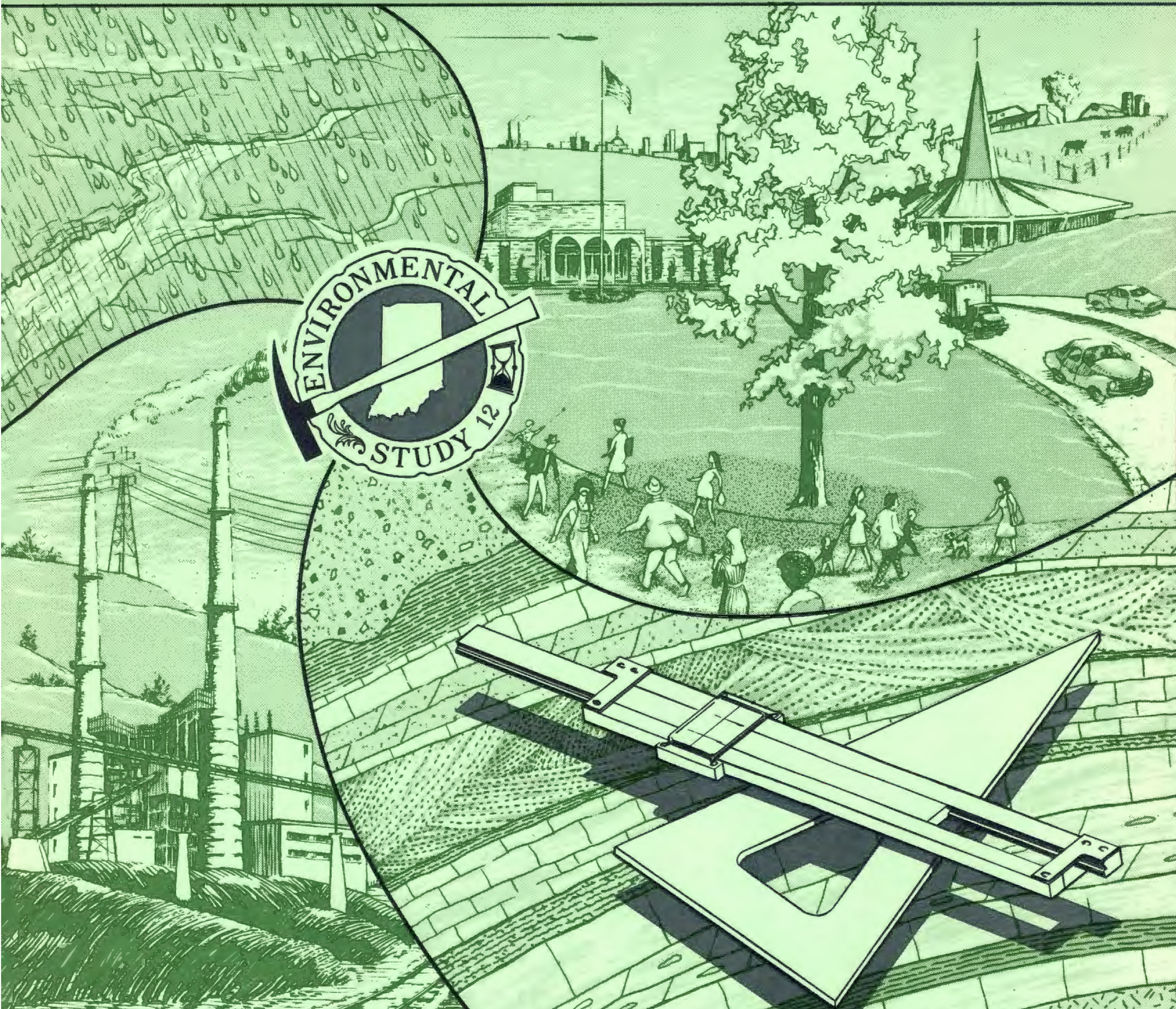
ENVIRONMENTAL GEOLOGY OF THE EVANSVILLE AREA, SOUTHWESTERN INDIANA

Special Report 12



State of Indiana
Department of Natural Resources
GEOLOGICAL SURVEY

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Environmental Geology of the Evansville Area Southwestern Indiana

By W.T. STRAW, HENRY H. GRAY, *and* RICHARD L. POWELL

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Introduction

Since early in human history, land has been considered to be the single most indispensible resource. Indeed, some students of economics believe that all wealth is derived ultimately from the land. Land is not, however, an inexhaustible resource, and as populations increase, more and more people are coming to realize that wise use of the land is required to preserve land resource values for future generations. Geology—or to translate the term freely, earth science—provides basic data that can contribute to planning for wise land use.

