restrictions to mining arising out of new environmental regulations. PACER and GARNET were supplanted by the public domain GIS software called GRASS (Geographical Resources Analysis Support System). A USGS Coal Branch modified version of the GRASS software was put into use specifically for Coal Availability.

The Kentucky Geological Survey, in cooperation with the U.S. Geological Survey in 1987-88, initiated a pilot study of the 7.5-minute Matewan quadrangle, whose purpose was to refine this new GRASS-based coal analysis program and document procedures. The guidelines and procedures developed from the study are documented in USGS Circular 1055 (Eggleston and others, 1990) and are the routines used in the Coal Availability Studies that followed in Kentucky, Virginia, and West Virginia.

The Pennsylvania Geological Survey in 1978 became involved in the NCRDS program, providing the USGS with additional coal data from Pennsylvania. This coal stratigraphic and geochemical information was gleaned from county coal mapping studies, which were initiated in conjunction with this cooperative program. This cooperative effort in subsequent years has lead to the development of a very large computer database of coal data for Pennsylvania, which is electronically accessible by Pennsylvania Geological Survey geologists. With this information now in a digital format suitable for extraction and manipulation, it was anticipated that new resource estimates for Pennsylvania might be readily calculated. Coal Availability seemed to be the next logical step. The Pennsylvania Geological Survey in 1992 proposed to the U.S. Geological Survey several quadrangles for study. The first quadrangle chosen was the Hackett 7.5-minute quadrangle, in Washington County, Pennsylvania. Basic concepts and the methodology applied to this study, and similarly in the other quadrangle studies, are contained in this appendix, whereas data generated for this study can be found in the main body of this report.

Restrictions

General

The Coal Availability Study program, for the purpose of determining available resources, identifies potential restrictions to mining, which are cataloged into two broad categories: land-use and technological. Land-use restrictions represent those cultural features that may restrict surface and underground-mining operations by requiring protection from obliteration or damage, and are defined by the various regulations promulgated during 1966 and described in Title 25, chapter 86 of the Pennsylvania Code. Examples of these are streams, roads, cemeteries, public buildings, and wetlands. Each restriction usually has its own associated "buffer zone of exclusion" as dictated by those regulations. Technological restrictions represent those factors that can impinge upon both surface and underground mining. Typically, they are adverse geological conditions such as bad roof conditions, interburden between coals too thin, coal too thin to mine, and/or physical constraints like oil and gas wells, gas storage reservoirs, and deep-mine barriers. Their buffers are based either on existing mining practices or by regulations developed in 1966 (further modified in 1994). Many more physical constraints, other than these few examples, existed prior to the new legislation passed in 1994 (Act 54).

Resource restrictions were identified for this quadrangle based upon review of Commonwealth and local regulations, current mining practices, and the past experiences of mining company personnel. A map of the various land-use restrictions is displayed in Figure 17 on page 36. These restrictions can hinder the production of the remaining coal resource and are, therefore, important in defining how much coal is actually available for mining. The following restrictions were defined for this study: power lines, gas pipelines, oil and gas wells, improved roads (but is contingent upon township rules), railroads, most streams, lakes, wetlands, buildings (including homes), cemeteries, Pennsylvania Natural Diversity Inventory sites (PNDI), urbanized areas (a town), parks (county/township park), bed too thin to mine, and mine barriers between underground mines. These restrictions are divided into two groups; those that affect surface mining, and those that affect underground mining. Some restrictions were found to be common to both groups (e.g., oil and gas wells). The software program was designed to define the cut-off point between surface- and underground-minable coals at less than 200 feet, or greater than or equal to 200 feet of overburden, respectively. Depending on the reliability of

data about mining practices, this cut-off number could be changed up or down to reflect mining practices for individual study quadrangles. It also may be expressed as a ratio if necessary through additional programming.

