Availability of Coal Resources for Mining in Illinois

Newton and Princeville Quadrangles, Jasper, Peoria, and Stark Counties

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Open File Series 1996-3

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ACKNOWLEDGMENTS

This project was supported by the U.S. Geological Survey, Department of the Interior, under assistance award No. 1434-94-A-1266. We are especially appreciative for the information on criteria that limit the availability of coal given to us by mining experts. Interviews were conducted with Philip Ames, Michael Engleman, and Chris Padovich of Black Beauty Coal Company; James Hinz and Randy Stockdale of Consolidation Coal Company; Michael Caldwell and Neal Merrifield of Freeman United Coal Mining Company; James Grimm of Midstate Coal Company; and Eric Quam of Old Ben Coal Company. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government or the mining companies.

ILLINOIS

DEPARTMENT OF NATURAL RESOURCES

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EXECUTIVE SUMMARY

This report is part of a series examining the availability of coal resources for mining in Illinois. Coal resources and related geologic features in the Newton and Princeville Quadrangles were described and mapped. Interviews with experts from coal companies, consulting firms, and state government indicated how regulatory restrictions, cultural features, mining technology, geologic conditions, and economic conditions affect resource availability in the two quadrangles. The Newton Quadrangle is representative of many of the geologic and physiographic conditions common to the central part of the Illinois coal field. Many of the conditions typical of the northwestern portion of the coal field are found in the Princeville Quadrangle.

Of the 1.1 billion tons of original resources in the Newton Quadrangle, 61% (668 million tons) is available for underground mining, 34% (375 million tons) is unavailable because of technical restrictions, and 5% (59 million tons) is unavailable because of land use. No surface minable resources were in the quadrangle, and no resources have been mined. Technical restrictions include thin interburden between minable seams (22% of total resources), coal less than 4 feet thick (7%), excessive parting material within seams (4%), and small block size (less than 1%). Land use restrictions are towns (5%) and cemeteries (less than 0.5%).

Of the 198 million tons of original resources in the Princeville Quadrangle, 18% (35 million tons) is available for surface mining, 65% (131 million tons) is unavailable because of technical restrictions, and 16% (32 million tons) is unavailable because of land use. Less than 1% of the resources (1.5 million tons) has been mined out. Technical restrictions on surface mining are high stripping ratios (40% of original surface minable resources), thin coal (11%), thickness of unconsolidated overburden (9%), and size of mining block (5%). Land use restrictions for surface mining are towns (12% of original surface minable resources); roads (3%); pipelines (1%); and railroads, cemeteries, and transmission towers (less than 1%). Only 7 million tons of resources in the Princeville Quadrangle are classified as underground minable, and none of these are available for mining as a result of seam thickness and block size.

INTRODUCTION

Accurate estimates of the amount of coal resources available for mining are needed for planning by federal and state agencies, local communities, utilities, mining companies, companies that supply goods and services to the mining industry, and other energy consumers and producers. Current inventories of coal resources in Illinois provide relatively accurate estimates of the total amount of coal in the ground. There is serious doubt, however, regarding the percentage of coal resources that can actually be mined. Environmental and regulatory restrictions, the presence of towns and other cultural resources, current mining technology, geologic conditions, and other factors significantly reduce the amount of coal available for mining.

Recognizing the significant difference between the reported tonnage and the probable tonnage of coal actually available for mining with current technology and mining regulations, the United States Geological Survey (USGS) initiated a program in the late 1980s to assess the amount of available coal. This report is part of an ongoing, cooperative effort between the USGS and the Illinois State Geological Survey (ISGS) to assess the availability of coal resources for future mining in Illinois. It specifically covers the assessments of the availability of coal resources in the Newton Quadrangle in east-central Illinois and the Princeville Quadrangle in northwestern Illinois (fig. 1). The background of the program as well as the framework for the investigations in Illinois has been described in previous reports (e.g., Treworgy et al. 1994).

Treworgy et al. (1994) divided Illinois into seven regions, each representing a distinct combination of geologic and physiographic characteristics. Two to four quadrangles representative of the mining conditions in each region have been selected for assessment of their available coal resources (see table 1). The selection of quadrangles and the assessment of resources in them focuses on resources that have the highest potential for development (e.g., those that are thick or have a lower sulfur content). This approach ensures that the most economically important deposits receive sufficient study and that minimal time is spent assessing resources that are clearly too thin or inaccessible ever to become available for mining. When a sufficient number of quadrangle studies has been completed, the results from the individual quadrangle studies will be extrapolated to larger regions to estimate the quantity of available coal.

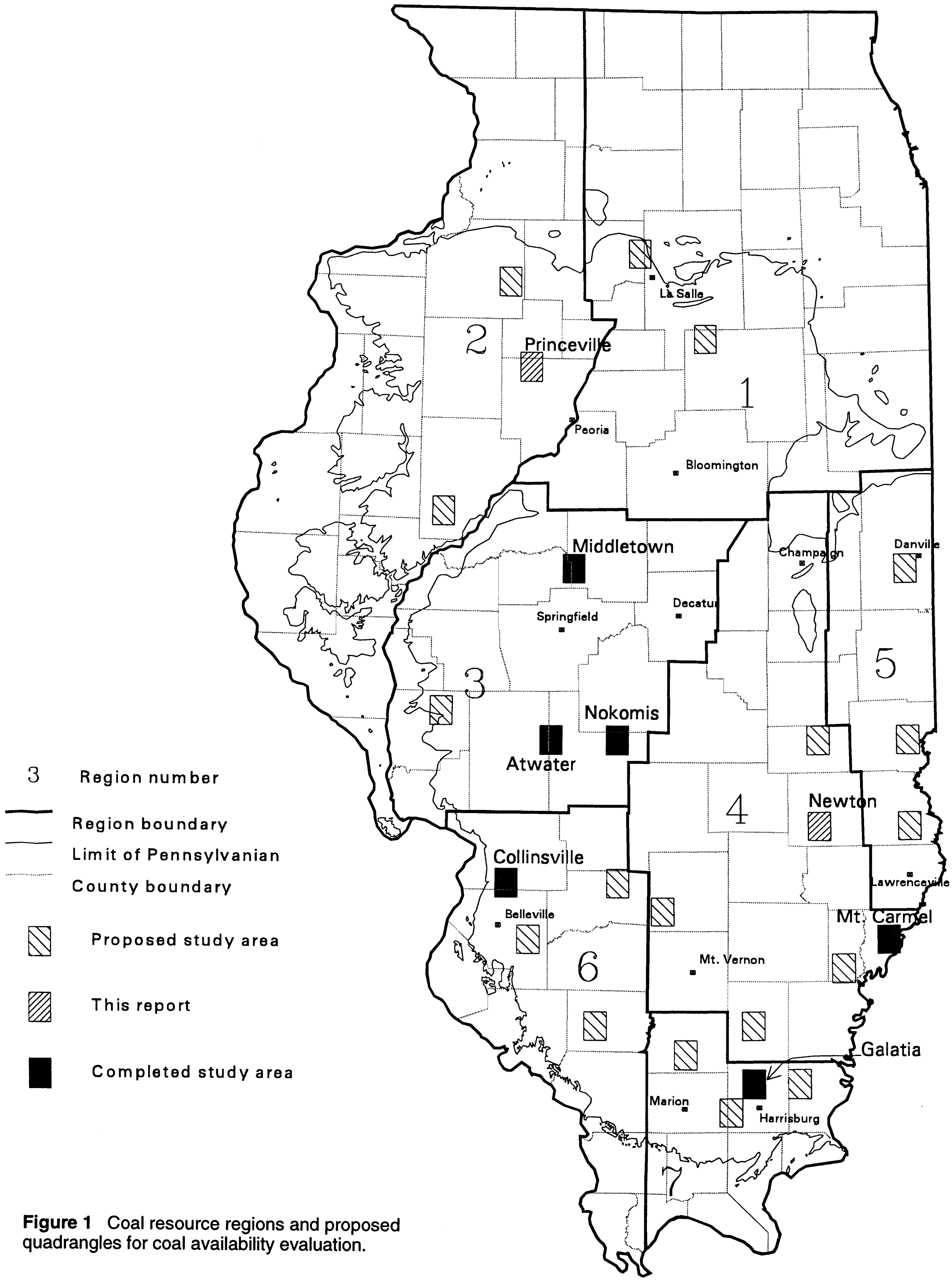

Figure 1 Coal resource regions and proposed quadrangles for coal availability evaluation.

Table 1 Criteria used for selecting quadrangle study areas.

- Select at least two to four quadrangles in each region.
- Select at least one per region with surface minable resources and one with deep minable resources.
- Quadrangles should generally contain resources screened as having a high potential for development.
- Include as many different land cover/land use situations as possible.
- Study at least one quadrangle in each of the major low-sulfur deposits (Quality Circle, Hornsby, Troy, Charleston, Galatia, Darwin, Murphysboro, Francis Creek).

The assessment of each quadrangle consists of three steps: (1) compilation of data on the geology and coal resources of each quadrangle, (2) identification of the criteria defining available coal, and (3) application of these criteria to each quadrangle to calculate available resources. Insights provided by previous regional investigations of mining conditions, resources, and geology enabled us to compile 1:24,000-scale maps of the major coal seams, related geology, mines, and land use in each quadrangle. These maps were then used to provide the basis for detailed discussions with mining experts to identify the factors that affect the availability of coal in each quadrangle. The results of these interviews were used to develop a set of rules defining available coal. Application of the rules to the resources in each quadrangle allowed us to calculate the amount of available resources and identify the factors that restrict significant quantities of resources.

Coal Resource Classification System

The ISGS follows the terms and definitions of the USGS coal resource classification system (Wood et al. 1983). With minor modifications to suit local conditions, these definitions provide a standardized basis for compilations and comparisons of nationwide coal resources and reserves. Some ISGS publications written prior to the development of this classification system in 1976 use terms in a different manner. For example, the term *reserves,* as used by Cady (1952), is comparable to the term *resources,* as now defined.

In this report, resources are defined as all coal in the ground that is 18 or more inches thick and less than 150 feet deep or all coal that is at least 28 inches (2.3 feet) thick. The term *original* when used as a preface to *resources* or *available resources* refers to the amount of coal present prior to any mining.

The term *available coal* is not a formal part of the USGS system, although it is commonly used by the USGS and many state geological surveys. Available coal, as used in this report, is not meant to imply that particular coal deposits can be mined economically at the present time. Rather, the term is used to designate deposits that have no significant characteristics likely to render them technically, legally, or economically unminable for the foreseeable future. Further engineering and marketing assessments are needed to determine the actual cost and profitability of mining these deposits.

Sources of Data

Geologic data for this study were compiled from well logs, field descriptions, and records of mines on file at the ISGS as well as data obtained from coal mining companies. Surface elevations were digitized from USGS 7.5-minute topographic quadrangle maps (scale 1:24,000). Land cover features such as cemeteries, railroads, and towns were digitized from topographic maps and verified in the field.

The rules for delineating available coal were developed from interviews with mining engineers and geologists from five coal mining companies active in these areas and the Illinois Department of Mines and Minerals. The mining experts reviewed maps and cross sections of the coal resources and related geology of the quadrangles. Using this information, as well as their own experience in the area, the experts delineated areas that they thought were available for mining. Results from the individual interviews were combined to create a set of rules defining available coal in the Newton and Princeville Quadrangles.

Other Investigations of Available Coal

In related investigations, the ISGS has evaluated the availability of coal resources in the Middletown Quadrangle in the central part of the state (Treworgy et al. 1994), the Galatia Quadrangle in southern Illinois (Treworgy et al. 1995), the Mt. Carmel Quadrangle in southeastern Illinois (Jacobson et al., in press), and the Atwater, Collinsville, and Nokomis Quadrangles in west-central Illinois (Treworgy et al. 1996). These four studies have evaluated a total of sixteen coal seams. The percentage of available resources in each quadrangle, including the results from this report, has ranged from 18% to 76% of the original resources.

Each quadrangle represents a different geologic and geographic setting in Illinois. A major goal of each quadrangle study is to identify and define the factors that influence the availability of resources in that setting. Some factors, such as roof conditions, are different with each seam whereas other factors, such as minimum seam thickness, are applicable to all seams. Factors such as cemeteries are the same throughout the state, but other factors, such as roads, are dependent on the region of the state and value of the underlying coal deposits.

NEWTON QUADRANGLE

The Newton Quadrangle, in Jasper County, is located in region 4 (fig. 1). The town of Newton (population 3,200) is in the northeast corner of the quadrangle (fig. 2). The Embarras River flows along the north edge of the town, and a railroad crosses the north boundary of the quadrangle. There are no interstate highways, major pipelines, or transmission lines. Most of the quadrangle consists of flat or gently rolling farmland and pasture.

The Newton Quadrangle is representative of mining conditions in the central part of the Illinois Basin. Illinois' major coal seams, the Herrin and Springfield Coals, are more than 1,000 feet deep in this area, which is their deepest position in the basin (fig. 3). Because of the depth of these seams, there has not been any major mining activity in the area. However, several companies have done exploratory drilling, and the area is known to contain billions of tons of resources.

The geology and coal resources of the region containing the Newton Quadrangle were described by Williams and Rolley (1955), Allgaier and Hopkins (1975), and Treworgy (1981). Nance and Treworgy (1981) reported on surface minable resources in the region but did not map any surface minable resources in the quadrangle.

Strata in the eastern part of the Newton Quadrangle dip gently westward, off the flank of the Clay City Anticline into the Bogota-Rinard Syncline (Nelson 1995). The trough of the syncline, which trends roughly north to south, lies along the west boundary of the quadrangle. The structure, in combination with relatively level surface topography, results in coalbed depth increasing toward the west. The total thickness of Pennsylvanian sediment in this area is more than 2,000 feet.

The bedrock in the area is covered by relatively thin glacial and alluvial sediments (less than 50 feet thick). The uppermost bedrock contains several thin, widespread coals. One or more of these coals have been mined locally, including a 28- to 32-inch-thick unnamed coal in Wade Township just southeast of Newton (Nance and Treworgy 1981). Available data in or adjacent to the Newton Quadrangle are insufficient to map resources of these coals. Coal test holes drilled in the area targeted thicker seams at greater depths.

The coal resources of the Danville, Herrin, Springfield, and Seelyville Coals were mapped using data from 54 coal test holes supplemented by geophysical logs from 309 oil tests. Twenty-five of the coal test holes and 74 of the oil tests were within the quadrangle (fig. 2); the remainder were in a 4-mile buffer zone surrounding the quadrangle.

The Danville Coal ranges from somewhat less than 1 foot to just over 3.5 feet thick (fig. 4) and about 950 to more than 1,200 feet deep. The Herrin Coal is generally 5 to 6.5 feet thick and lies at depths of 970 to 1,250 feet (figs. 5, 6). The Springfield Coal is 3 to 5 feet thick and 20 to almost 40 feet below the Herrin Coal (figs. 7, 8). The Seelyville Coal ranges from less than 1.5 feet to about 8.5 feet thick and commonly contains one or more shale partings (figs. 3, 9). These partings range from a few inches to several feet in thickness. The seam is 1,230 to about 1,550 feet deep (fig. 10).

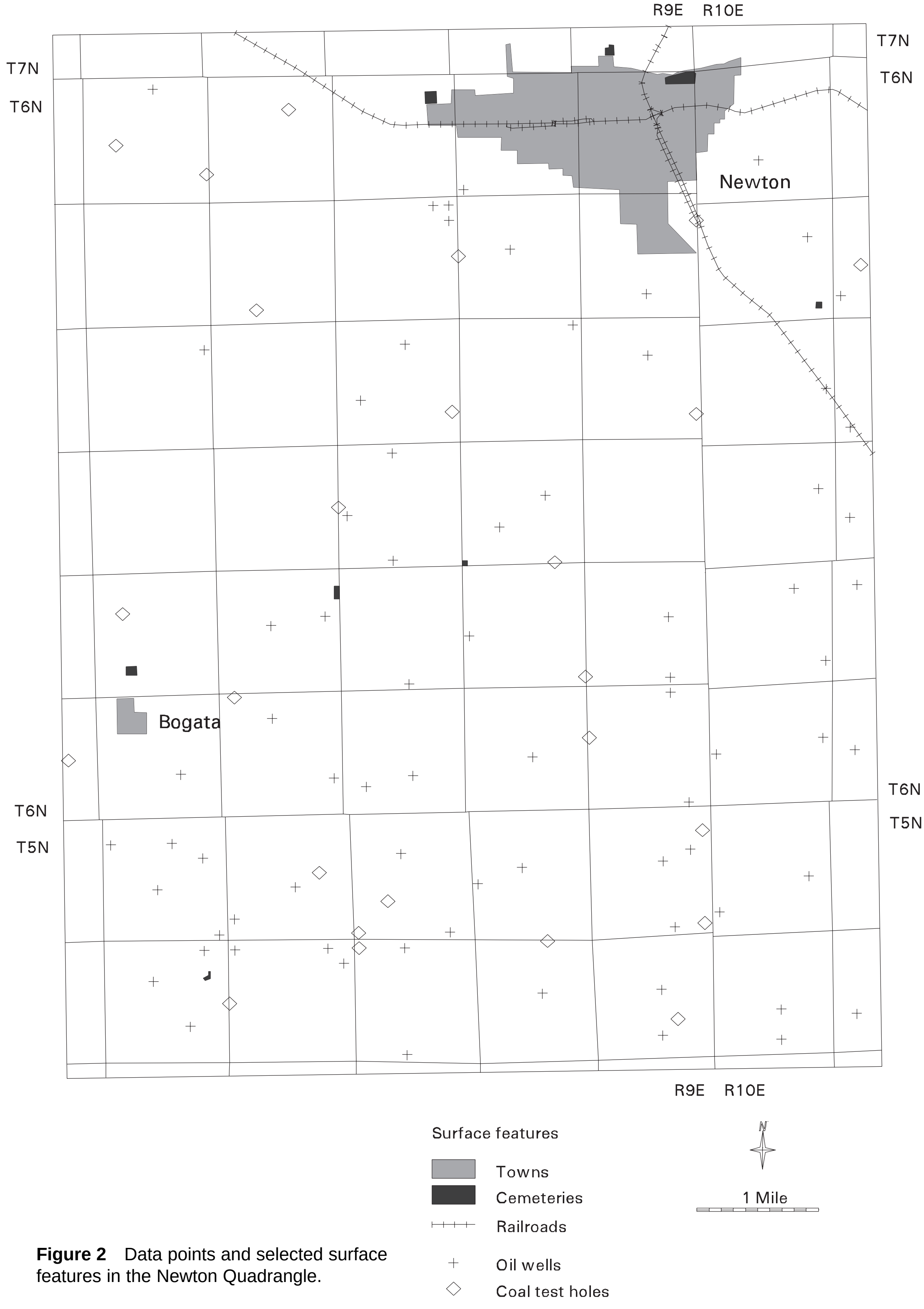

Figure 2 Data points and selected surface features in the Newton Quadrangle.