This report covers an area of about 185 square miles (480 square kilometers) surrounding the city of Evansville in southwestern Indiana (fig. 1). Fieldwork was done in the spring of 1970 by Straw; this was followed by airphoto analysis, including the study of color infrared imagery, by Powell and Gray. Geologic data on file in the offices of the Geological Survey, Bloomington, and the Division of Water, Indianapolis (both of which are agencies of the Indiana Department of Natural Resources), were reviewed. Mine maps were secured from the files of the Indiana Bureau of Mines and Mining in Terre Haute. Drill records and soil samples for testing were provided by the Division of Materials and Tests, Indiana State Highway Commission, and by consultant engineers. And finally, geologic data of many kinds were obtained from a wide variety of published and unpublished reports.

SCOPE OF THIS REPORT

This report covers parts of six 1:24,000 scale U.S. Geological Survey topographic maps—Kasson, Evansville North, Daylight, West Franklin, Evansville South, and Newburgh Quadrangles (fig. 1). The distribution of the principal types of geologic deposits is shown on a geologic map (fig. 2).[1] These deposits are described in the text, and the landforms and land use characteristics associated with each are considered. Among the land use factors that are discussed are engineering properties of the materials, ground-water availability, and suitability for sanitary landfills and septic tanks.

Other topics discussed are the bedrock formations along with their mineral resource potential and the geologic hazards of flooding, earthquakes, and mine subsidence. Not discussed are more specific subjects, such as foundation conditions for heavy construction or deep-well disposal of liquid wastes; these uses require detailed and onsite studies.

The text of this report is based on the text of an open-file report that was made available to the Southern Indiana and Kentucky Regional Council of Governments early in 1972. Some additional data are included that were not available at the time that the open-file report was prepared. The set of large-scale maps that was provided with the open-file report is not reproduced here; instead, a smaller scale compilation (fig. 2) is furnished. The open-file report and the larger maps may be consulted in the offices of the Regional Council of Governments in the Civic Center Complex at Evansville or at the Indiana Geological Survey in Bloomington.

OUTLINE OF GEOLOGIC HISTORY

The geologic history of the Evansville area is long and complex, but for introductory discussion it may be divided into three episodes. First, some 230 million years ago, a sequence of sediments was deposited along the margins of an ancient sea. As these were buried by additional sediment, they became the beds of sandstone, shale, limestone, and coal that make up the bedrock of this area. When deposition ceased, erosion began to shape the land, carving it into hills and valleys. This second episode lasted many millions of years and ended only about 2 million years ago.

The third and final episode is related to the repeated advances of glacial ice that moved southward from Canada. The Evansville area escaped these glaciations, one of which reached only as close as the northwest corner of Vanderburgh County (fig. 1), but the landscape nevertheless was much altered. First,

[1]Figures 2 through 8 follow page 8.