Surface-Mining Restrictions

Local mining practices may vary, but based on the overall past surface-mining practices in this quadrangle where surface mining had occurred in areas of high cover, a 200 feet thick threshold to distinguish between surface and underground mining seemed reasonable to use. Land-use restrictions typically affect surface-mined coal. Technological restrictions, such as coal too thin to mine may also impact upon this surface-minable resource. For this report, 14 inches of coal is the minimum thickness at which a coal bed is considered a surface-minable resource. Some of the restrictions are strictly adhered to, while others seem to be resolved on a case-by-case basis (e.g., oil and gas wells). Table 3 lists those restrictions that are regulated and are found for all coal beds, which occur in this quadrangle. Location information for most of the restrictions was taken from the U.S. Geological Survey Saxonburg 7.5-minute Topographic Quadrangle Map (1958, photorevised 1969, photoinspected 1977), and was field checked for accuracy. Wetland areas were compiled and digitized from the U.S. Department of Interior's Fish and Wildlife Service National Wetlands Inventory Map prepared by the Office of Biological Services for the Saxonburg quadrangle in 1977. A search of a computer database maintained by the Commonwealth's Bureau of Forestry, an agency through which all mining permit applications must pass, provided all the known Pennsylvania Natural Diversity Inventory (PNDI) sites for Saxonburg and the surrounding quadrangles. It is a dynamic database, one that changes through time as additional rare animals or plants are identified. These sites are subsequently verified by a check of a topographic map file the Bureau of Forestry maintains which shows location and type of restriction present. The park restriction was compiled and later digitized from a Mylar tracing of a map used in field reconnaissance of the quadrangle. Additional oil and gas wells and homes were added to the Saxonburg base map based upon findings from field reconnaissance, deep-mine maps, and the Pennsylvania state oil and gas location map of the area.

A buffer for each restriction of an appropriate size required by Commonwealth regulations was automatically created around the digitized line and point data by GRASS (see Table 3). Oil and gas wells are protected by law and use various sized buffers per circumstance.

Coal companies are allowed to mine within a 125-foot radius of an active well. By law, this radius can be made smaller if the coal mine operator can assure the integrity of the well, the oil or gas well operator files no objection to the change, and the Commonwealth's Department of Environmental Protection approves. For this study, a 100-foot radius buffer was chosen for each well based mostly upon local practices by the coal companies. Exceptions to the regulations are railroads, pipelines and power lines. Although protection is not required, pipelines, power lines and railroads often are protected anyway. Field experience suggests that coal companies tend to maintain a buffer of about 100 feet from the utility's right of way. And if a coal company can show that they can maintain the integrity of the power line, pipeline or railroad tracks during mining, then the company is allowed to mine closer. Yet due to the cost of moving such obstacles or trying not to disturb them, mining operators tend to avoid them. This100-foot buffer is what was used in the resource tabulations. The buffer for a PNDI site represents an area of statutory inclusion, whose size is based upon the type of rare or endangered plant or animal species encountered. This zone of inclusion is digitized as another data layer for importation into GRASS. Regulations provide an additional buffer to protect perennial and intermittent streams (see Table 3), which may be waived through application for a variance. Wetlands and lakes are given by inference a similarly sized buffer, although no specific buffer is required. Towns or population clusters are not buffered, but rather the area polygon representative of the town jurisdictional area or population cluster is defined and digitized as a restriction. Parks are required to have, according to regulation, a 300-foot buffer to protect them from mining. Such a buffer was added to the park found in the southern part of the Saxonburg quadrangle. This newly defined area was digitized and imported into GRASS.

Underground-Mining Restrictions

For the purposes of this report, underground/deep mining is defined as that coal occurring with greater than or equal to 200 feet of overburden. This is complicated by past deep mining practices where some areas of the quadrangle have had deep mining in under less than 100 feet of overburden. In those instances, the coal taken by underground extraction will show up in the surface-mined coal tally. In those situations it is better to consider the total coal removed by mining, rather than if it was a surface- or underground-mining method that extracted it.

Table 3. Buffer Zones Associated With the Various Identified Resource Restrictions in the Saxonburg Quadrangle

Land Use Restrictions	**Buffer Zone (in feet)**[1]
Cemeteries	boundary+ 100
Houses, public buildings, schools, churches, community or institutional buildings	structure + 300
Lakes	shoreline + 100
Railroads*	right-of-way + 100
Towns	corporate boundary
PNDI sites	site + one mile radius
Public parks	boundary + 300
Oil and gas wells	100 foot radius
Streams	bank + 100
Wetlands	area + 100
Pipelines*	right-of-way + 100
Power lines*	right-of-way + 100
Roads	right-of-way + 100
Technological Restrictions	**Buffer Zone (in feet)**[1]
Deep-mine barriers	200 foot diameter
Oil and gas wells	100 foot radius
Public buildings[2]	structure + 300

*Interpretive; no specific law; based on field practices.