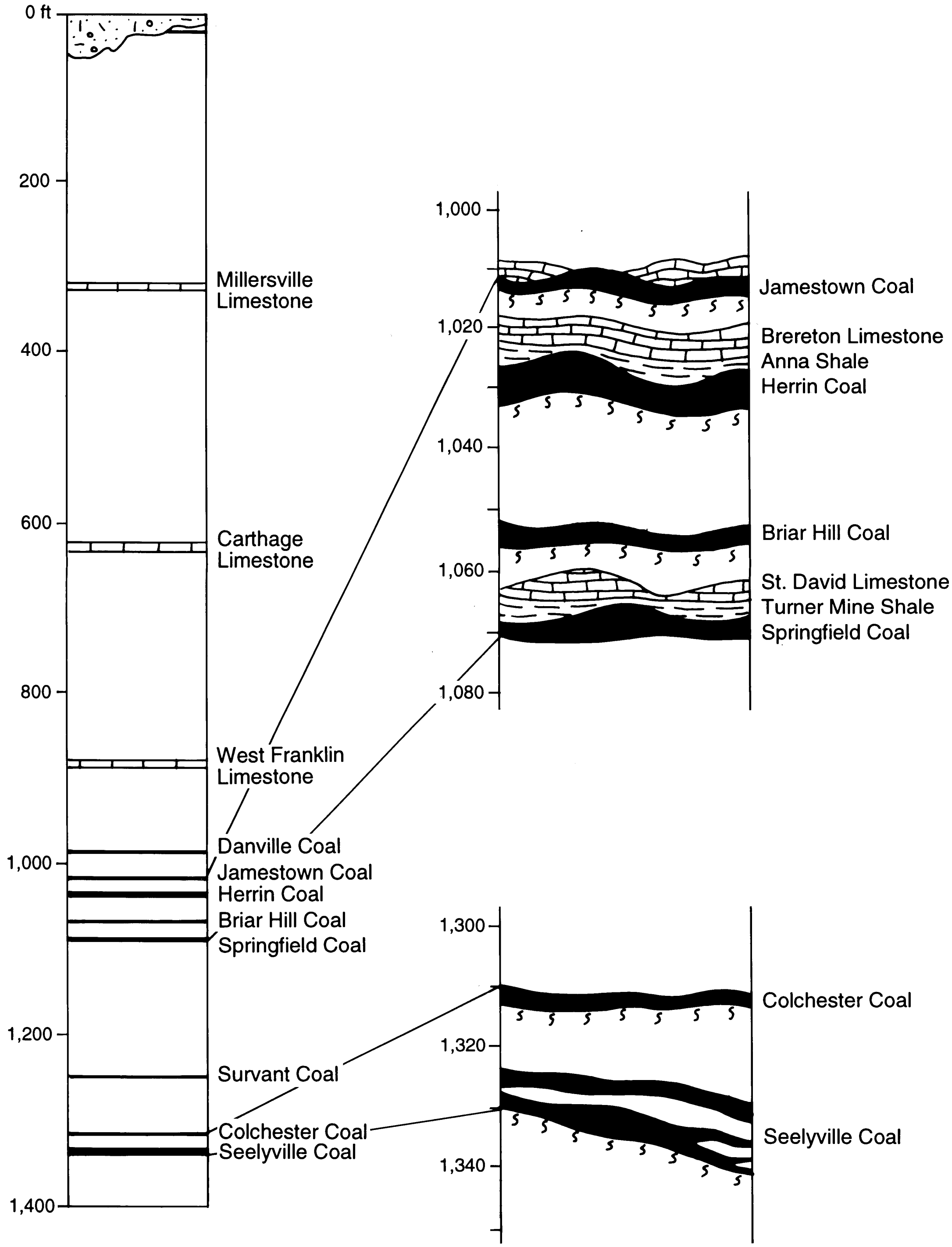

Figure 3 Stratigraphic section showing approximate vertical relations of selected units in the Newton Quadrangle.

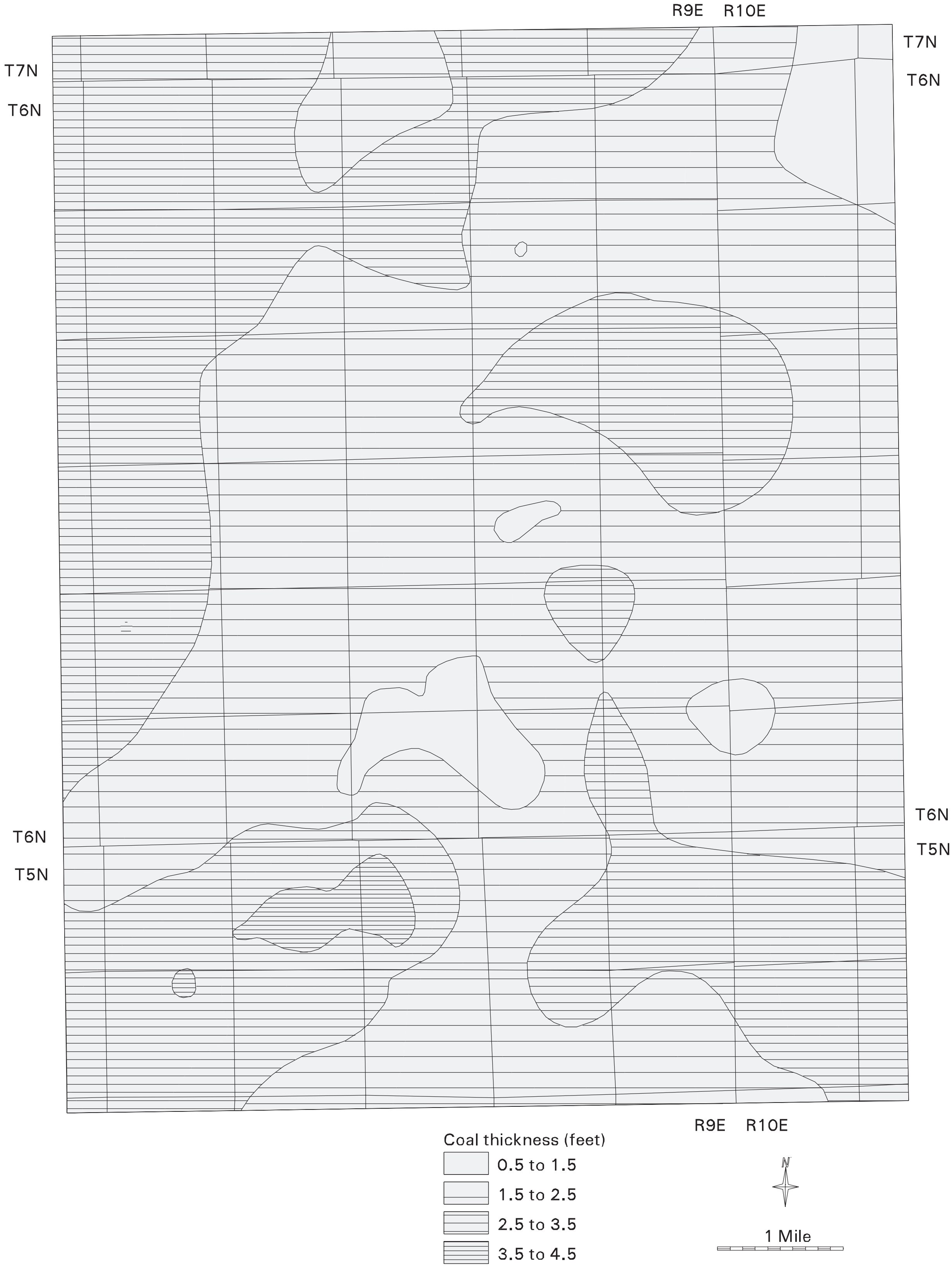

Figure 4 Thickness of the Danville Coal in the Newton Quadrangle.

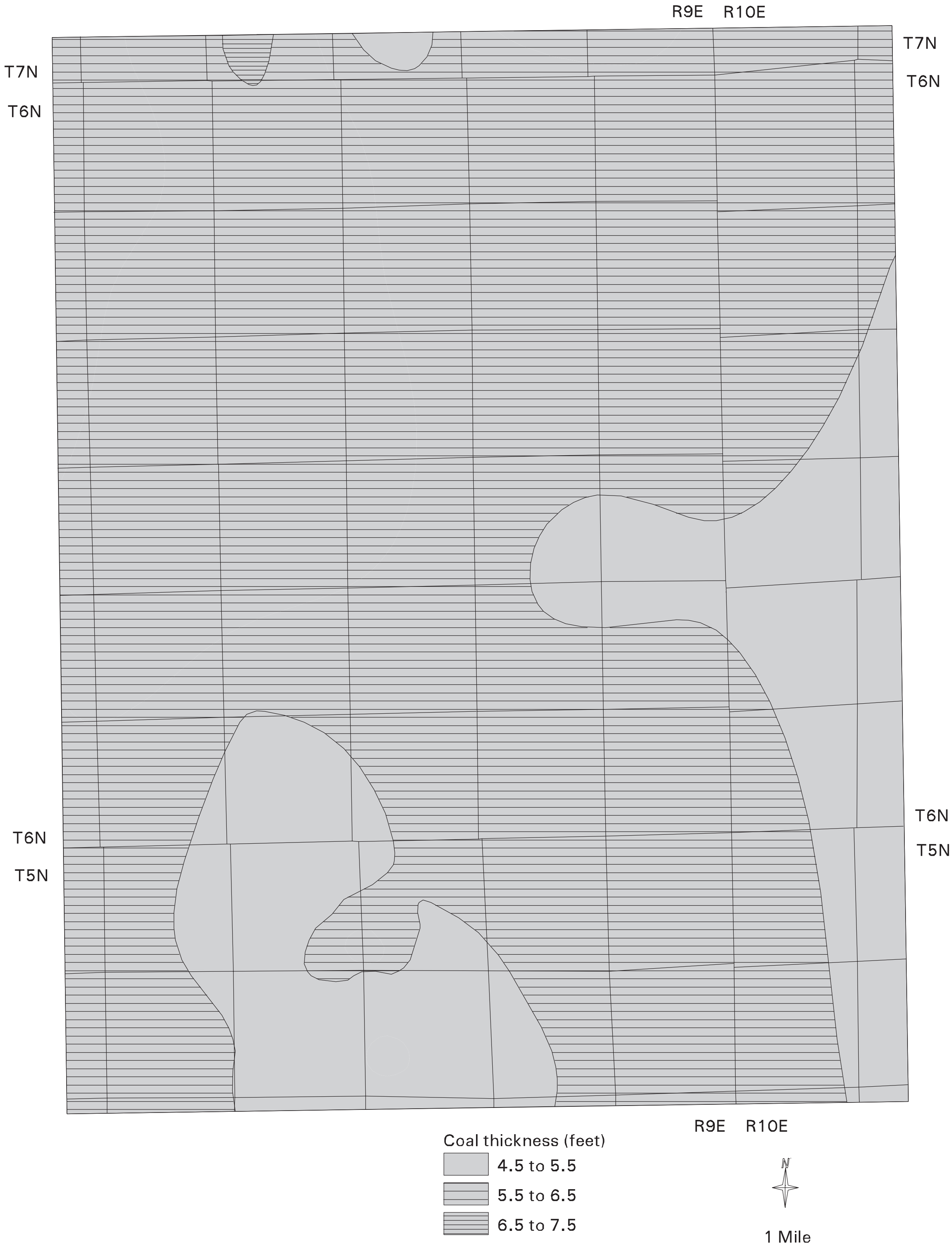

Figure 5 Thickness of the Herrin Coal in the Newton Quadrangle.

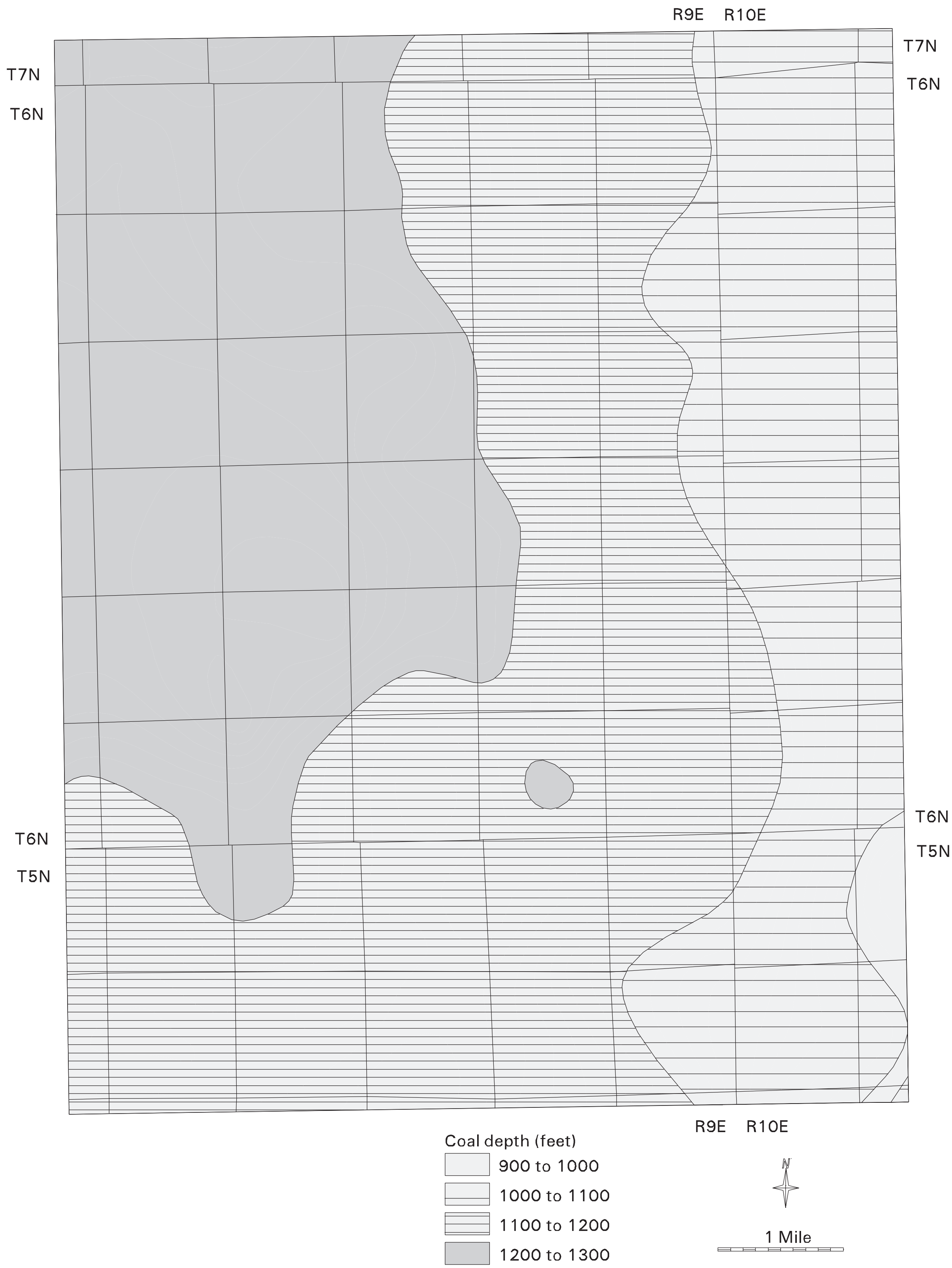

Figure 6 Depth of the Herrin Coal in the Newton Quadrangle.