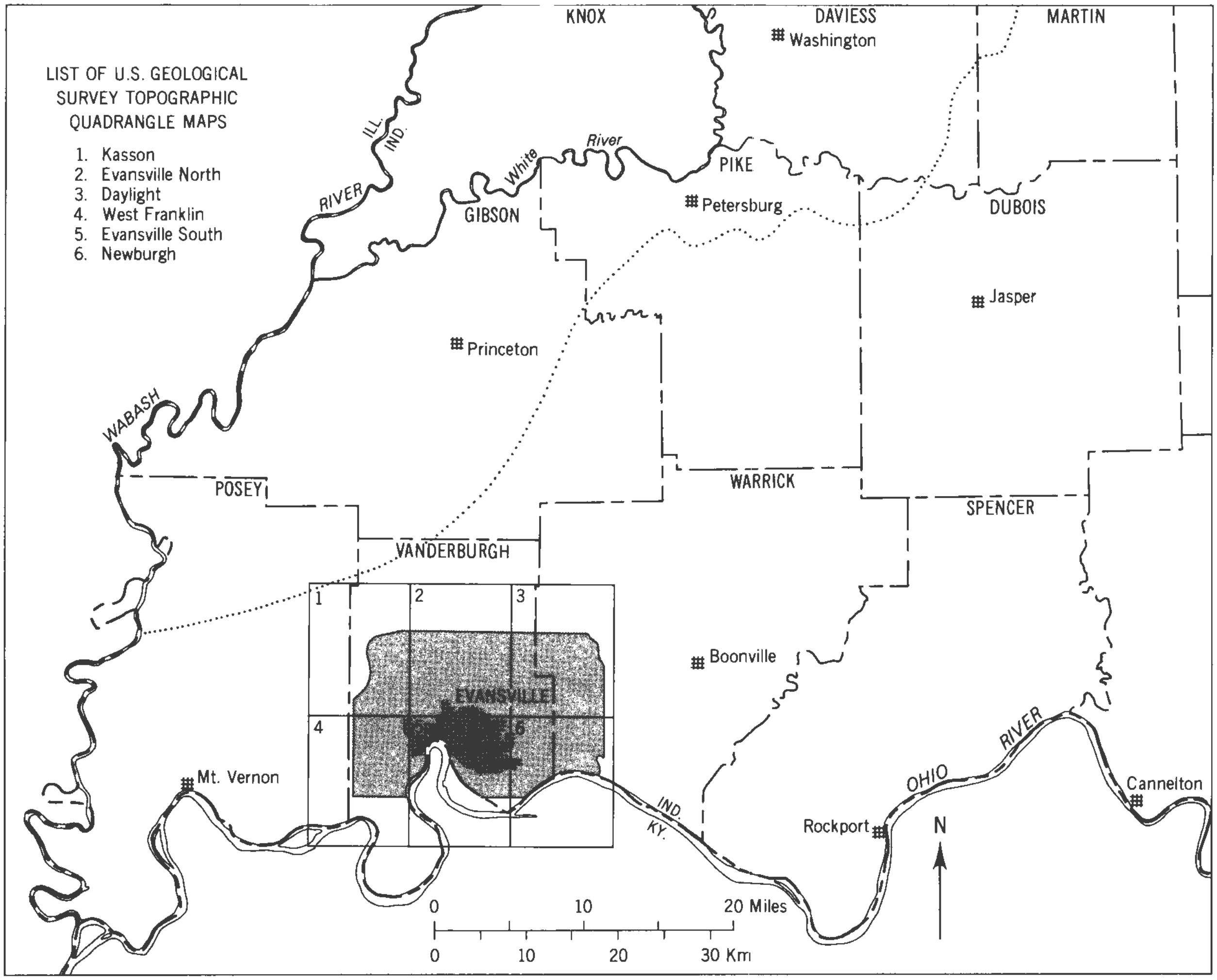


Figure 1. Index map of southwestern Indiana showing geologic and geographic setting of Evansville and area discussed in this report (shaded). Dotted line shows maximum extent of glaciation.

long before each glacier reached southern Indiana, climatic changes and a lowered sea level combined to cause the major streams to deeply entrench their valleys. Later, meltwater from each of the great ice sheets brought floods of sand and gravel to fill the valley of the Ohio River. This, in turn, ponded the tributary valleys. Thick deposits of silt and clay were laid down in the lakes thus formed. In winter the vast expanses of fresh sediment were barren and dry, and windstorms whipped up great quantities of silt and deposited it as a blanket over hills and valleys alike.

Most of the unconsolidated deposits in this area are associated with a glacier that is much younger than the one that reached the corner of Vanderburgh County, but this is a mere detail. When the glaciers finally receded, the landscape was left in much the form that we now see it. Changes since that time largely reflect the impact of man.

The Geologic Materials

AREA 1. STREAM AND FLOODPLAIN DEPOSITS; MOSTLY SILT

Broad areas along the Ohio River and narrower areas along smaller streams (fig. 2) are floodplains that are underlain by alluvial (stream-deposited) silt, sand, and minor amounts of gravel. Organic materials (mainly plant remains) are scattered throughout these deposits, and in places there are beds of peat and muck. Alluvial areas are subject to frequent overflow. With each flood, processes of erosion and deposition to some extent reshape the surface of the land. Because of this, few structures of permanent or essential character have been built on these floodplains (fig. 6); structures that must be or that appropriately are placed there—for example, waterworks and sewage disposal facilities—must be protected by diking or other suitable measures.

The floodplain along the Ohio River is at an altitude of about 360 feet (110 m). Most of the floodplain is flooded almost every year, and during the highest flood ever recorded, the 1937 flood, the floodplain was beneath more than 20 feet (6 m) of water). Floodplains of the smaller streams are at slightly higher altitudes, but these too are inundated frequently.

Low ridges that form the higher parts of the floodplain along the Ohio River (fig. 6) are underlain by sand; in other parts of the plain, silt is the more common material. Clay and muck are found in the sloughs. Near the river the alluvial deposits are about 50 feet (15 m) thick and are underlain by sand and gravel (glacial outwash) to a depth of 120 feet (37 m). Floodplains along the smaller streams are underlain by 5 to 20 feet (1.5 to 6 m) of alluvial silt.

Much of Area 1 is farmed, but crop losses to spring floods are fairly frequent. If streambanks and lower parts of the floodplains were placed under permanent vegetation as woodland, this would retard erosion and also would help the floodplains to perform better their natural function—retention of floodwater to recharge ground-water resources and to help minimize flooding downstream.

The alluvial deposits of Area 1 have several unsatisfactory engineering properties. Most importantly, they are variable and their behavior is difficult to predict. Some of the deposits are cohesive and on the standard engineers scale of consistency range from stiff to very soft; other materials are incohesive and on the scale of density range from very loose to medium. Because of their low topographic position and high organic content, the deposits commonly contain moisture well in excess of optimum for proper compaction and maximum strength. Foundation conditions therefore are poor for all except very light loads, and the material is poor for use as fill. Slumping is common along unprotected streambanks, particularly when stream levels are falling after the banks have become thoroughly saturated with water during a period of flooding.

The broad parts of Area 1 near the Ohio River are nearly everywhere underlain at depths of about 50 feet (15 m) by sand and gravel from which large quantities of ground water may be obtained. The narrower floodplains of the small streams generally overlie silt and clay from which little or no water may be produced.