[1]Compiled from the Pennsylvania Code, Title 25, Chapter 86, *Surface and Underground Coal Mining: General*, and other sources.
[2]Amended 1994—Legislative Act 54; surface structures (houses) no longer constitute a restriction to underground mining; instead, public buildings do.

Factors that physically hinder or impact the underground mining of coal are grouped together as technological restrictions. Examples of these type of restrictions are: bad roof conditions, bed too thin, bed too deep, deep-mine barriers, interburden less than 40 feet thick, and oil and gas wells. Only oil and gas wells (as objects) remain currently regulated; prior to 1994, cultural structures (e.g., houses) also fell under regulatory purview. Subsequently, those pre-1994 restrictions (i.e., houses) have been removed from the list for consideration as a mining restriction. Added to the list of protected structures in 1994, public buildings (churches, schools, and other large structures) are now regulated and require protection from damage caused by underground mining. Also regulated is the practice of mining near existing mines. Regulations

stipulate that a 200-foot distance remain between mines, as one mine approaches the other, hence the practice of leaving barrier pillars in a mine to separate it from an adjacent mine.

Perhaps a little background should be given about why this procedure changed, as the authors understand it. Legislation enacted in 1966 had as its goal the mitigation of structural damage to homes and buildings caused by mine subsidence, as well as aquifer loss prevention, and was proactive toward protecting the property of the owner. So prior to 1994, such features like oil and gas wells, roadways, streams and lakes, buildings, railroads, and utilities might have been an impedance to underground mining, because existing regulations at that time mandated that these objects be protected from the effects of mine subsidence. Room-and-pillar mines, and to some extent longwall mines often were designed in such a way to avoid concentrations of these excluded surface structures. This practice tended to result in a loss of coal from production. With passage by the Pennsylvania Legislature of Act 54 in 1994, protection of structures, except for oil and gas wells and public buildings, is no longer necessary and mine permits can now be obtained that allow mining beneath them. Prevention is no longer the goal. The protection of property has moved into the realm of the reactive. The owner now must ask the coal company for compensation if damage does occur, and the coal company is obligated to compensate the owner for irreparable structural damage or loss of water supplies once damage is proven. Ultimately, the Pennsylvania Department of Environmental Protection will have the final say about which structures can be undermined.

Deep-mining regulations are now favorable to longwall mining interests and until legal confusion ensuing from passage of Act 54 about what can or can not be protected is cleared up, underground-mining interests will continue to mine under everything and, therefore, see more coal extracted out of the ground than ever before. Lost-in-mining ratios should fall, too. This report has been modified to reflect the new rules.

Several technological restrictions occur within the Saxonburg quadrangle. They are public buildings, oil and gas wells, deep-mine barrier pillars, and bed too thin to be mined. Public buildings are to be protected from subsidence damage. The block size of coal needed to support such a surface structure would vary, depending upon depth and thickness of the coal seam. As an average for this study, an area defined as structure plus 300 feet was used. Ordinarily, oil or gas wells require two different radii of exclusion, dependent upon whether the well is an abandoned or an active well. In most circumstances, the coal companies are allowed