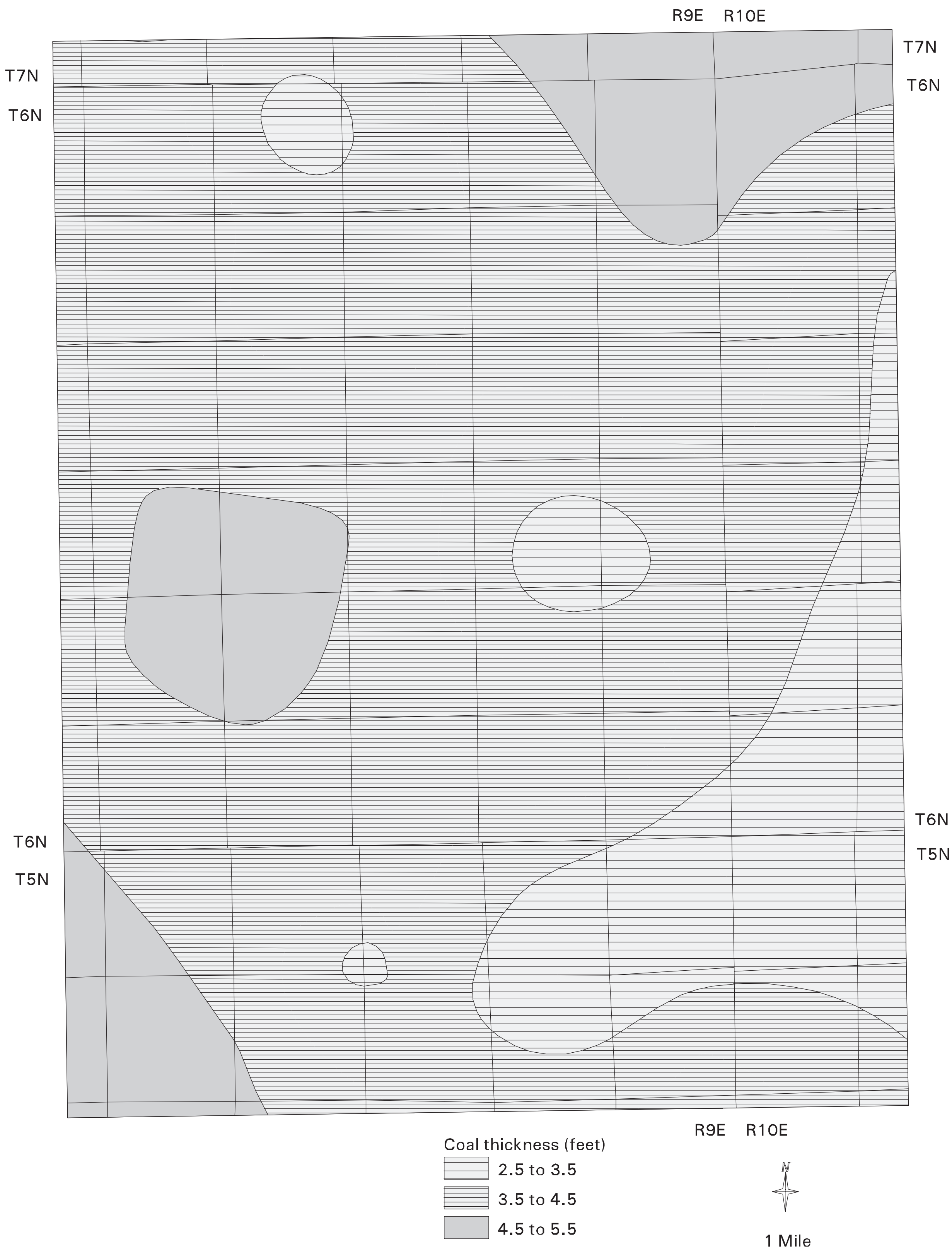

Figure 7 Thickness of the Springfield Coal in the Newton Quadrangle.

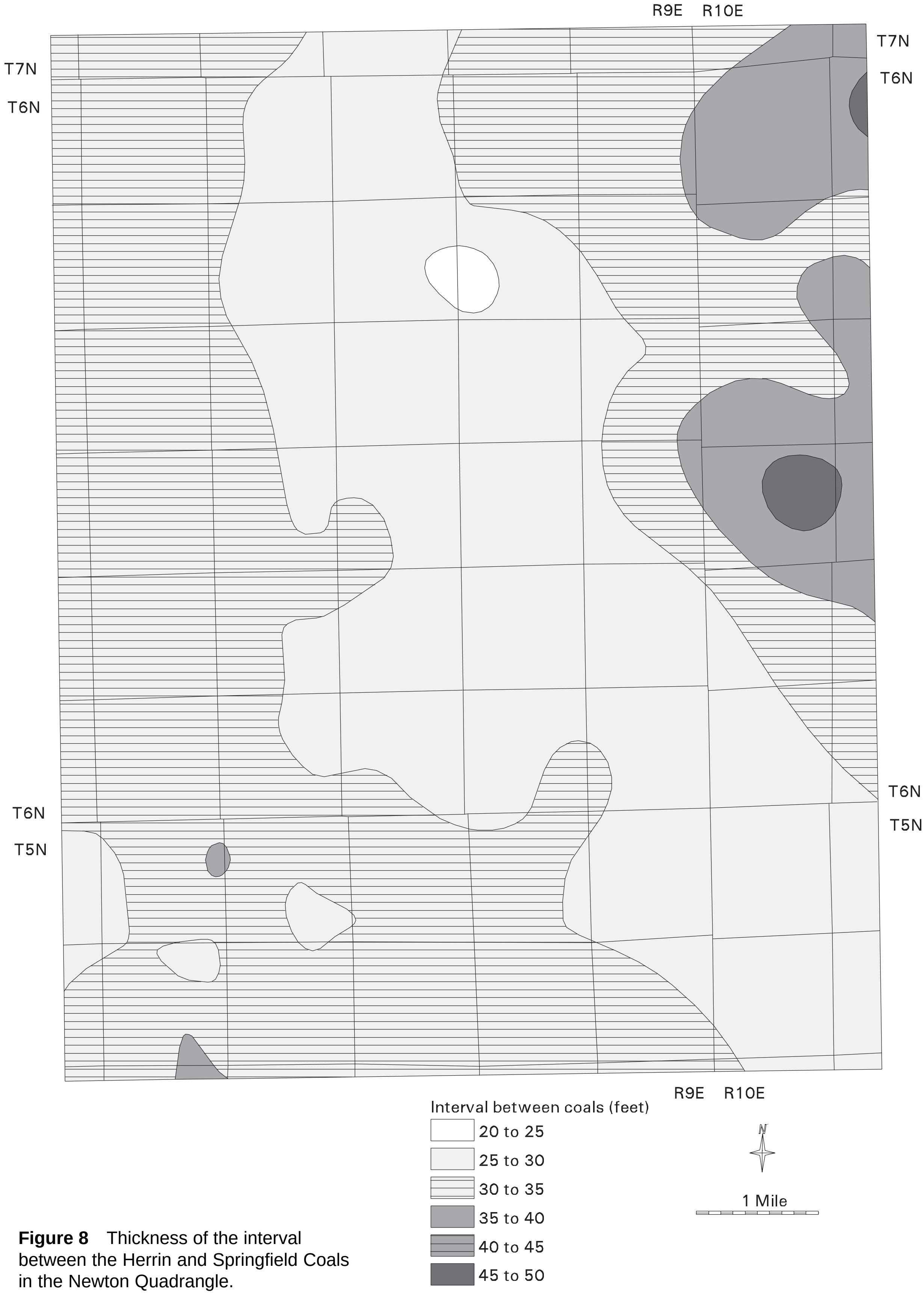

Figure 8 Thickness of the interval between the Herrin and Springfield Coals in the Newton Quadrangle.

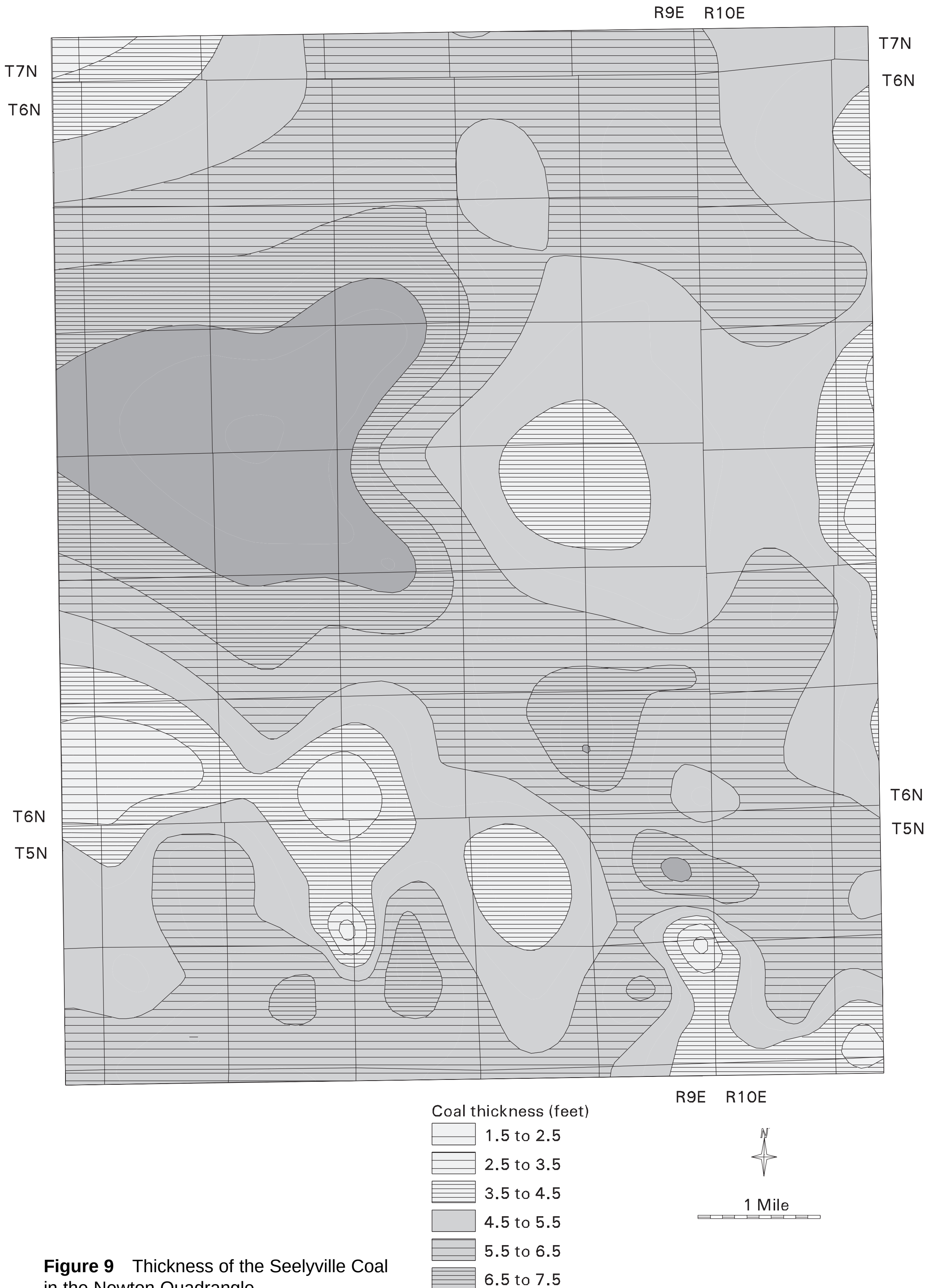

Figure 9 Thickness of the Seelyville Coal in the Newton Quadrangle.

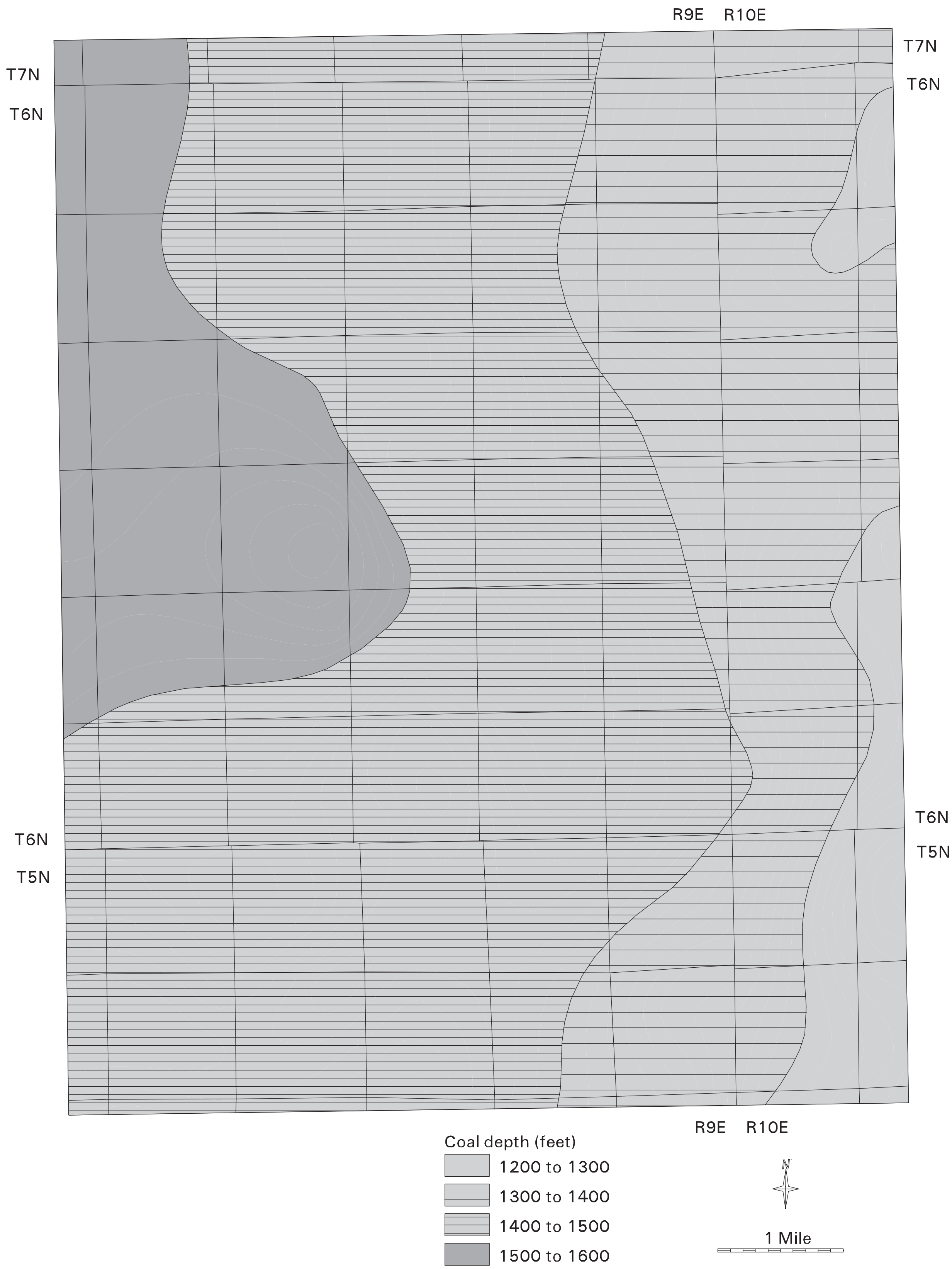

Figure 10 Depth of the Seelyville Coal in the Newton Quadrangle.

Criteria for Delineating Available Coal

Because there has been no mining of the deep coals in the Newton Quadrangle, mining conditions must be inferred. Currently, the deepest mining in the state is at a little more than 1,000 feet. The Herrin and Springfield Coals have been extensively mined at shallower depths elsewhere in the state, although the closest mines in these coals are 40 to 80 miles to the east, south, and west. The Seelyville Coal has been mined at only one location in Illinois, about 50 miles to the northeast near the Illinois-Indiana border. The Seelyville has been mined at several locations in Indiana. The experts we interviewed had experience at deeper mines in other states as well as from mining these seams at shallower locations elsewhere in the state.

Depth of seam Although all of the experts interviewed expressed a preference for mining shallower coals available elsewhere in the state, they did not consider any of the resources in the Newton Quadrangle too deep to mine. Depth to the seam increases the exploration and development costs of a mine and reduces the recovery rate of reserves. Larger pillars are needed to support the greater weight of roof rock, and, depending on the angle of draw used by the permitting authorities, larger buffers may have to be left around surface features. The net effect of these factors is that a larger reserve block is needed to support a mine.

Thickness of seam Productivity drops significantly in seams less than about 4 feet thick. The physical dimensions of the required reserve block become prohibitively large, movement of men and equipment is more difficult, and the tonnage produced per mining cycle is reduced. These factors make it difficult to extract coal at a rate necessary to recover the capital investment in mine facilities. For example, more than 25 square miles of coal averaging 3.5 feet thick is needed for a 100 million ton reserve. Only 15 square miles of land is needed if the coal averages 6 feet thick. In this study, 4 feet was used as the minimum thickness of available coal (table 2).

Size and configuration of mining block Because of the relatively high capital costs for exploration and development of a mine in this area, the minimum reserve block is 50 to 60 million tons of clean coal or about 100 million tons of coal in-place (table 2). Blocks must be a minimum of 6,000 feet on a side, the approximate width of four longwall panels.

Table 2 Criteria used to delineate available coal in the Newton Quadrangle.

Surface Mining
- No surface minable resources are mapped

Underground Mining
- Minimum seam thickness: 4 feet
- Maximum in-seam parting: 65% yield of clean coal per ton of material mined
- Maximum depth: not applicable (none of the coal in the quadrangle is too deep)
- Minimum reserve block size: 100 million tons in place
- Minimum width of mining block: 6,000 feet
- Minimum interval between seams: 40 feet
- Land use restrictions: 400 feet around towns and cemeteries

Partings in seams The Seelyville Coal in this area commonly contains one or more partings of shale and siltstone. The partings vary in number, thickness, and position within the seam. The limited drilling information available appears to indicate that mining selected benches of coal will not be feasible; the partings will have to be mined with the coal, thereby raising the cost of mining, cleaning of coal, and disposing of mine wastes.

Areas with excessive parting material will not be mined. For this assessment, we classified resources as unavailable if the yield of clean coal (by weight) per ton of material mined is less than 65% (table 2, fig. 11). The yield of clean coal was calculated by dividing the weight of the clean coal that could be produced (raw coal minus about 5% lost in cleaning) by the total weight of material mined (raw coal plus partings plus 0.5 foot of out-of-seam dilution from the roof and floor). The coal was assumed to have a minimum parting of 1 foot.