For reasons explained above, the floodplains are sparsely settled and the question of septic tank use is not really important. It is worth mentioning, nevertheless, that because of the high water table and the frequency of flooding, septic tank tile fields will not function properly on floodplains. Tile fields require aereated soil; this requirement cannot be met in Area 1.

No part of Area 1 should be used for sanitary landfill because of the hazard of flooding. In parts of Area 1 near the Ohio River, leachate from a landfill would descend rapidly through the permeable surface material into the underlying sand aquifer, where it would contaminate the ground water. Ultimately, this contamination would seep into the Ohio River.

AREA 2. GLACIAL OUTWASH DEPOSITS; SAND AND SILT WITH SOME GRAVEL

A broad terrace area along the Ohio River that includes much of downtown Evansville and areas to the southeast and southwest (fig. 2) is underlain by silt that caps deposits of sand and gravel which extend to a depth of 100 feet (30 m) or more in many places (fig. 3). The sand and gravel are outwash deposits left by meltwater flowing from glaciers that advanced nearly to the Ohio River at Cincinnati some 20,000 years ago. The silt, an overbank deposit left by floodwaters of streams that were weakening as the glacier receded, is 10 to 20 feet (3 to 6 m) thick and the sand therefore is not seen at the surface, but the sandy substratum affects soil drainage, ground-water availability, and other important geologic factors.

The outwash deposits occur as terraces some 40 feet (12 m) above the present level of the Ohio River. After the episode of valley filling that they record, the river, no longer carrying a heavy load of sand and gravel, cut much of the original outwash deposit away. The level of the present floodplain is about 20 feet (6 m) below the level of the outwash deposits; thus in many places a small scarp separates Area 2 from Area 1 (fig. 6). In other places, erosion has blurred the surface distinction, but the difference in materials beneath the surface remains.

The southeastward expansion of Evansville has been primarily across the outwash terrace of Area 2, but southwestward the outwash area is still largely in agricultural use. One reason for the lack of development in the southwestern area is that it lies at a somewhat lower altitude—360 to 370 feet (110 to 113 m)—than does the southeastern area, which lies at 370 to 380 feet (113 to 116 m). Thus the southwestern area is flooded rather frequently, and the ridge-and-slough topography of its surface clearly shows this. At the height of the 1937 flood, the southwestern part of Area 2 was entirely under water. The southeastern part of Area 2 had severe flood losses in 1937 but inundation was not complete, and it has since been possible to protect most of this area from floods of similar magnitude with a levee (fig. 6).

Soils in the outwash area are moderately permeable and runoff from heavy rainfall is not a severe problem, except in low spots and in urbanized areas where grading, large areas of pavement, and areas covered by buildings increase the runoff and impede the natural infiltration and drainage routes. Storm sewers are necessary in many such developed areas.

The glacial outwash deposits are mostly incohesive in character. The upper 10 to 20 feet (3 to 6 m), which is mostly silt, ranges on the engineers scale of density from very loose to loose; the underlying sand and gravel are loose to medium dense. Water commonly is encountered in deep excavations, and sheet piling or some other form of control over caving is required for excavations more than a few feet deep. Area 2 is underlain by sand and gravel to considerable depth (fig. 3), and driven pilings usually cannot be seated on bedrock. Adequate bearing capacity for most loads, however, can be obtained with pilings that terminate in the sand.

Almost anywhere within the outwash area, wells to a depth of 80 to 100 feet (25 to 30 m) will produce large quantities of ground water. Beneath the 10- to 20-foot (3 to 6 m) layer of surface silt are water-bearing sand and gravel to a depth of 100 feet (30 m) or more (fig. 3). At most places shale that is not productive of water underlies the sand.

Depending on local soil conditions, septic tanks may be practicable in Area 2. Permeability of the silty soil normally is adequate except where a pan is present in the soil. The usual 10 to 20 feet (3 to 6 m) of silt cap forms an adequate filtration medium above the sand, which is an important aquifer and which therefore merits careful protection from contamination. Septic tanks should never be used, however, on small lots, nor should great numbers of them be clustered as in subdivisions. This causes excessive and continued wetness, which in turn contributes to clogging of the soil, increasingly poor drainage, and eventual failure of the tile fields.

Sanitary landfills should not be constructed in Area 2. The silt layer is not an adequate barrier to the downward movement of the quantity or concentration of leachate that would be produced by a landfill. This leachate would therefore enter the underlying sand aquifer without renovation, would then contaminate the ground water, and would eventually seep into the Ohio River.

AREA 3. LAKE DEPOSITS; SILT AND CLAY

The broad plain that extends east, northeast, and north of Evansville, principally along Pigeon Creek and its tributaries, is the floor of a former shallow lake (fig. 2). Beneath the ground surface are sediments, mostly silt and clay, that were deposited in this lake. In many places these deposits are as much as 100 feet (30 m) thick (fig. 3). Historically the lake plain has been used principally for agriculture; in recent years, however, it has become extensively urbanized. (Compare figs. 4 and 7.)