to mine through an abandoned oil or gas well that has been properly plugged. But it also requires permission to do so from the oil or gas company. Active wells on the other hand must not be disturbed and coal companies usually leave a block of coal behind of a predetermined size to support the well. Commonwealth regulations allow underground mining within 500 feet of a well without a permit from the Commonwealth Department of Environmental Protection. Acquiring such a permit will grant mining within 150 feet of a well. If there are no objections from the well owner and there are no extenuating circumstances related to the site, the Department of Environmental Protection may grant permission to the coal mine operator for a smaller radius of less than 150 feet, or whatever is needed to support the well. Coal mining companies in the Saxonburg quadrangle most often used a radius around a well of 100-150 feet. In order to provide consistency with surface-mining practices, a minimum radius of 100 feet was used in GRASS as the buffer size. Another type of restriction common to underground mining is the barrier pillar. These mine barriers physically separate the different mines from one another and are not usually extracted. According to the regulations in order to provide a degree of safety in the mines, a buffer 200 feet in diameter must be left between mines. However, historically, that particular diameter is not followed. Perhaps that regulation was not in force at the time the majority of the mining occurred, or common practice was to use a smaller diameter thickness. Whatever the reason, due to the uneven application of this practice in the Saxonburg quadrangle, not all deep-mine barriers are of that size, or they not even exist at all in places. Consequently, only the remaining barriers were individually digitized, and given a 200-foot buffer in GRASS, and then placed in the restriction category "deepmine barriers." By using a 200-foot buffer for all barriers, some consistency could be maintained, and all coal potentially lost in mining due to all barriers averaged out. As it turns out, because of the spatial location of deep mines, merging of mine companies, and poor record keeping by the mine owners, areas where these barriers should have existed cannot be shown for this study. Instead the approximate area is incorporated in such a way that it can be incorporated as part of the resource lost in mining. The last technological restriction to mining used in this report is coal too thin to mine. In this report, 28 inches or greater was chosen as the practical threshold at which a coal bed can be divided between being deep minable or not deep minable. All coal less than 28 inches thick was, therefore, excluded from the remaining coal resource.

As a historical reminder, although they are not excluded today, structures (houses) would have required protection from subsidence prior to 1994. Therefore, a mining company using room-and-pillar or longwall methods to mine would have had to leave an appropriately sized block of coal behind for support. That is coal removed (restricted) from the resource and therefore unavailable for mining. Post 1994, because of the changes in the law, if one were to recalculate resources for the same area, one might expect an increase in the amount of coal available for mining. Thus, it was important to reevaluate the resource based on the new regulations rather than the old when providing a resource estimate for this quadrangle.

Data Issues

Types of Data

Data basically fell into two types: point data and line data. The point data included core logs, measured sections, and coal chemistry analysis values. They typically contain information about their location, elevation, a physical description of the core or measured section, and a coal sample number for those coals collected for analysis. The line data included the outline of surface- and underground-mined-out areas, identified land-use and technological restrictions to mining, and coal crop lines. Line data of the mined-out areas and most restrictions, such as streams, lakes and wetlands, were converted into polygons prior to their inclusion in GRASS.

Data Criteria

A set of general criteria was established to determine which coals would be used in the study. They are enumerated below:

1. Coal has been historically mined in the study area and is potentially minable today; or
2. The coals are thick enough and are of good enough quality to warrant mining; or
3. A sufficient number of data control points existed providing definition of the resource.

Original resources, as defined by the Coal Availability software program, is any in situ coal greater than or equal to 14 inches thick. Remaining and available resources were calculated for the Saxonburg quadrangle by combining three overburden categories, 0-200 feet, 200-1000 feet and greater than 1000 feet, with two coal thickness categories, namely 14-28 inches, and greater than 28 inches. At each control point per coal bed name, only those lithologies called "coal" were summed for the seam. This eliminated partings and extraneous rock material from

consideration in the coal tonnage calculations. A follow-up to this study by employees of the former U.S. Bureau of Mines reintroduces these partings in the total seam thickness to determine how much available coal is in fact actually recoverable (i.e., economic reserve).

Past mining practices considered coal found deeper than 1000 feet below the surface as too prohibitive to mine, because it was either technologically more difficult to mine or it was uneconomical to mine at that depth. Such a deep coal bed would be considered a restriction to mining. However, in this study area depth of overburden as a restriction is not a problem; overburden for the deepest coal bed considered (Clarion) is less than 1000 feet within the quadrangle area.