The Danville, Herrin, and Springfield Coals in this area do not contain a significant amount of parting material. No computation of clean coal yield was made for these seams.

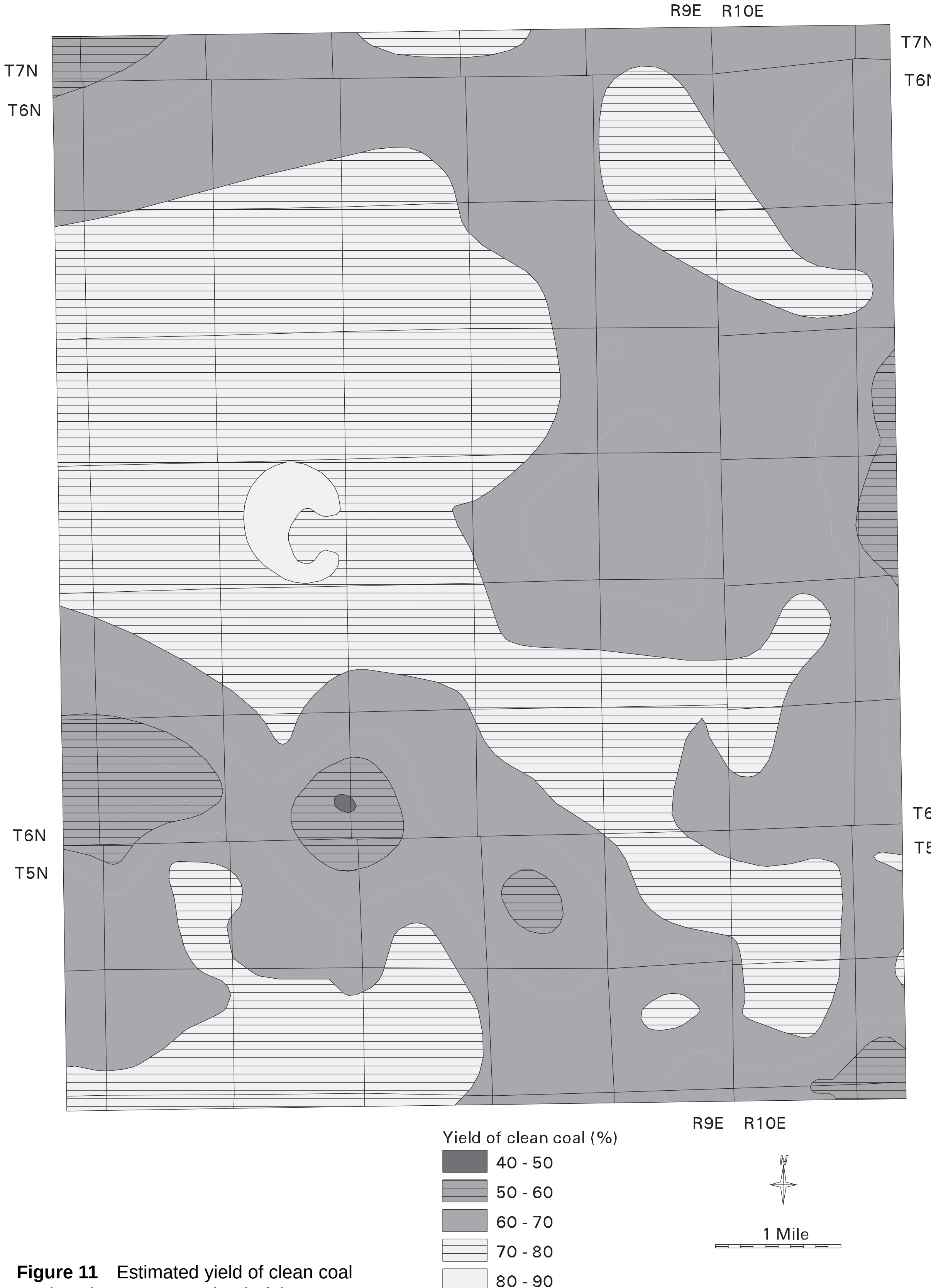

Figure 11 Estimated yield of clean coal produced per raw ton mined of the Seelyville Coal in the Newton Quadrangle.

Interburden between minable seams The interburden between two seams must contain competent strata of sufficient thickness so that mining of one seam will not disrupt the stability of the roof or floor of the other seam (Chekan et al. 1986). The minimum thickness of interburden required between two seams depends on several geologic and engineering parameters, including the lithology of the interburden, the thickness and depth of the seams, and the method and sequence of mining the seams (Hsiung and Peng 1987a, 1987b).

The interburden between the Springfield and Herrin Coals consists of black shale (at the base), thin limestone, underclay, a few feet of Briar Hill Coal, and gray shale (fig. 3). Mining engineers regard these as potentially weak strata that will make mining of both seams difficult. The minimum thickness of interburden for mining both seams in this area is considered to be 40 feet (table 2).

The interburden between the Danville and Herrin Coals was not evaluated because the Danville was too thin to be of interest for mining. The interval between the Springfield and Seelyville Coals is more than 200 feet thick, an ample thickness for a two-seam mining operation.

Surface features Although any surface feature may be undermined if a company obtains permission from the owner and agrees to repair damages, companies generally find it impractical to mine under large towns (e.g., Newton) and cemeteries. Limited extraction may take place under small towns such as Bogota. Previous studies of quadrangles in this series have excluded resources underlying railroads from available coal. Coal operators will probably limit or avoid room-and-pillar mining under railroads. However, two longwall mines in Illinois are now extracting coal underlying railroads. The planned subsidence of longwall mining makes this extraction feasible. Because longwall mining is the preferred method of extraction for the Newton Quadrangle, coal under railroads was considered to be available.

A buffer of unmined coal must be left around any surface feature that cannot be subsided. The size of the buffer depends on the depth and thickness of the coal, the composition of the overburden, and the angle of draw used to calculate the area that could be affected by subsidence. For this quadrangle, we calculated that a buffer of 400 feet might be left around towns and cemeteries. Actual buffer widths are determined by the coal operator's engineering studies, and they are approved by the Illinois Office of Mines and Minerals on the basis of rock mechanics tests and specific mine operation plans. A 400-foot buffer width allows for a 15° angle of draw at a depth of 1,500 feet and a 20° angle of draw at a depth of 1,000 feet.

Quality of coal The coal resources in the Newton Quadrangle are of high-volatile B bituminous rank with high sulfur (3%–5%) and high chlorine (~0.5%) contents. Although the current market for coal of this quality is limited, the technology for utilizing this coal is proven and readily available. Therefore, the quality of the coal is not a restriction on availability of the resources for mining. However, the coal is unlikely to be mined in the foreseeable future because of the weak demand.

Available Resources

The original resources for Newton Quadrangle are 1.1 billion tons. All of the resources are underground minable, and none are shallow enough to be mined at the surface (table 3). Coal resources available for mining in the quadrangle are estimated to be 668 million tons, or 61% of the original resources (fig. 12). Technical restrictions cause 34% of the resources to be unavailable: 22% of the resources are too close to an overlying seam that is more attractive for mining, 7% is less than 4 feet thick, 4% contains thick rock partings, and less than 1% is in blocks that are too small (table 3). Land use restrictions, the presence of cemeteries and towns, affect 5% of the resources.

None of the Danville Coal resources are available for mining. The entire seam is too thin (fig. 13), and there is not sufficient tonnage of Danville Coal to support a mine. The Herrin Coal resources are restricted only by surface features (fig. 14). Almost 92% of the Herrin resources is available. Ninety-three percent of the Springfield Coal resources is unavailable because the interval to the overlying Herrin Coal is too thin to allow mining of both seams (fig. 15). The Herrin Coal is the more likely of the two to be mined because it is about 50% thicker.

About 82% of the Seelyville resources is available for mining. Factors restricting the availability of resources include excessive parting material, surface features, and thin coal (fig. 16). It should be noted that none of the coal companies we interviewed were interested in mining the Seelyville Coal because of its depth and the presence of partings. Although most of this coal's resources are available for mining, the availability of ample resources with more favorable mining conditions

Table 3 Underground minable coal resources in the Newton Quadrangle (thousands of tons).

	Danville	Herrin	Springfield	Seelyville	Total
Original	80,012	379,833	266,019	376,256	1,102,120
Available	0	359,401	0	308,725	668,126
Land use restrictions					
Towns	2,373	18,796	14,888	18,551	54,608
Cemeteries	357	1,636	1,169	1,629	4,791
Total	2,730	20,432	16,057	20,180	59,399
Technical restrictions					
Coal <4 ft	77,282	0	1,363	1,004	79,649
Partings	0	0	0	46,347	46,347
Block size	0	0	964	0	964
Interburden	0	0	247,635	0	247,635
Total	77,282	0	249,962	47,351	374,595

makes it unlikely that the Seelyville Coal will be mined in the foreseeable future.

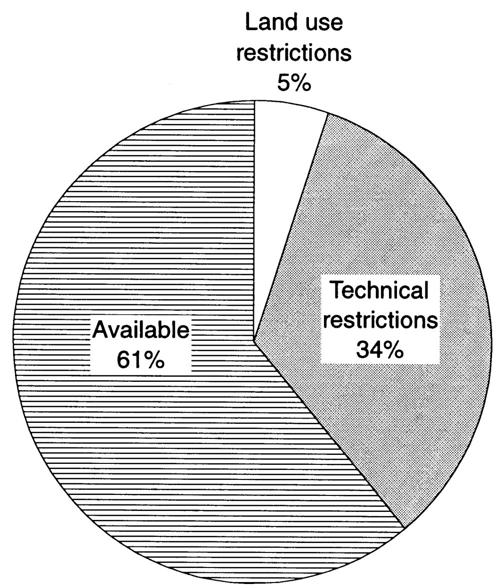

Figure 12 Availability of coal resources in the Newton Quadrangle.

PRINCEVILLE QUADRANGLE

Minable coals lie at relatively shallow depths over a broad area of several hundred square miles in region 2. During the first half of the 20th century, coal was produced in this area for local consumption by small underground operations. During the middle part of the century, underground mining gave way to extensive surface mining. Geologic conditions were ideal for areal surface mining using the large shovels, draglines, and bucketwheel excavators developed at that time.

Production from surface mining in region 2 has declined steadily for the past decade. Depletion of the best resources, the high sulfur content of the coal, and local opposition to surface mining in prime farmland are all cited as reasons.

The Princeville Quadrangle, straddling Stark and Peoria Counties, is located in region 2 and is representative of mining conditions in northwestern Illinois. The town of Princeville (population 1,400) lies along the east edge of the quadrangle, and the town of Monica occupies a small area in the center of the quadrangle (fig. 17). The town of Duncan lies near the north edge of the quadrangle outside of the area of known resources. Most of the area consists of flat to gently rolling farmland, pasture, and woodland. A major railroad crosses from east to west through the center of the quadrangle as does a major gas pipeline. High-voltage transmission lines extend across the northeast corner of the quadrangle.

The geology and coal resources of the region containing the Princeville Quadrangle have been described by Green (1870), Cady (1921), and Smith and Berggren (1963). Except for exposures along creek banks, the bedrock is covered by a layer of unconsolidated sediment consisting of glacial drift and alluvium. These sediments are generally less than 40 feet thick. Unconsolidated sediments more than 100 feet thick are found along the Spoon River and in a couple of buried bedrock valleys extending southward from the Spoon River.

The coal resources of the quadrangle were mapped for this study using data from 137 coal test holes within the quadrangle (fig. 18) and an additional 222 holes within a 4-mile buffer surrounding

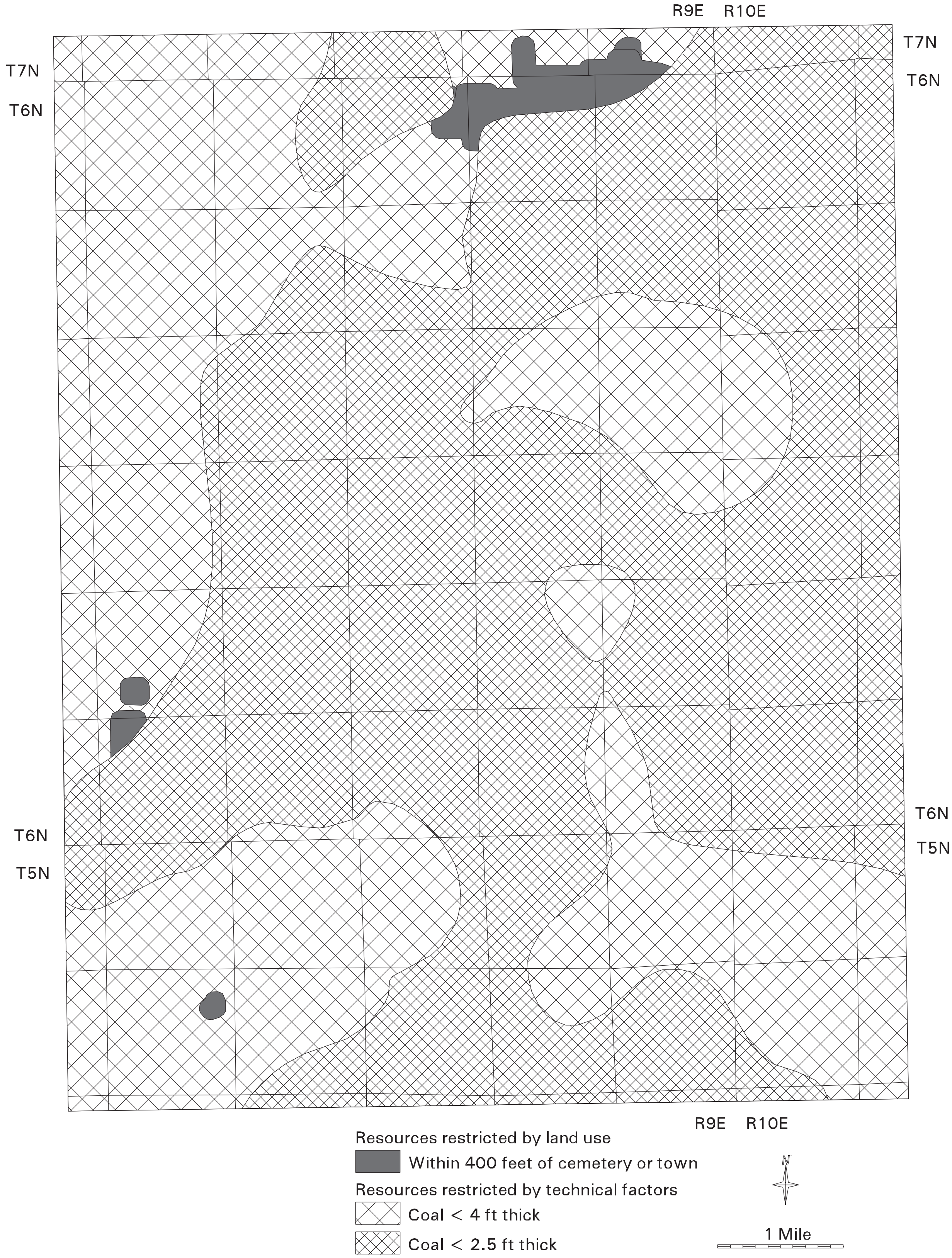

Figure 13 Availability of Danville Coal resources for mining in the Newton Quadrangle.

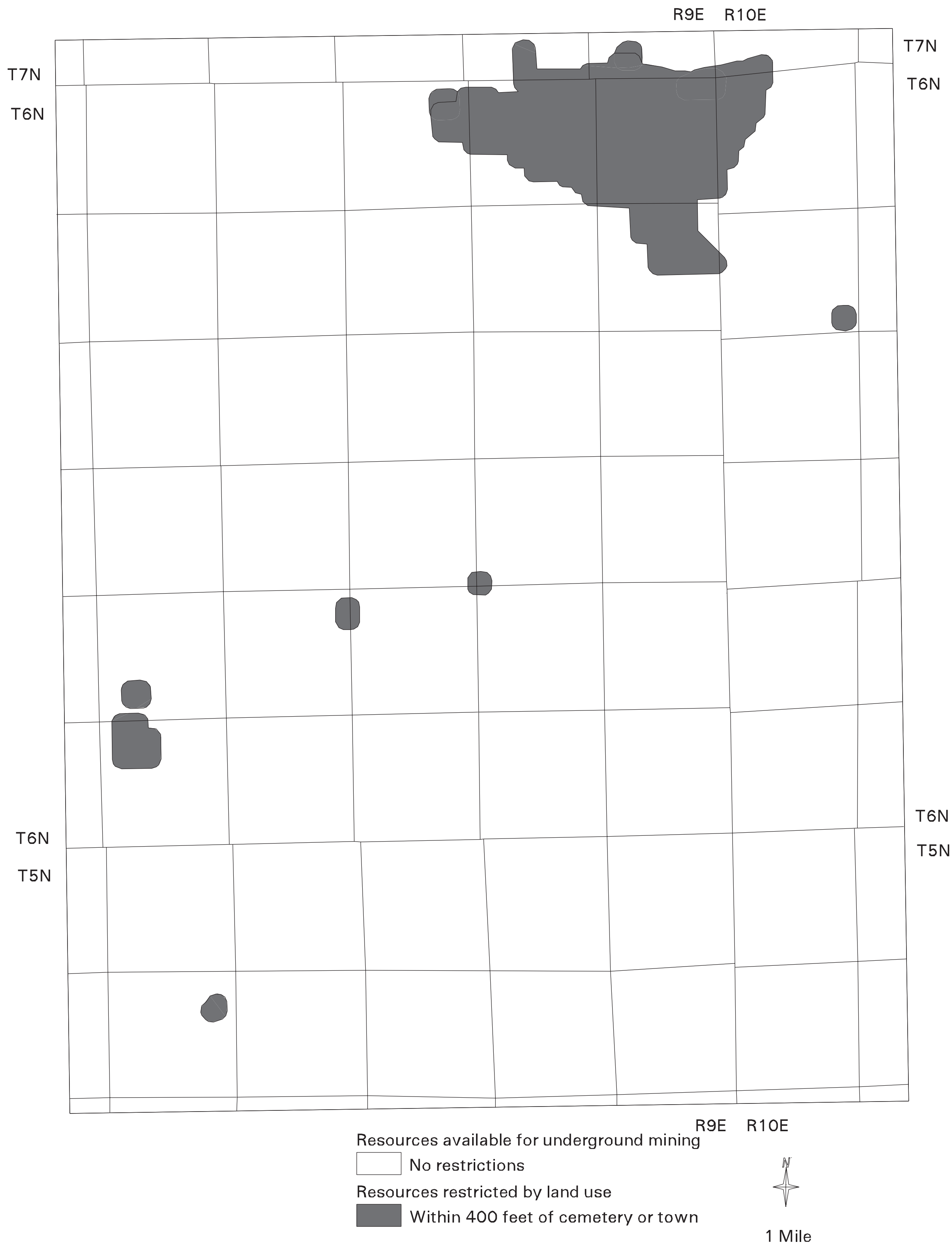

Figure 14 Availability of Herrin Coal resources for mining in the Newton Quadrangle.