Central parts of the lake plain are nearly flat at altitudes close to 380 feet (116 m). The plain rises in all directions from the central areas, so that the margins of the lake plain are typically at altitudes of 390 to 405 feet (119 to 123 m). Present streams flow sluggishly across the old lake floor in channels that are 5 to 35 feet (1.5 to 11 m) below the level of the plain; as a rule, larger streams are more deeply entrenched than smaller ones.

The soils are very slowly permeable and therefore the quantity of runoff is high. Because of the flatness of the area and the low gradient of the streams, however, surface drainage is poor. Ponding and local flooding are common after periods of heavy rainfall. Local flooding can occur in any part of the lake plain independently of the stage of the Ohio River, and is therefore distinct from backwater flooding, which results from high water on the Ohio River and which affects only the lower parts of the plain. Only areas lower than about 383 feet (117 m)–the maximum stage of record on the Ohio River at Evansville–have been subject to backwater flooding.

Ditching and channel straightening (fig. 7) have been widely used in Area 3 to help carry away water of local floods. The ditches, along with field tiling, have the added advantage of helping to lower the water table in immediately adjacent areas. Because of the slow permeability of the soil and subsoil materials, however, the water table in many parts of the lake plain is less than 3 feet (1 m) below the surface of the ground. Basements and other excavations in the lake area are almost certain to be objectionably wet.

Engineering properties of the silt and clay are unsatisfactory for some uses. At shallow depth, the material is saturated and has soft to very soft consistency and a field moisture content that is well above optimum moisture for proper compaction and maximum strength. Foundation conditions therefore are poor for all except relatively light loads, and sheet piling usually is required to keep excavations open. For use as fill, the material should first be stockpiled and allowed to drain. Slumping that occurs naturally along creek and ditch banks and in excavations is aggravated by the addition of water at or near the surface, as through watering of lawns and golf course greens or from septic tank tile fields.

Although the lake deposits are water saturated below rather shallow depths, they can produce little water because they are very slowly permeable. A few wells in the lake area yield water from lenses of sand or fine gravel within or at the base of the lake silt and clay. Most of the productive wells in the lake area, however, produce from beds of sandstone in the underlying bedrock. Production usually is adequate only for domestic use; for larger supplies, surface impoundments or connection to city water supply normally is necessary.

Septic tank tile fields are almost certain to fail rapidly because of the wetness described above. In some places, effluent from the tile fields breaks out to the surface of the ground; in others, saturation of the field causes the entire septic system to "back up" and refuse to flow. Sanitary sewers are essential to urban development on the lake plain.

Conventional sanitary landfills should not be located in Area 3 because of the hazard of frequent ponding or flooding and because of excessive wetness of soil and subsoil materials. Silt excavated from the lake plain, if stockpiled and drained, may provide satisfactory cover for landfills in other areas.

AREA 4. WINDBLOWN SILT DEPOSITS (LOESS)

The low hills of the Evansville area are covered with 5 to 30 feet (1.5 to 9 m) of windblown silt, known as loess, and some associated windblown sand (fig. 2). Beneath the loess is bedrock—principally shale and sandstone, but including in some places beds of limestone that formerly were quarried for road metal. Thin noncommercial coalbeds crop out in a few places.

Area 4 is principally in agricultural, rural nonfarm, and residential land use (fig. 8). The steeper slopes generally are unsuited for agriculture because sheetwash on bare ground leads rapidly to severe gullying. Many types of urban use also create erosion problems. Reforestation of steep areas is advisable to prevent serious loss of soil. In areas of moderate to steep slopes, addition of water to the soil through watering of lawns or septic tank drainage is apt to cause local subsidence or landslips. Here also reforestation of slopes is an indicated treatment.

Engineering properties of Area 4 present few unexpected problems. The silty material is cohesive and of medium stiff consistency. It has a bearing capacity that is normally in the range of 1 to 2 tons per square foot and is adequate for light to moderate foundation loads; commonly this capacity is significantly less, however, when the material is saturated than when it is dry. If a more competent foundation material is needed, bedrock of good bearing capacity is present at shallow depths in most places and can be reached by piles in others. The silt is not free draining and is therefore susceptible to frost damage, but this is a relatively minor problem in the Evansville area because the depth of freezing is not great. The internal structure of the loess is such that it may stand better in clean vertical cuts than on grassed slopes, but if the internal drainage at the base of such cuts is poor, as it is, for example, where shale lies close beneath, then changes in moisture content may cause failure and serious slumping of the cut walls.

The loess is not a good source of ground water, and in Area 4 sandstone aquifers in the bedrock are the principal source of water. Wells usually yield supplies that are adequate for domestic use only; for larger quantities of water, surface impoundments or connection to established municipal supplies generally are required.