Procedures for Data Manipulation

Seven coal beds were chosen for study based on the criteria above. Then the NCRDS database was searched for all relevant records about each of the coal beds centered on the Saxonburg quadrangle and extending for a distance in latitude and longitude equal to 3 miles into the adjacent eight surrounding quadrangles. This extra 3-mile search radius was chosen because it added extra points outside the study quadrangle which then could be used to smooth out any "edge effects" at the study quadrangle borders. Any unusual edge effects can become an important deleterious factor when gridding and contouring coal thickness and coal elevation values for each coal resulting in potentially erroneous resource calculations. The data records (point data) found by the search had to be initially proofed and any gross errors corrected by the authors using a computer printout of those records. These initial corrections were sent to the U.S. Geological Survey Coal Branch personnel in Reston, Va., who then corrected the data in NCRDS. Later, in order to fine-tune the data, a further editing and verification step was completed on-line by Pennsylvania Geological Survey staff using the NCRDS Ingres database manager software.

The USGS provided to the Bureau a copy of GRASS 4.1 (Geographical Resources Analysis Support System), one that it had further modified for use in Coal Availability. This version of GRASS was loaded on to the Bureau's Sun Microsystems Sparc2 Workstation. The newly corrected NCRDS point data were searched by bed name and downloaded for use in the GRASS software, from which raster sites files of coal-bed thickness and elevation could be created and gridded. The grid of the elevation file (data layer) created for the top of each coal

was subtracted from the Digital Elevation Model (DEM) 30-meter spaced grid of surface elevations for the Saxonburg quadrangle, which was acquired from personnel in the Eastern Energy Resources Team of the U.S. Geological Survey in order to provide an overburden raster map file for the quadrangle. The coal lithology thickness raster grid of each named coal bed was contoured. This was accomplished by using one of the several algorithms available in GRASS. In order to take advantage of the rather evenly spaced nature of the data in the Saxonburg quadrangle, the GRASS algorithm s.surf.idw was chosen to contour the data. The result from the GRASS algorithm s.surf.idw when combined with another GRASS subroutine, r.mapcalc, provided the two broad categories needed in the resource calculations (i.e., coal thickness ranges and overburden thickness categories).

Correlation of each coal seam was accomplished through manual (analog) methods using data from driller's logs, geologist's logs, and measured sections. A persistent coal bed, or if available, a marine zone was used to provide stratigraphic control throughout the quadrangle.

Mining information and coal crop lines were compiled from work maps created by Dodge (1985). These work maps were further updated by collecting recent mining information for the Saxonburg quadrangle off of mining permits stored at the Pennsylvania Department of Environmental Protection district mining offices in McMurray, and Greensburg, Pennsylvania, and through the use of recent aerial photography (for surface mining), and some field reconnaissance. Land-use practices and technological restrictions to mining were determined from state and local regulations.

The mining and crop line data associated with each of the seven coal beds were digitized using the U.S. Geological Survey software program GSMAP version 8 residing on a NEC 486-DX 33 Personal Computer at the Bureau. Once digitized, the data were converted in GSMAP into a GRASS-format file using the GSMAP utility GSMGRASS. The digital data were then edited and processed in GRASS to create the data layers used in the resources module. The digitized restriction data, imported as individual data layers from GSMAP into GRASS, were proofed, buffered (s.poly for oil and gas wells, r.buffer for roads, streams, etc.), when necessary, and then labeled for use in various GRASS tables. This data had to then be rasterized before it could be used in the various GRASS and Perl (a programming language) modules used to compute resources. Once completed, the tonnage calculated from the mined-out areas raster is subtracted from the original resource raster, and the various restriction rasters are totaled and

subtracted from the remaining resource total raster, leaving a raster of the amount available for mining.

The GRASS program script, resources.init, allows for the creation of a series of input and output tables, in which are assigned names to the various restrictions, thickness categories, etc. The values in this table must match names given elsewhere in the program data files for the restrictions, thickness categories, etc. so that tonnages are correctly placed with the corresponding nametag. The GRASS-created raster files, when manipulated by the Perl resource scripts, result in the calculation of tonnages for the following parameters: original, mined out, remaining, the various restrictions, and available coal. All coal resource calculations were executed on the Bureau's Sun Workstation.

Equipment Used in Data Manipulation

Pennsylvania Geological Survey geologists and summer interns digitized line data used in this Coal Availability Study by using a GTCO Corporation Digi-pad 5A® 24 by 36 inch digitizing table and the U.S. Geological Survey geologic map preparation software, GSMAP-version 8 (Selner and Taylor, 1992).