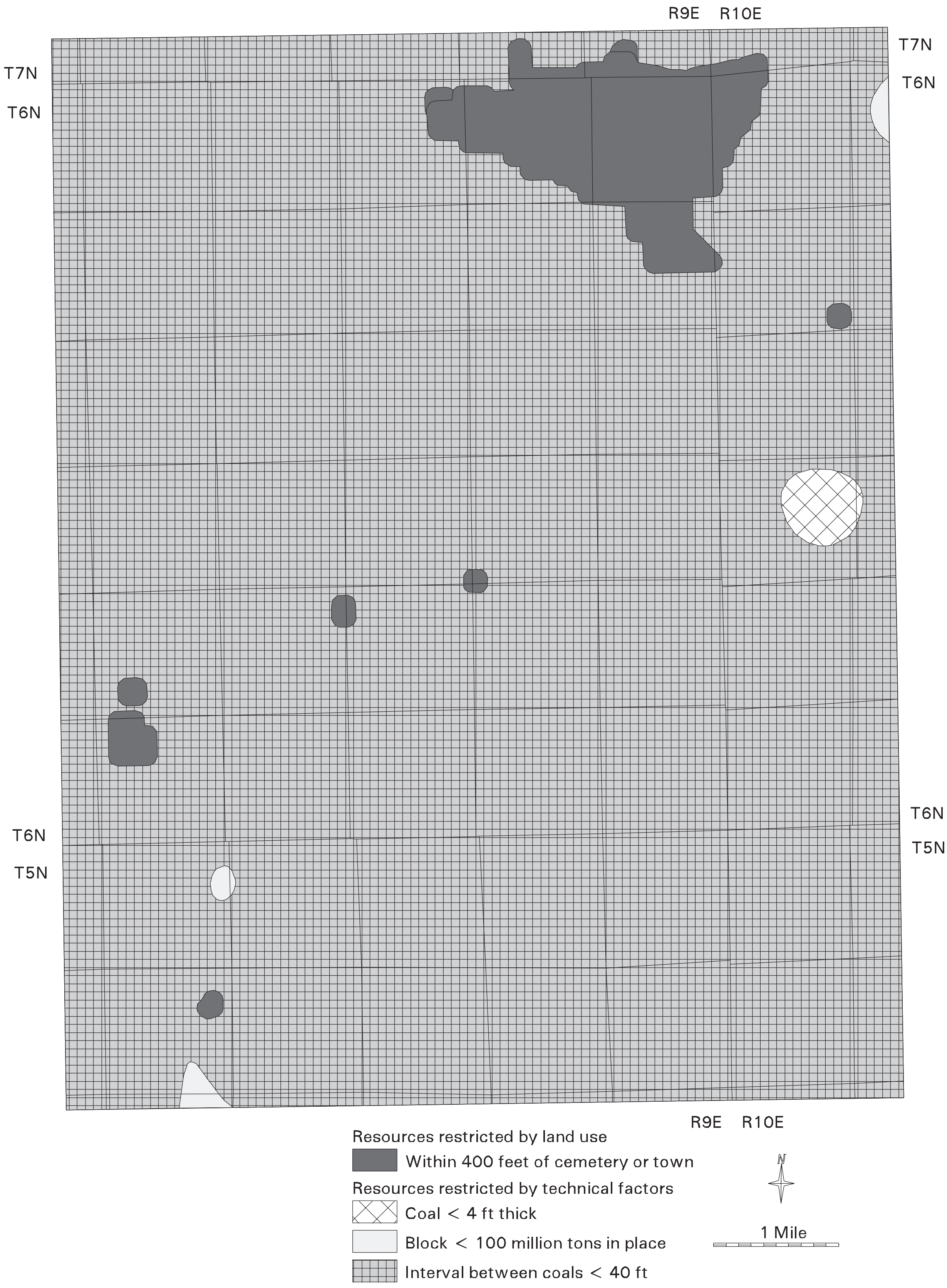

Figure 15 Availability of Springfield Coal resources for mining in the Newton Quadrangle.

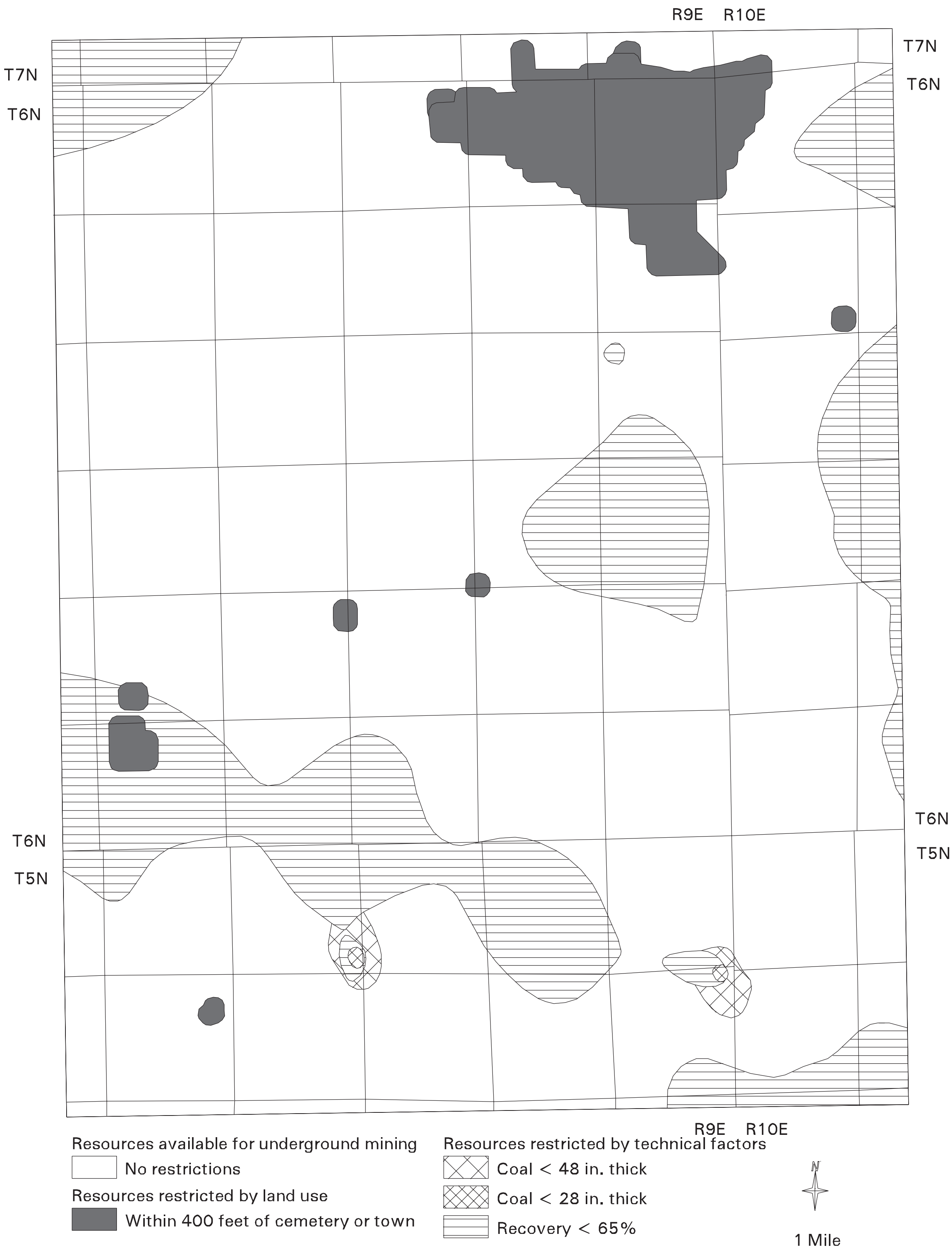

Figure 16 Availability of Seelyville Coal resources for mining in the Newton Quadrangle.

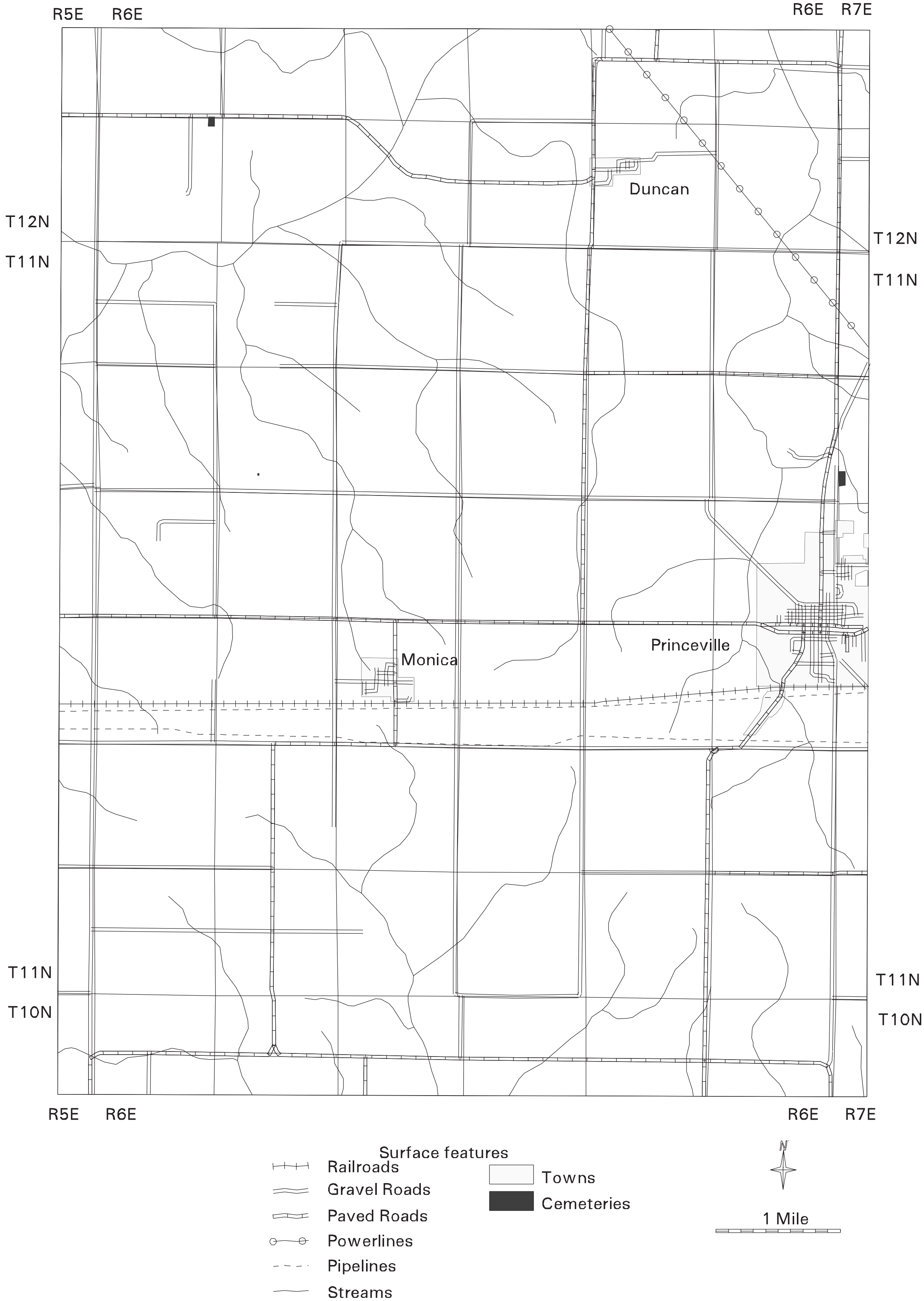

Figure 17 Selected surface features in the Princeville Quadrangle.

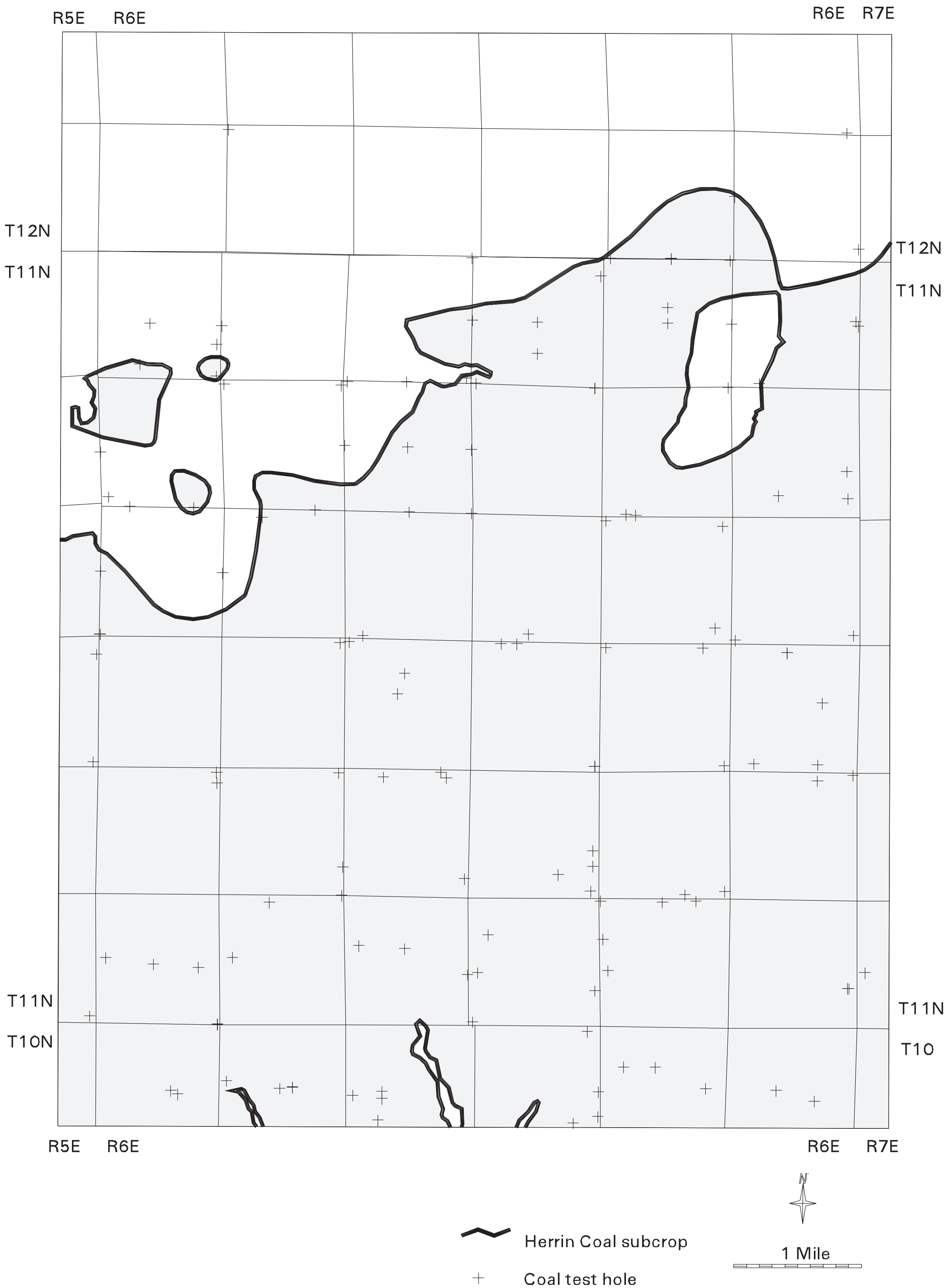

Figure 18 Distribution of data points in the Princeville Quadrangle.

the quadrangle. Additional logs from water wells were used to map thickness of the unconsolidated sediments.

The Danville Coal is the uppermost coal resource in the quadrangle (fig. 19). The coal is about 0.6 foot to almost 3 feet thick, and it can be found at the surface to just over 100 feet deep (figs. 20, 21). The coal has never been mined in this quadrangle, but it has been surface mined in surrounding areas in conjunction with mining of the underlying Herrin Coal.

The Herrin Coal is about 1 foot to slightly more than 5 feet thick, and it can be found at the surface to just over 150 feet deep (figs. 22, 23). The Herrin Coal was mined during the early 1900s in several small underground operations. No mines are currently active in the quadrangle.