A clay pan is present in some places in Area 4, and where this is the case, soil drainage is poor. In other places the loess cover is thin, and bedrock, which principally is shale of very slow permeability, lies close to the surface. In both of these situations, septic tank tile fields will not drain properly. The usual sign of failure is the breaking out of effluent to the ground surface. Where the loess deposit is thick and no clay pan is present, septic tanks may be practicable, but concentrated use, as in grouped lots of subdivision size, will lead to a raised water table, increasingly poor drainage conditions, and consequent failure of the tile fields.

Area 4 is the only part of the Evansville area in which geologic conditions are satisfactory for sanitary landfills. Only in the loess area is there slowly permeable soil and rock above the water table in thickness sufficient to minimize the possibility of ground-water contamination. Many parts of Area 4, however, lack sufficient material for cover; other parts should not be considered for landfill sites because of the steepness of the slopes. Cover for sites that are otherwise suitable may be obtained from nearby areas in the lake plain. Silt from the lake plain may be excavated by dragline, stockpiled and allowed to drain, and hauled to the landfill site for use as cover. The pit from which the silt was excavated will fill with water and could eventually be used for recreational purposes.

BEDROCK FORMATIONS

Bedrock formations at or near the ground surface in the Evansville area include, in ascending order, the Dugger, Shelburn, and Patoka Formations, all of which are Pennsylvanian in age—the age of the great coal deposits in the eastern United States. The Dugger Formation is about 120 feet (37 m) thick and is mostly shale, but includes two beds of coal 4 to 6 feet (1.2 to 1.8 m) thick near the top. This formation does not crop out and is present in the area only beneath thick unconsolidated deposits; near downtown Evansville the upper of the two coalbeds is about 50 feet (15 m) below the normal level of the Ohio River.

The Shelburn Formation is nearly 150 feet (45 m) thick in the Evansville area and consists mainly of sandstone, sandy shale, and shale. A bed of limestone, the West Franklin Limestone Member, is at the top of this formation and is about 15 feet (4.5 m) thick. This limestone crops out or is present beneath a variable loess cover in the hills of the area at altitudes of 400 to 470 feet (120 to 140 m), mostly to the west and north of Evansville. Other rocks near the top of the formation crop out in a few places, but generally the formation is covered by unconsolidated deposits as much as 100 feet (30 m) thick.

About 60 feet (18 m) of the Patoka Formation caps hills in the Evansville area. This formation consists mainly of shale and sandstone. It crops out in only a few places because in most places it is covered by loess as much as 30 feet (9 m) thick.

Some of the bedrock units have or have had economic value. At several places in the area, the West Franklin Limestone Member of the Shelburn Formation has been the source of small quantities of crushed stone. It is not quarried commercially at present, although large reserves of available (though currently uneconomic) stone remain. Among the coalbeds, only those deeper than the rocks described have been considered economic; the only coalbed that has actually been mined is the Springfield Coal Member (V) of the Petersburg Formation, which lies at a depth of about 250 feet (75 m) beneath downtown Evansville and 100 feet (30 m) beneath Newburgh. Mining has been extensive in both these areas (fig. 5). Near-surface beds of shale in the Shelburn and Patoka Formations have been used and may have future value for manufacturing brick or tile. In years past, some of the sandstone beds have been quarried on a small scale for building stone. More importantly, several beds of sandstone at various depths are minor aquifers and produce small quantities of water for domestic use.

The Geologic Hazards

FLOODS

Flooding of the Ohio River, Pigeon Creek, and smaller streams has been recognized as a hazard in the Evansville area since first settlement, and numerous studies of floods in the area have been carried out by the U.S. Army, Corps of Engineers; the U.S. Geological Survey, Water Resources Division; and the Indiana Department of Natural Resources, Division of Water. For detailed flood data, these agencies should be consulted. A brief summary, however, is appropriate here.

The greatest flood in the history of Evansville took place in January 1937. This reached a gauged level of 383 feet (117 m) above sea level and flooded large areas in Evansville. The 1913 flood at 377 feet (115 m) was nearly as devastating, and lesser floods of 1936 and 1964 reached stages of 374 and 376 feet (114 and 115 m), respectively. Flood stage on the river, which signifies an overbank condition that occurs practically every year, is considered to be 370 feet (113 m). For planning purposes, the "standard project flood"—considered the maximum likely ever to occur—is set at 387 feet (118 m). This is the level to which levees and other protective structures must be built if near-certain protection is to be obtained.

Depending on rainfall distribution, flooding on Pigeon Creek a few miles upstream from its confluence with the Ohio may be caused by a backwater condition, in which case the level on Pigeon Creek may for a time be a foot or so lower than it is on the Ohio, or flooding may be caused by floodflow in Pigeon Creek itself, in which case its level may be several feet above that of the Ohio. As an example of this local type of flooding, in May 1961, Pigeon Creek at the gauge on U.S. Highway 41 reached a height of 380 feet (116 m), at which time the Ohio at Court Street reached only 374 feet (114 m).