Access to Pennsylvania's point data in the NCRDS, which is stored on a U.S. Geological Survey Sun Microsystems fileserver, was through a Sun SPARCstation 2® workstation computer with an Internet connection located at the Bureau's Harrisburg office (in 2001 moved to Middletown, Pa.). The Pennsylvania Geological Survey's Sun workstation is locally connected to a high-speed local area/wide area network (LAN/WAN) with access to the Internet provided via a Department of Environmental Protection (formerly Department of Environmental Resources) Server located in downtown Harrisburg, which connects to a node, provided by Verizon/Bell Atlantic-PA. A non-commercial service provider called PREPnet (recently acquired by Veriocity) provides the Internet service from that node.

Original, Mined, Remaining, and Available Resource Calculations

Concept

The original coal resource for the Saxonburg quadrangle was calculated using the U.S. Geological Survey's modified GRASS resource script, which is modeled after criteria developed by Wood and others (1983) and published in U.S. Geological Survey Information Circular 891.

The objective of Circular 891 is to provide a method of characterizing the certainty of a resource in a consistent manner. Several levels of confidence are possible, with a lesser degree of certainty occurring with progressively farther distance away from a data point of known value. For Coal Availability this measurement of confidence in the resource is classified as *measured* for a distance of 0.25 mile from a data point, *indicated* for a distance of 0.25-0.75 mile from a data point, *inferred* for a distance of 0.75-3.0 miles from a data point, and *hypothetical* for a distance greater than 3.0 miles from a data point. Therefore, when reading the data tables in this report, expect the most confidence in a value determined for any "measured" or "indicated" tonnages and much less confidence in the tonnages calculated for an "inferred" or "hypothetical" value.

Coal-bed resources include all coal found within the measured, indicated, inferred, as well as hypothetical categories without any regard to economic considerations.

As defined by the USGS in Circular 891, original resources represent coal greater than 14 inches thick. GRASS automatically factors this requirement into its calculation of original resources of a coal bed.

Remaining resources can be calculated once original resources are known. Surface-mined and deep-mined coal tonnages are calculated by totaling individual (digitized) mined-out-areas (files). These extracted coal tonnages reflect the total of coal mined out and coal lost in mining for the quadrangle. Remaining coal resources for each coal bed can be easily calculated by subtracting the mined-out-areas total from the original resource total.

Each of the digitized data layers, which represents a type of restriction, was rasterized and then individually subtracted from the remaining resource raster files in GRASS and totaled using Perl scripts for each coal bed. First, this was done for the surface-mining category (i.e., overburden less than 200 feet), and then it was done for the deep-mining category (i.e., overburden greater than or equal to 200 feet). The resultant individual restriction tonnages and their summation are shown on Table 1, page 34, in the text. Because they are individual totals, these tonnages depict a greater amount of coal excluded when compared to the restriction tonnages given in the tables in Appendix B. However, because restrictions can overlap, the restricted resource total on a coal bed is not necessarily equal to the sum of the individual restrictions. Fortunately, GRASS adequately accounts for the effect of these overlapping restrictions, usually by taking the largest overlapping restriction total and placing it in the tables

while ignoring the smaller overlaps. A more accurate restriction value is the result. The actual land-use and technological restriction totals in GRASS-derived v_*.tab files, which are also used to create the data found in Tables 1 and 2, are based upon that factoring in of any overlapping restrictions and may have a different value from that seen in the other tables of Appendix B. This "corrected" total is subtracted from the remaining resource by the Perl scripts for each coal bed and category in the final tally to arrive at an available resource.

Application

Available resource tonnages are summarized in Table 2, and are illustrated as a series of bar diagrams in Appendix A. Note in Table 2 that the categories 0-200 feet and >200 feet are provided as a convenient way to segregate tonnage values for surface-mined and deep-mined coals. See the individual coal-bed summary tables in Appendix B, of this report, for a more thorough breakdown of coal resource tonnages using the measured, indicated, inferred, and hypothetical categories of resource classification for original, mined-out, remaining, and available coal.