The Springfield Coal is about 1 foot to about 4.5 feet thick, and it can be found at the surface to more than 200 feet deep (figs. 24, 25). The coal has never been mined in this quadrangle, but it has been surface mined in areas about 10 miles to the south.

At least two additional coals, the Colchester and Wiley, are known to underlie the Princeville Quadrangle (fig. 19). These coals are more then 200 feet deep and have only been tested by a few drill holes. The information from these and other drill holes throughout the area indicates that both coals are commonly 3 feet or less in thickness. Because of the lack of data, these coals have not been mapped by this study or previous studies of the area.

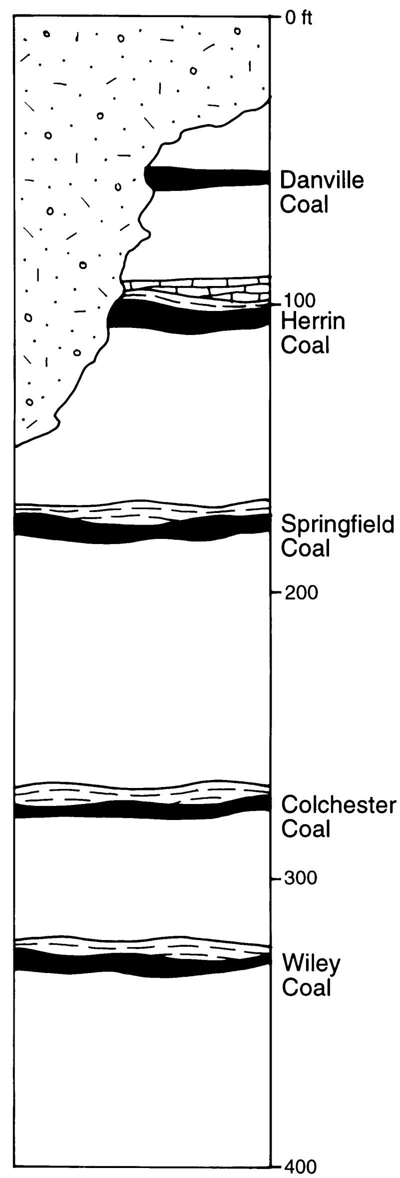

Figure 19 Generalized section showing approximate vertical relations of selected coal units in the Princeville Quadrangle.

Criteria for Delineating Available Coal

Surface mine operations in northwestern Illinois are of two types: (1) large-scale dragline/shovel operations and (2) truck/shovel operations. The dragline/shovel operations use large-scale equipment designed for specific mine conditions and built on site. The size and specialized design of the equipment and the large capital investment require a large mining block of relatively uniform geologic conditions. The truck/shovel operations use conventional earth-moving equipment, which is easily transportable and adaptable to a variety of geologic conditions and thereby enables the profitable mining of relatively small blocks of coal.

The criteria for delineating available surface minable resources were made on the basis of interviews with experts from two companies experienced in large dragline/shovel operations and from one experienced in small truck/shovel operations. Except for the minimum tonnage required for a mining block, the criteria for available coal are similar for the two methods.

The last underground mine in northwestern Illinois closed more than 20 years ago. The set of criteria for resources available for underground mining in the Princeville Quadrangle was determined on the basis of the information collected for the Middletown Quadrangle in west-central Illinois (Treworgy et al. 1994).

Depth of seam The maximum depth of coal that can be mined at the surface is dependent on the type and size of excavating equipment used. Practical experience in Illinois suggests that underground mining is more economical at depths greater than 175 to 200 feet. For this quadrangle, we used 200 feet as the maximum depth of surface mining. All resources more than about 125 feet deep were excluded because of other criteria however, and maximum depth was therefore not a factor in this quadrangle.

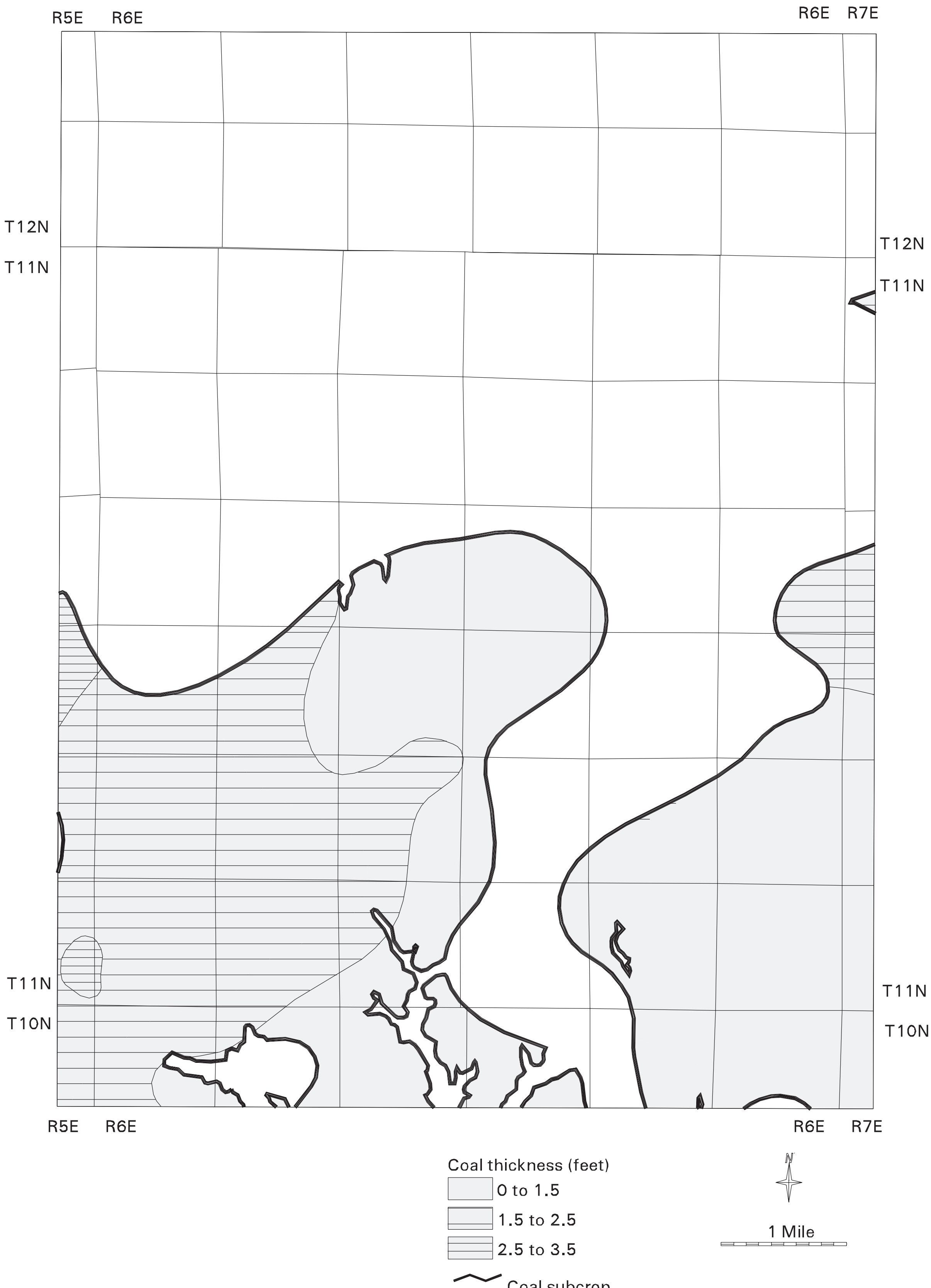

Figure 20 Thickness of the Danville Coal in the Princeville Quadrangle.

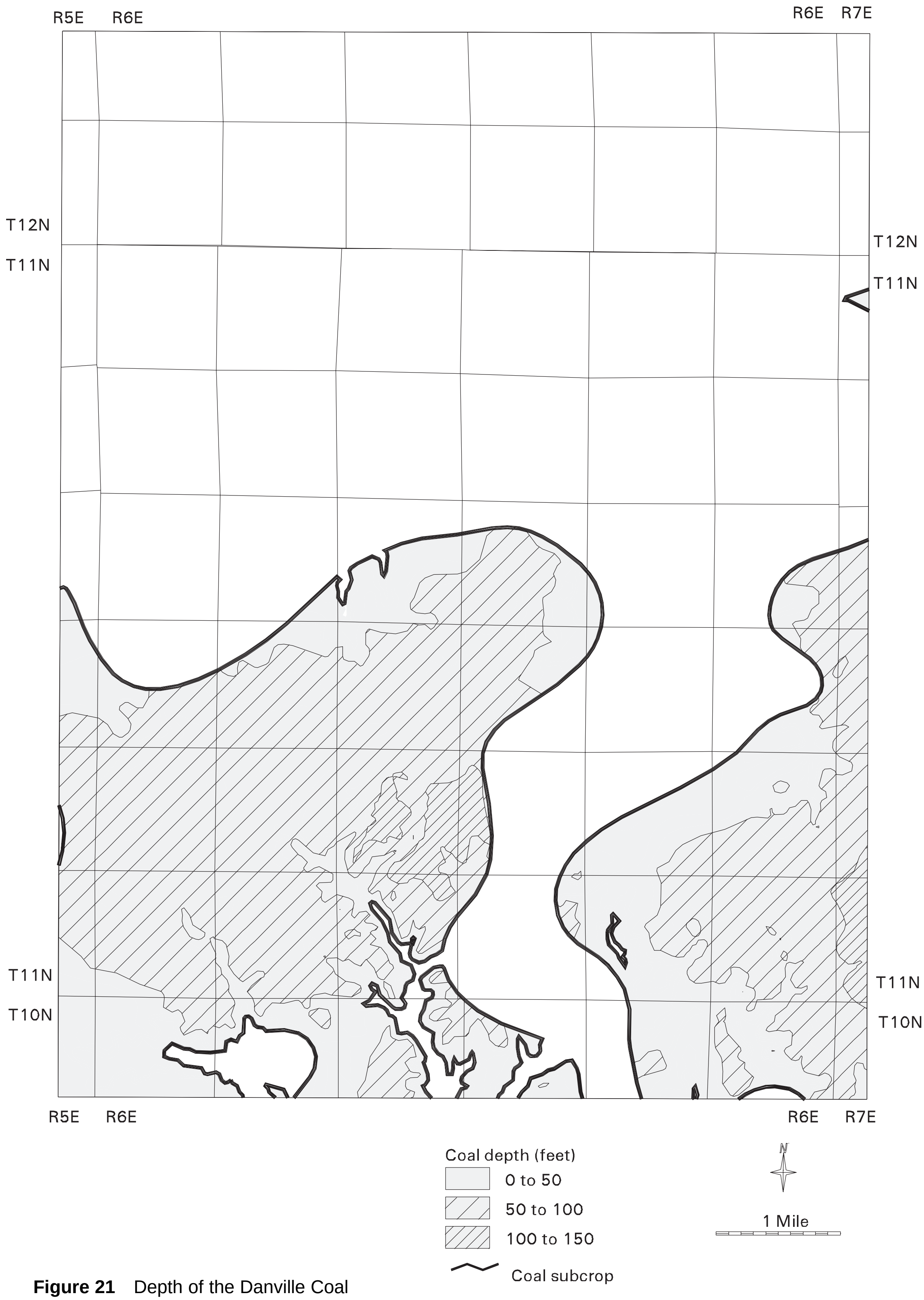

Figure 21 Depth of the Danville Coal in the Princeville Quadrangle.

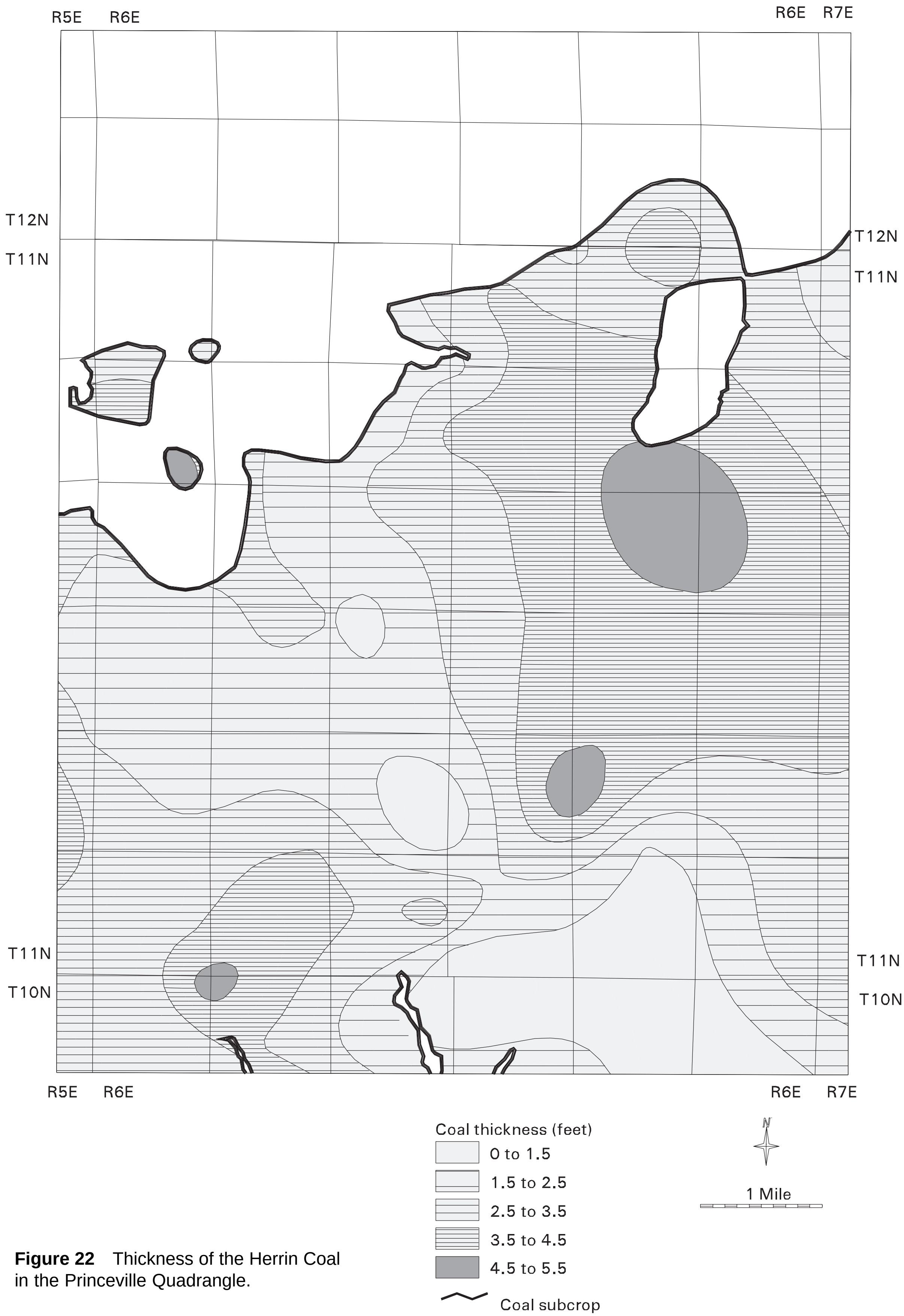

Figure 22 Thickness of the Herrin Coal in the Princeville Quadrangle.

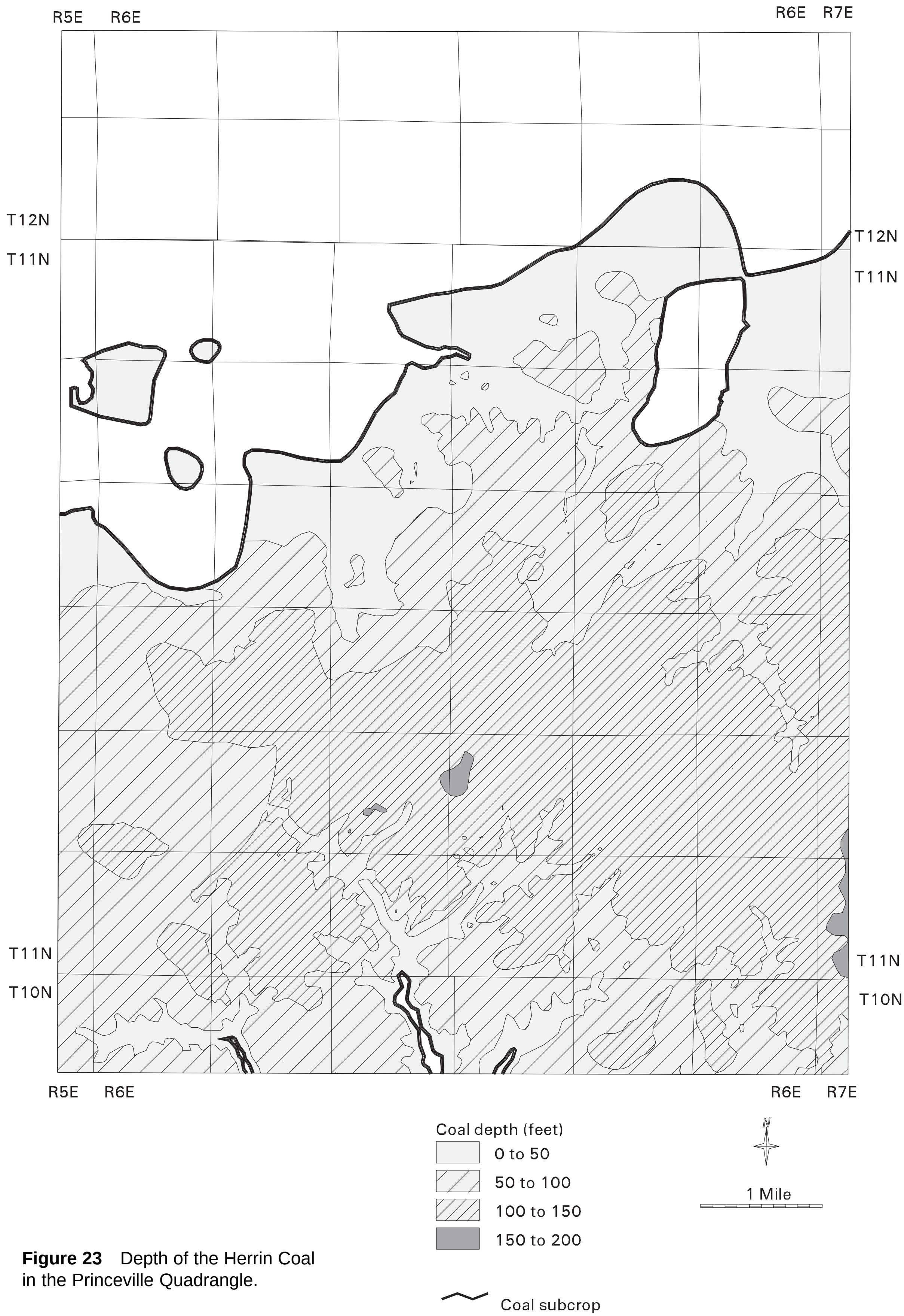

Figure 23 Depth of the Herrin Coal in the Princeville Quadrangle.