Nearly all of Area 1 (fig. 2) is likely to be flooded annually. Small parts of Areas 2 and 3 are likely to be flooded annually as well, and large parts of these areas will be flooded less frequently. The "standard project flood" would cover nearly all of Areas 2 and 3, except those parts that are protected by adequate levees or floodwalls.

EARTHQUAKES

Evansville lies along the northern border of an area in which the possibility of severe earthquake damage exists. The area is shaken rather frequently by discernible shocks, and minor structural damage is occasionally done. The strongest earthquake felt in the area, however, occurred while Evansville was still only an unnamed cluster of cabins on the riverbank at the foot of Vine Street.

The New Madrid [Missouri] earthquake, the most severe in the history of the United States, actually consisted of numerous minor tremors and three major shocks over a period of several months during 1811 and 1812. Effects were felt more than a thousand miles from the center of the disturbance. Physical damage ranging from minor to devastating was reported in different areas, but the severely shaken area was sparsely populated at the time and there was very little loss of life. A similar series of shocks in the same area today, however, would cause billions of dollars of damage, and probably also would cause loss of life in a few urban areas. In addition, there would be widespread disruption of public services and communications.

The largest of the New Madrid shocks is considered to have been slightly greater than the Alaska earthquake of March 1964, which at 8.6 on the Richter scale is the largest that has been instrumentally recorded. By contrast, the Illinois earthquake of November 9, 1968, which caused only minor damage but was distinctly felt in Evansville, was of magnitude 5.5—a little less than a thousandth of the energy of the Alaska earthquake. A repeat of the New Madrid shocks of 1811-12 would be felt as intensity VIII (considerable damage even in well-built structures) in those parts of Evansville that are underlain by firm dry soil or by bedrock (Area 4, fig. 2). In areas underlain by thick, loose wet soil (Areas 2 and 3 and especially Area 1), the perceived motion would be as much as one intensity level greater, and might well result in partial collapse even of substantially built structures.

Because the New Madrid earthquakes occurred a century and a half ago, and because recent shocks in the Evansville area have been relatively minor, little or no consideration of the earthquake hazard is usually taken in planning or construction. The hazard nevertheless exists, and no major structure should be built in the area without a full evaluation of the earthquake hazard. For a more complete evaluation of the seismic risk in Indiana, with specific reference to the Evansville area, see Blakely and Varma, "The Seismicity of Indiana Described by Return Periods of Earthquake Intensities," Indiana Geological Survey Occasional Paper 16, 1976.

MINE SUBSIDENCE

A large part of downtown Evansville is built over abandoned underground coal mines, and mining was extensive also in the Newburgh area (fig. 5). The voids left by mining now are filled with water, but they are subject to collapse of the roof material, which in most places is shale, and to subsequent failure of other overlying materials. Collapse eventually may extend to the surface and cause damage to existing structures, particularly to underground utility lines where the damage may long go undetected. Under some circumstances, leakage from broken water or sewer lines may accelerate the collapse.

No large structures should be sited above any mined area without careful consideration of the hazard presented by possible subsidence, or without adequate preconstruction testing and treatment of the site. Boundaries of the mined areas shown on the accompanying map (fig. 5) are accurately known to within about 50 feet (15 m) in those areas for which detailed mine maps are available; boundaries of areas shown as "indicated" are only approximate. For further detailed information, the mine maps may be examined at the Coal and Industrial Minerals Section of the Indiana Geological Survey, or at the Indiana Bureau of Mines and Mining in Terre Haute.

Summary and Prognosis

Because the city of Evansville is the business, transportation, and manufacturing center of southwestern Indiana, its continued growth in the foreseeable future is likely and in fact is quantitatively predicted by demographic studies. Consideration should therefore be given to the directions that such growth should take. In order of their adaptability to urbanization, the geologic units mapped (fig. 2) rank as follows, from most adaptable with fewest difficulties to least adaptable with most difficulties.

Area 4, the loess-covered hills, presents relatively few problems to construction of roads and buildings, although the hills are not well adapted to the conventional rectangular urban street and utilities patterns. The extension of facilities–for example, sanitary sewerlines–is readily accomplished even though bedrock is at shallow depth in a few places. Drainage and flooding present very few problems of consequence. The agricultural value and productivity of this land is relatively high but is not the highest in the region, and urban development in parts of Area 4 may be considered appropriate.

Area 2, the glacial outwash terrace, presents only one serious problem to further urbanization. Foundation conditions are generally good, the land is relatively flat, and utilities are easily provided, but most of Area 2 is subject to at least occasional flooding. Agricultural productivity of this land is very high, and an important consideration is that for agricultural purposes, protection from occasional floods is not usually considered necessary. Thus the attractiveness of this area for further urbanization must be balanced not only against the cost of extending flood protection, but also against the consequences of taking highly productive land out of crop production.