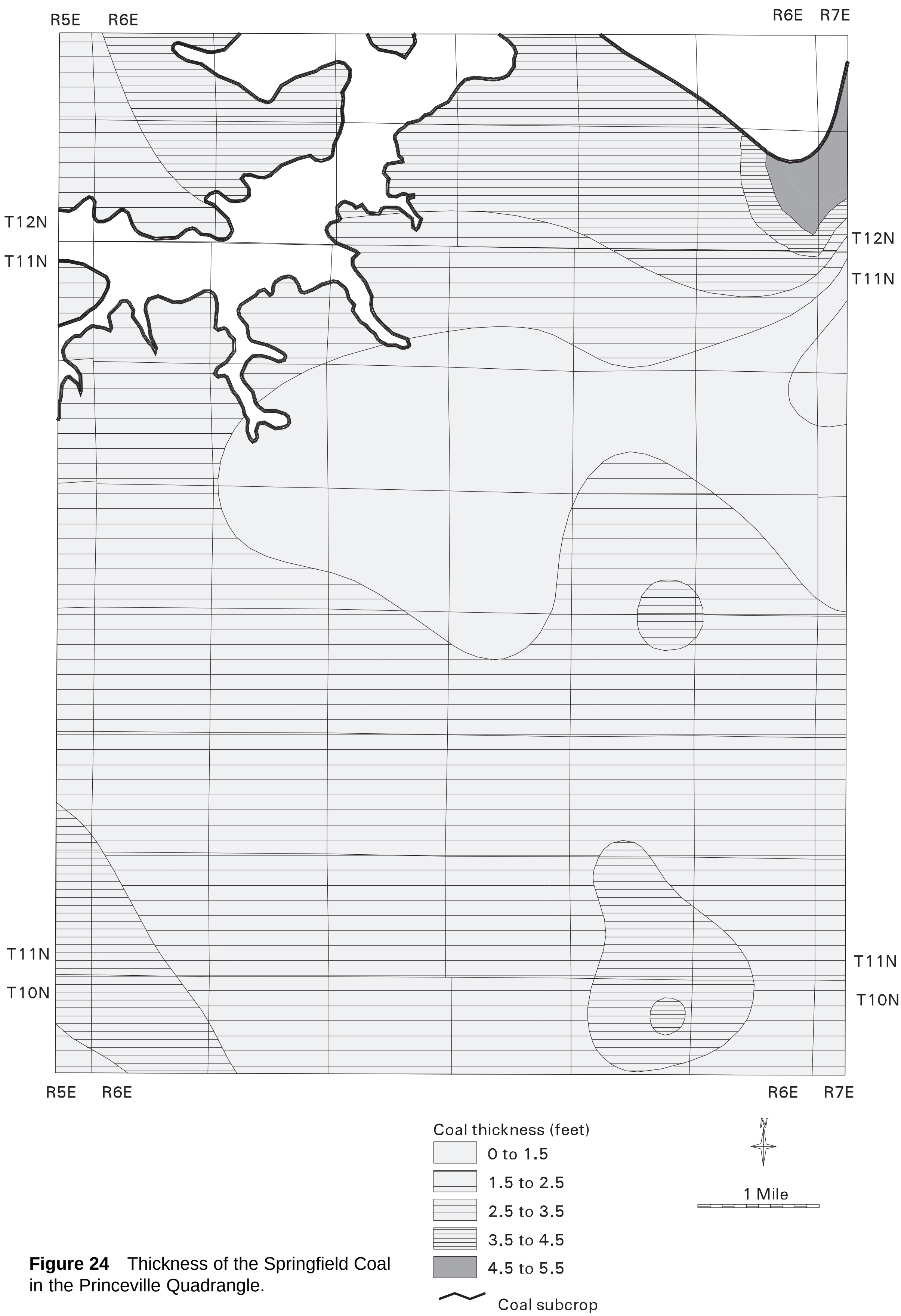

Figure 24 Thickness of the Springfield Coal in the Princeville Quadrangle.

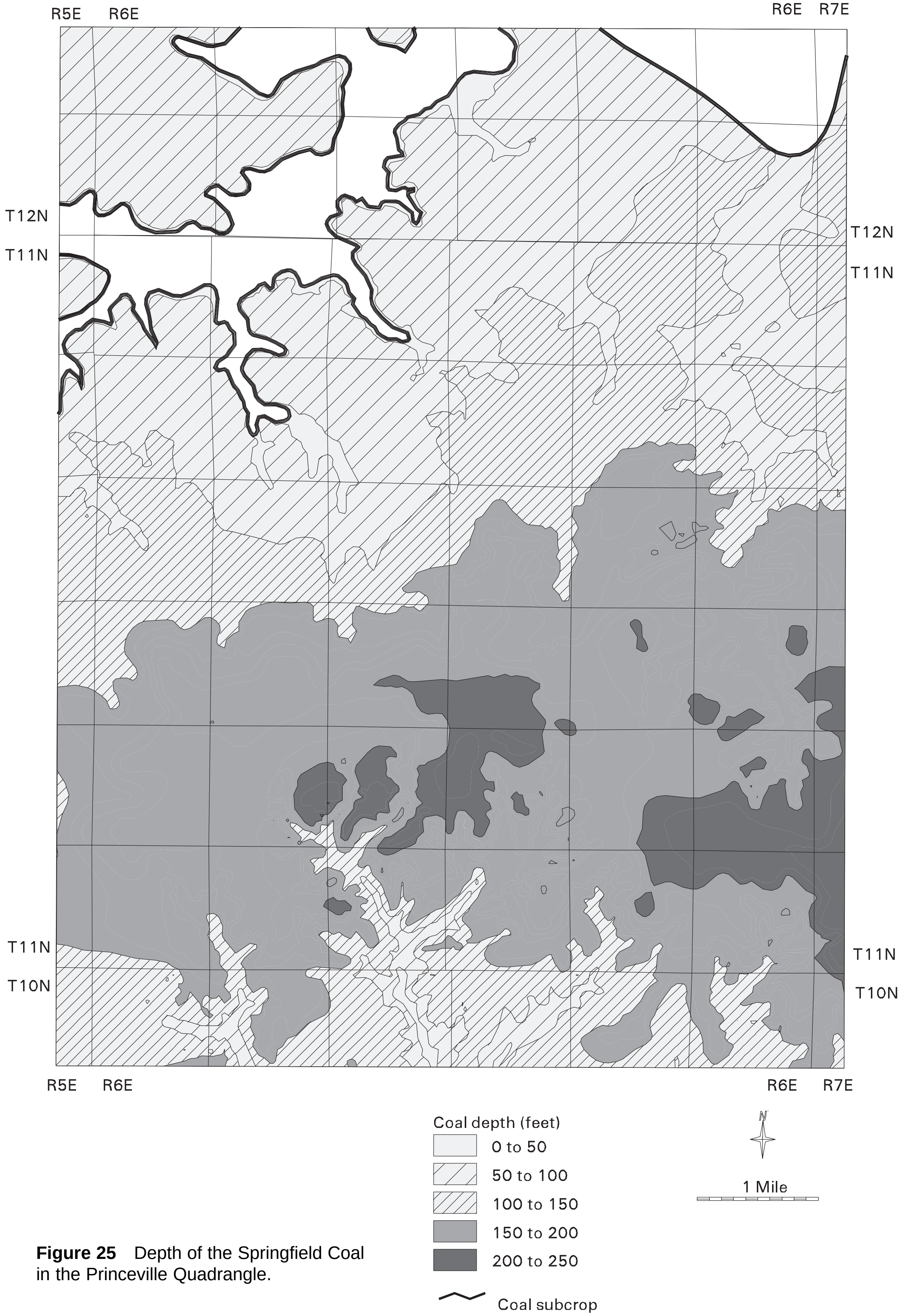

Figure 25 Depth of the Springfield Coal in the Princeville Quadrangle.

Table 4 Criteria used to delineate available coal in the Princeville Quadrangle.

Surface Mining
- Minimum seam thickness
  - Main seam: 2 feet
  - Overlying seams: 1 foot
- Maximum depth: 200 feet
- Stripping ratio (cubic yards of overburden/ton of raw coal)
  - Maximum: 25:1
  - Maximum average ratio for a mining block: 20:1
- Minimum reserve block size: 1.5 million tons (recoverable, clean coal)
- Land use restrictions
  - 100 feet around paved roads, railroads, cemeteries, pipelines, and transmission towers
  - 0.5 mile around towns

Underground Mining
- Minimum seam thickness: 4 feet
- Minimum block size: 10 million tons (recoverable, clean coal)
- Land use restrictions: 200 feet around towns and cemeteries

Thickness of seam Minimum thickness for the main seam to be mined at the surface is 2 feet (table 4). Seams as thin as 1 foot will be recovered if they overlie or closely underlie the main seam. Seams must be at least 4 feet thick to be available for underground mining.

Stripping ratio The stripping ratio is the number of cubic yards of overburden that must be removed to recover 1 ton of coal. Whereas the thickness and depth of coal that can be mined are values controlled in part by technical factors such as mining equipment, the maximum stripping ratio is strictly an economic limit. Coals with high stripping ratios may be more economical to mine by underground methods or may remain unmined until the market price for coal rises relative to production costs.

Companies calculate stripping ratios on the basis of the anticipated tonnage of clean coal that will be produced. This calculation requires assumptions about the type and performance of mining and washing equipment to be used as well as tests of the washability of the coal. For the purposes of this study, we used stripping ratios based on in-place seam tonnages (coal plus in-seam partings). Some companies use a "swell factor" to account for the increase in volume of overburden after it is blasted. We did not use any swell factors in our calculations. The maximum stripping ratio adopted was 25 cubic yards of overburden per ton of raw coal (25:1), and the maximum average stripping ratio for any reserve block was 20:1 (table 4). Because we have not used clean coal tonnages or swell factors, these ratios are higher than the limits currently used by most companies in most cases. The companies we interviewed mine maximum ratios of 20 to 25 cubic yards of overburden per clean ton of coal.

Unconsolidated overburden Thick deposits of glacial or alluvial sediment can restrict surface mining because of their tendency to slump into the pit, fail under the weight of large draglines, and provide a path for groundwater movement into the pit. The maximum thickness of unconsolidated material that can be handled is dependent on its lithologic composition, physical properties (e.g., load bearing capacity), and the presence or absence of groundwater.

We did not have sufficient information to assess the character of the unconsolidated sediment in the Princeville Quadrangle. In this area, company experience suggests that the maximum thickness of the unconsolidated overburden that can be handled is 40 feet or one-third of total overburden thickness, whichever is greater (table 4). Small areas of thicker unconsolidated overburden can be mined, but large areas of thick unconsolidated overburden will be avoided.

Underground mining requires a sufficient thickness of bedrock overburden to support the mine roof. Unconsolidated overburden adds to the weight that must be supported by the bedrock overburden, and care must be taken that fractures in the bedrock do not allow water from sand or gravel deposits within the unconsolidated sediment to seep into the mine. The minimum thickness of bedrock required depends on the competency of the strata, the thickness of unconsolidated overburden, and the thickness of the coal. Generally, about 75 feet of bedrock overburden is necessary for room-and-pillar or longwall mines. Small areas of coal have been mined with less than 75 feet of bedrock overburden.

Size and configuration of mining block The minimum tonnage required for a truck/shovel operation is 1.5 million tons of clean coal. For this area, we calculated this to be equivalent to about 2.6 million tons of coal in the ground. Individual blocks of coal can be as small as 100,000 tons as long as they are in close proximity to one another and the total tonnage of clean coal is at least 1.5 million tons. The minimum size for a dragline operation is 10 to 20 million tons of clean coal (17–35 million tons in-place). The minimum block size for an underground mine is 10 million tons of clean coal, or about 20 million tons in the ground.

Surface features Illinois mining law requires that a barrier at least 100 feet wide be left around roads, cemeteries, dwellings, and other surface development. Exceptions can be granted if the mining company obtains permission from the owner. In practice, the size and style of mining operation in this area does not justify the relocation of paved roads, railroads, cemeteries, pipelines, or transmission towers. Companies generally do not attempt to surface mine within ½ mile of towns because of the problems that can be caused by blasting vibrations and dust.

Quality of coal The coals in the Princeville Quadrangle are high-volatile C bituminous in rank and have a 3% to 5% sulfur content. Although the demand for coals of this quality is weak, there continues to be a local industrial market for this coal. The coals commonly contain clastic dikes, commonly called horsebacks or rolls (Damberger 1973). These small-scale features cannot be avoided in mining and reduce the tonnage of clean coal produced per ton mined. The strata overlying clastic dikes in coal are commonly fractured and difficult to support in underground mines.

Available Resources

Resources were mapped for three coals in the Princeville Quadrangle: the Danville, Herrin, and Springfield Coals. Original resources total 198 million tons: 191 million tons are surface minable, and 7 million tons are underground minable. Approximately 1.5 million tons of the surface minable resources have been mined or lost in mining (e.g., left as pillars in shallow underground mines); remaining surface minable resources are 189 million tons. None of the underground minable resources have been mined.

Thirty-five million tons (18%) of the original resources are available for mining, all of them surface minable (fig. 26). None of the underground minable resources are available for mining.

Technological restrictions limit 65% of the original resources, and land use restrictions limit 16%. The restrictions on surface minable resources are stripping ratio (40% of original resources), land use (17%), thin coal (11%), thickness of unconsolidated overburden (9%), and size of mining block (5%) (table 5). The underground minable resources are too thin (<4 feet thick; 99%) and occur in blocks too small for mining (<20 million tons in-place; 0.5%).

Resources of Danville Coal are available only where they overlie available resources of the Herrin Coal. One million tons of these resources are not part of the conventional resource base because they are less than 18 inches thick (fig. 27). However, they are of sufficient thickness that they would likely be recovered by operations mining the underlying Herrin Coal.

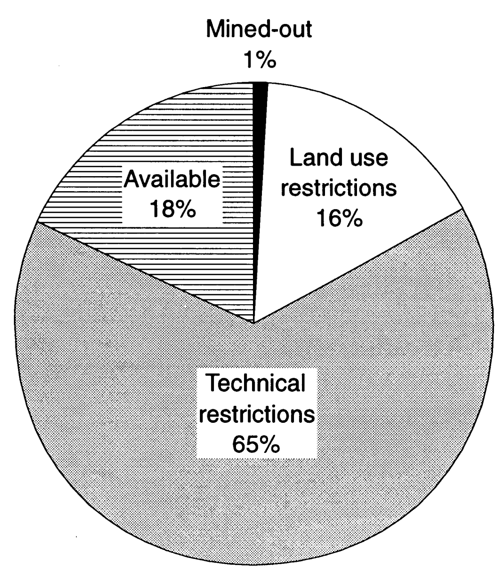

Figure 26 Availability of coal resources in the Princeville Quadrangle.

Herrin Coal resources are available in several large blocks along the northern outcrop of the coal between Princeville and Monica as well as along the stream valley in the southwest corner of the quadrangle (fig. 28). The blocks of available coal are dissected by roads, mined areas, and areas of thick unconsolidated sediments.

Table 5 Surface minable coal resources in the Princeville Quadrangle (thousands of tons).

	Danville*	Herrin	Springfield	Total
Original	20,511	111,872	58,526	190,909
Available	5,379	29,649	0	35,038
Mined out	0	1,545	0	1,545
Land use restrictions				
Towns	1,504	16,097	5,016	22,617
Railroads	178	787	34	999
Cemeteries	0	46	30	76
Roads	564	3,464	1,898	5,926
Pipelines	368	1,505	16	1,919
Utility towers	0	15	82	97
Total	2,644	21,914	7,076	31,634
Technical restrictions				
Coal ft	3,710	4,659	11,929	20,298
Stripping ratio	8,106	39,775	28,833	76,714
Block size	1,557	5,664	2,514	9,735
Unconsolidated overburden	59	8,666	8,174	16,899
Total	13,432	58,764	51,450	123,646

*The available Danville Coal includes 945 thousand tons of coal less than 18 inches thick. This tonnage is not included in the original resources of the Danville Coal.

None of the resources of Springfield Coal are available for mining. Thin coal and high stripping ratio are the major restrictions.

Consideration was given to the possibility of underground mining some of the restricted resources (both surface and underground minable) by entering from the highwall of a surface mine in the available resources. This would minimize development costs and reduce the size of the underground block needed and make it feasible to mine thinner seams (the highwall and preparation plant would already be in place as a result of the surface mining). Underground mining from a highwall can be done with a continuous miner or auger.

Although some additional coal in the quadrangle may be recovered by underground mining from a highwall, we do not think the amount will be significant. Underground operations will encounter difficult roof-control conditions caused by the abundance of clastic dikes and, in some areas, by the unfavorable ratio of unconsolidated to bedrock overburden. Much of the area that will be accessible by highwall (e.g., the boundaries of the available surface minable resources) is flat, prime farmland. Subsidence of the surface must be prevented or significant mitigation costs will be incurred. Avoidance of subsidence will be difficult given the shallow depth of the coal, the unfavorable ratio of unconsolidated to bedrock overburden, and the abundance of clay dikes.

CONCLUSIONS

This study provided some new insights on the availability of coal for mining in Illinois. Several restrictive factors that had not been encountered in previous quadrangle studies were identified. Also, the influence of geologic conditions and local attitudes on land use restrictions was illustrated.

Two of the restrictive factors in the Newton Quadrangle, the interburden between seams and excessive parting material in the Seelyville Coal, have not been encountered in other quadrangles. The thickness and lithology of the interburden between the Herrin and Springfield Coals are typical of areas in central and southwestern Illinois. This factor probably limits the availability of a significant amount of Springfield Coal resources.

Excessive parting material will be a restrictive factor for the Seelyville Coal in many areas. Other coals do not have large resources containing partings, but some seams, such as the Herrin and Springfield Coals, have significant amounts of low- to medium-sulfur resources that contain partings. The study of the Nokomis Quadrangle provided an example of excessive parting material in the Herrin Coal (Treworgy et al. 1996).

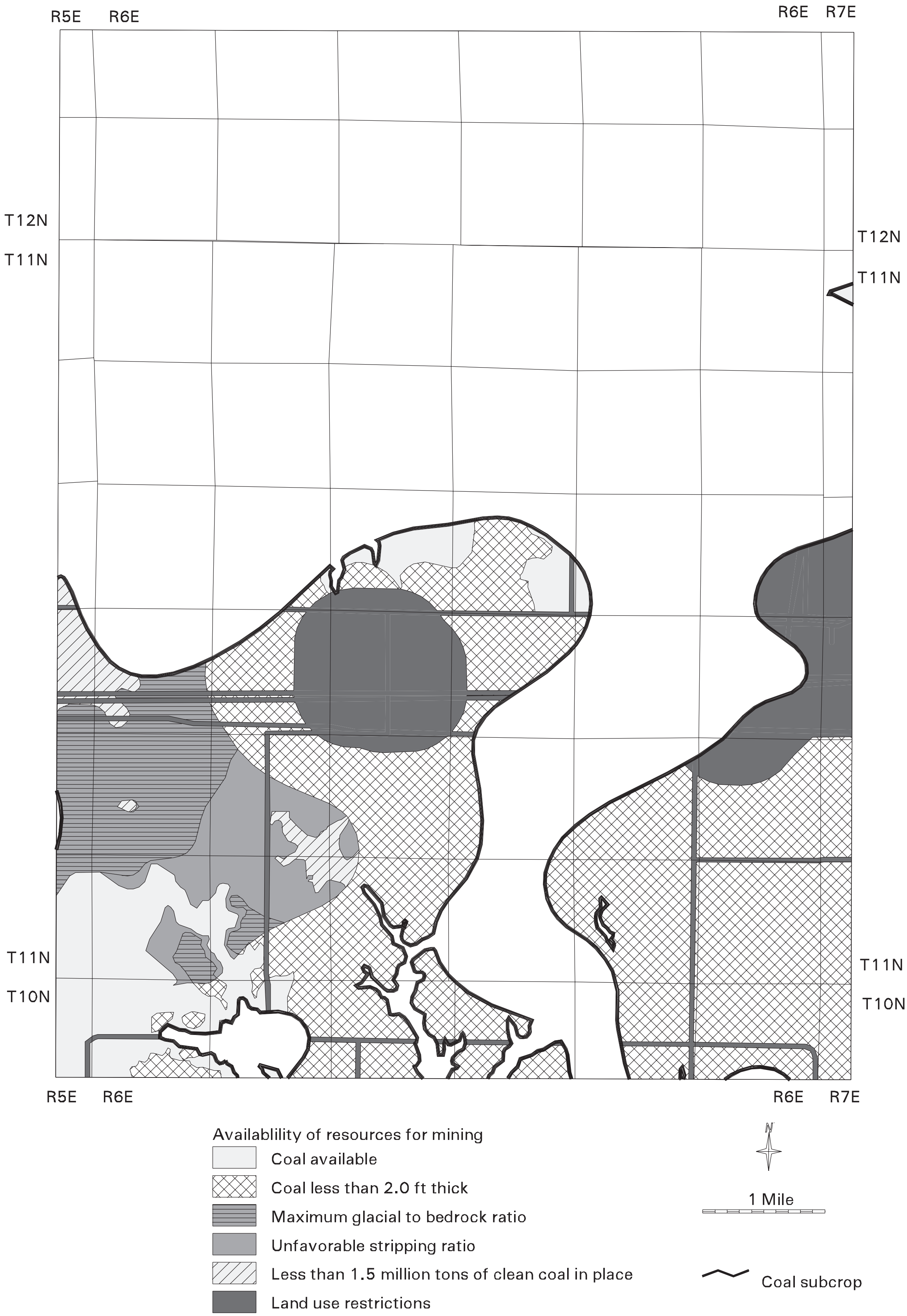

Figure 27 Availability of Danville Coal resources for mining in the Princeville Quadrangle.

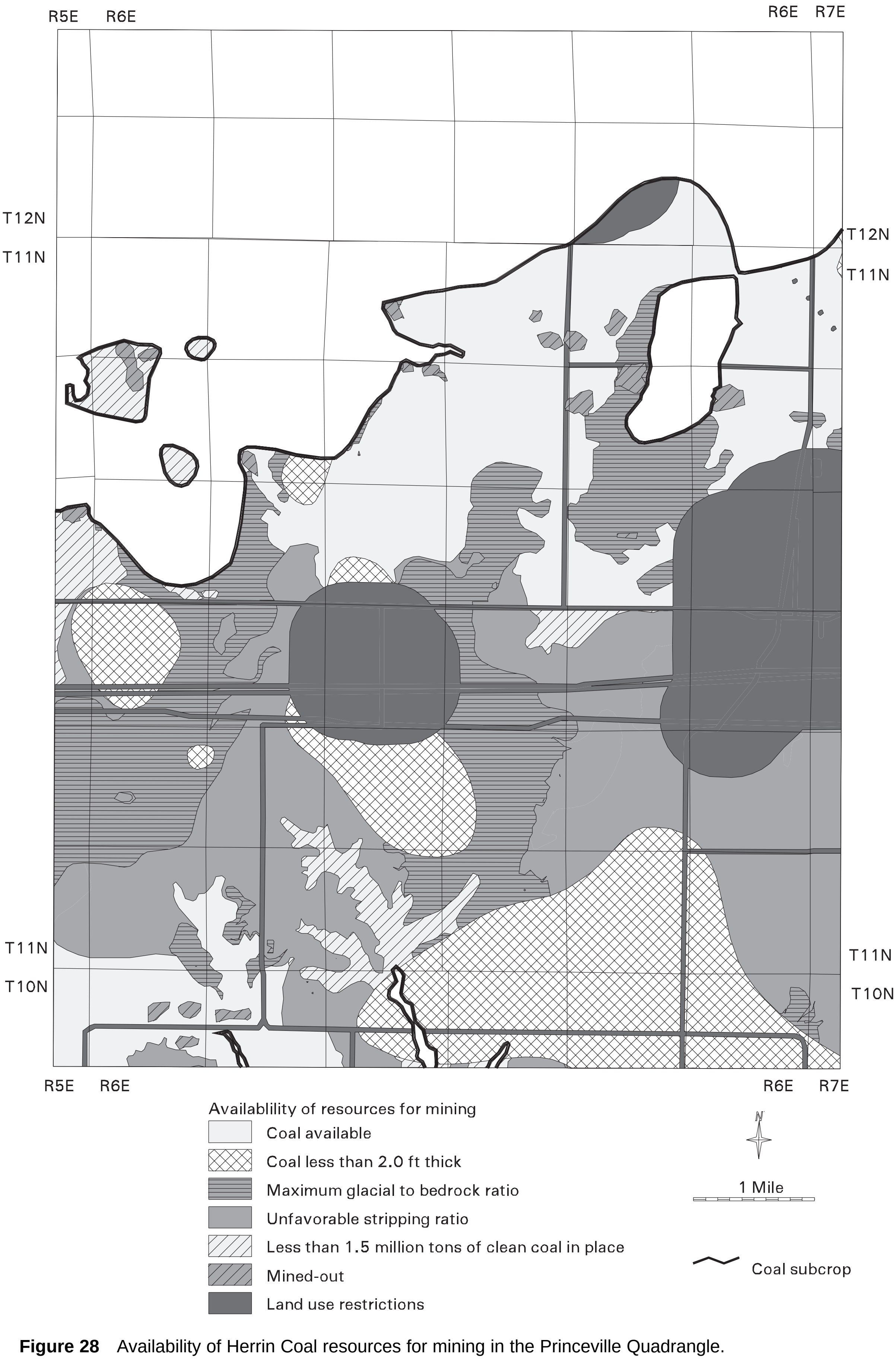

Figure 28 Availability of Herrin Coal resources for mining in the Princeville Quadrangle.

The thickness of unconsolidated overburden was identified as a potential restriction on surface mining in the Princeville Quadrangle. This factor was not considered a restriction in the previous quadrangles studied. Unconsolidated overburden should be examined carefully in future studies to determine the extent of this restriction.

The Princeville Quadrangle illustrates how land use restrictions can vary from one area of the state to another. In the southern part of Illinois, paved roads are not considered a barrier to surface mining. Many of the surface minable resources in southern Illinois are found in large, thick blocks of coal that can be very efficiently mined with large-scale equipment. The economics of mining these resources makes it feasible to incur the cost of relocating and rebuilding roads. Also, this practice is generally accepted by local governments because of the importance of mining to the economy.

In northwestern Illinois, the surface minable deposits are thinner and occur in smaller blocks; therefore, mining operations cannot afford to rebuild large sections of roads. Also, mining is not as accepted by communities, and many local governments are unwilling to grant permission for roads to be closed.

Summary of Results To Date

As of early 1996, the availability of coal for mining has been examined for eight quadrangles in Illinois. The amount of coal available for mining has ranged from 18% to 76% of the original resources (fig. 29). Technical factors such as thickness of the coal and overlying bedrock, roof and floor conditions, faults, and size of mining block account for most of the restriction on coal availability. Land use restricts from about 1% to almost 22% of the resources in the eight quadrangles.

Although the number of quadrangles studied is not sufficient to draw conclusions about the availability of coal in Illinois for future development, some interesting trends have emerged. Slightly more than 4 billion tons of original resources (about 3% of the state total) have been assessed. Of these, 45% is available for mining, 40% is restricted by technical factors, 7% is restricted by land use, and 8% has been mined or left as pillars (fig. 30).

Resources from 16 coal seams are included in these assessments. The majority of these resources are in three seams: the Herrin, Springfield, and Seelyville (and its equivalents the Davis, Dekoven, and lower Dekoven; fig. 31). Almost 52% of the original resources of the Herrin Coal in these eight quadrangles is available for mining. Just under 36% of the resources of the Springfield and Seelyville, and less than 13% of the resources of the other coals are available.

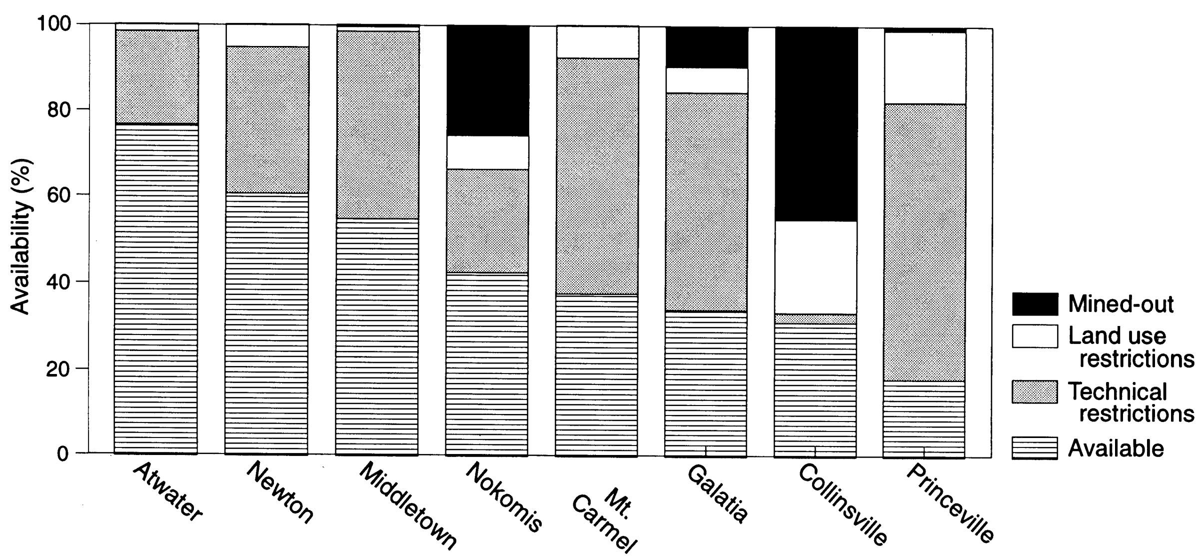

Figure 29 Availability of coal resources in eight quadrangles in Illinois.

The higher availability of the Herrin Coal reflects the relatively thick, uniform character of this seam and the excellent mining conditions associated with it. It should be noted, however, that a number of significant areas of resources of the Herrin Coal have yet to be assessed.

Need for Additional Quadrangle Studies

Additional quadrangle studies are needed to expand and refine our knowledge of the factors that limit the mining of coal in Illinois (fig. 1). To date, no quadrangles have been studied in regions 1 and 5, and only one quadrangle has been studied in each of regions 2, 3, 6, and 7. Important resources that have not been assessed by a quadrangle study are the low-sulfur resources of Herrin Coal in east-central and southern Illinois, low-sulfur resources of the Danville Coal in east-central Illinois, extensive surface minable resources of the Colchester Coal in western Illinois, and the surface minable resources of Herrin Coal in southwestern Illinois.

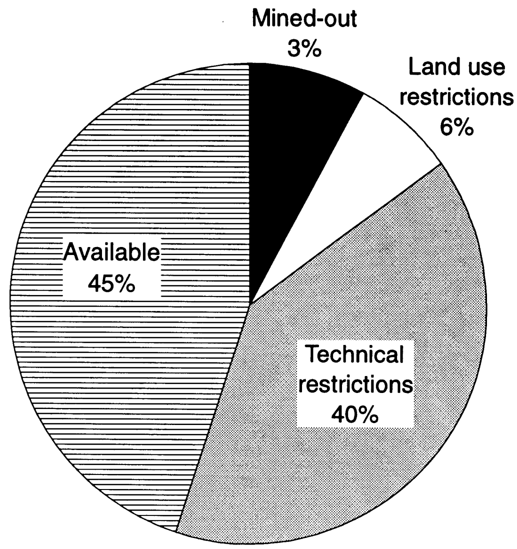

Figure 30 Cumulative availability of coal resources in eight quadrangles in Illinois.

Additional quadrangle studies are also needed to define the limits of factors identified in previous studies. For example, abandoned oil fields in the Mt. Carmel and Galatia Quadrangles were found not to restrict the availability of resources. In eastern Illinois, however, oil wells may be a restriction in some of the old fields having very closely spaced wells.

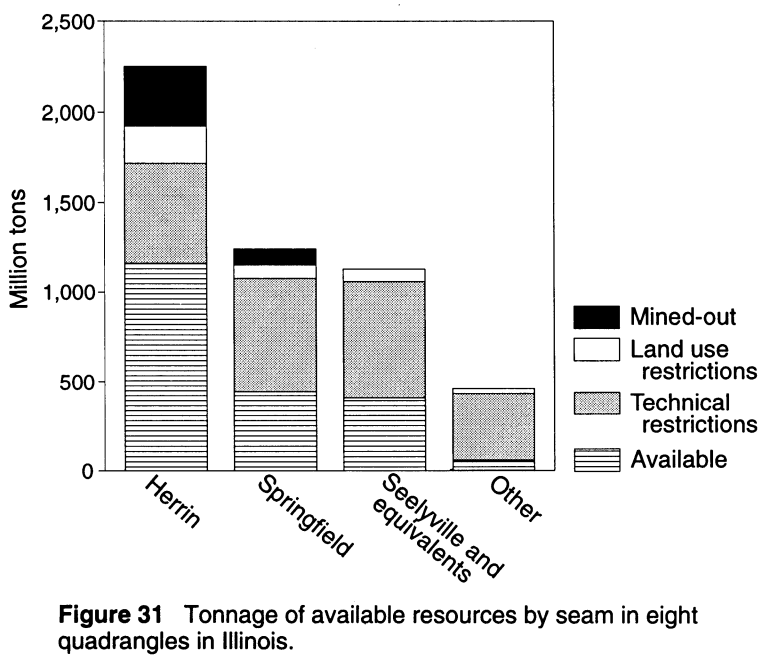

Figure 31 Tonnage of available resources by seam in eight quadrangles in Illinois.

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