Area 3, the lake plain, is poorly suited to urbanization. In addition to the hazard of frequent local flooding, soil properties are unsatisfactory for most urban uses. Drainage is slow, the water table is high, the materials are of soft consistency, and bearing capacity is poor. The extension of sanitary sewers into Area 3 would be an easy matter, but protection from floods is difficult. The agricultural value of the land in Area 3 is rather high, and agriculture (specifically including, in places, wetland and woodland for timber production, wildlife, and flood protection) appears to be a beneficial use for much of Area 3.

Area 1, the floodplain, is unsuited for most kinds of urban use because of frequent flooding and poor foundation conditions of the soils. A few parts of Area 1 could be made suitable to some kinds of urban use by filling, but in many places this would be unacceptable because it would restrict the temporary storage or passage of floodwaters. Despite rather frequent losses to floods, Area 1 is excellent agricultural land and the row crop-pasture-woodland-wetland use range is suitable for this area.

Although a principal concern of this report is the need to plan for wise land use, narrow recommendations concerning land use have deliberately been avoided. At some point, however, specific decisions will have to be made by appropriate government bodies. Good planning recognizes the wide variety of uses for which land is needed–industrial, residential, agricultural, recreational–and further recognizes the need to guide growth so that an appropriate and varied land use mix is maintained. Wherever variety in land use is severely diminished, wherever any important land use is excluded from a region, the quality of life there is likely to decline in terms of diminishing opportunities and rising costs. This report is intended to provide a basis for necessary geologic input into the planning process.

For Further Information

Many state and federal agencies are interested in the future of man's interaction with his geologic environment in the Evansville area. Basic data on earth materials to a relatively shallow depth are obtained by the Soil Conservation Service, U.S. Department of Agriculture, and a new report on the soils of Vanderburgh County has been prepared by this agency. The Indiana Geological Survey is interested in earth materials to greater depth, and may be consulted for information on seismology, on engineering properties of earth materials, and on mineral resources, such as clay, coal, limestone, sand, gravel, oil, and gas. Information on ground and surface water availability is compiled by the Indiana Division of Water and by the Water Resources Division of the U.S. Geological Survey. These two agencies and the U.S. Army, Corps of Engineers, compile flood records. Water quality data are collected by the Indiana Board of Health.

The information in this report provides an introduction to the prospects, properties, and problems of geologic materials in this area. This information can form a sound basis for land use planning and other studies of broad scope, but it cannot substitute for detailed onsite investigation that is required for many kinds of land use. Although the Indiana Geological Survey is prepared to offer general advice, detailed studies must be carried out by professional engineers and engineering geologists.

Figure 2. Geologic map of Evansville area, southwestern Indiana.

Figure 3. Map of Evansville area showing depth to bedrock. In part adapted from an unpublished map prepared by R. J. Wolf, Water Resources Division, U.S. Geological Survey (Indianapolis office).

Figure 4. Composite of parts of four 15-minute topographic quadrangle maps (Haubstadt, Boonville, Henderson, and Newburg [Newburgh]), dated 1901 to 1914, showing Evansville area. Extensive urban growth and many other land use changes since these maps were made are shown by comparison with later maps (figs. 6-8). Growth has been especially extensive southeast and north of the central city area; compare fig. 2.

Figure 5. Areas of known mining in Evansville area. All mines are abandoned underground mines in the Springfield Coal Member (V). Source: Mine maps on file at the Indiana Bureau of Mines and Mining, Terre Haute, and G. H. Ashley, 1899, 23d Annual Report, Indiana Department of Geology and Natural Resources. See table 1 for list of mines.

Figure 6*A*. Composite aerial photograph showing floodplain area south of Evansville. River stage is about 361 ft (110 m), or low flood stage, and falling. Light colors indicate higher, better drained parts of the floodplain; darker colors show increasing wetness. Water areas are dark, but sediment-laden water entering the Ohio from Green River (lower right) is lighter. Overbank floodwaters carrying sand and finer sediments sweep westward and northwestward across the floodplain. The sand settles out in ridges, and the finer sediment in sloughs. U.S. Geological Survey photographs of April 16, 1962.

Figure 6*B*. Composite topographic map showing same area as figure 6*A*. Heavy solid lines indicate boundaries of Area 1 (alluvium) and Area 2 (glacial outwash deposits). (See fig. 2.) Higher parts of Area 1 (a) have relatively sandier and better drained soils. Borrow pits (b) along the levee are in the overbank silt cap of glacial outwash deposits (Area 2), as is the abandoned clay pit (c) just east of the drive-in theater. This pit has been used as a sanitary landfill. From U.S. Geological Survey topographic quadrangle maps.

Figure 7*A*. Composite aerial photograph showing area of lake deposits northeast of Evansville. The lake beds are very flat and are channeled by abandoned meander loops of Pigeon Creek (a). Soils are mostly dark and clayey; the lighter shades (b) indicate better drained soils composed of coarse silt or fine sand. A segment of the old Wabash & Erie Canal is discernible as Lockwood Ditch (c). The Southern Railway follows the tow path on the north side of the canal. U.S. Geological Survey photographs of April 10, 1962.

Figure 7*B*. Composite topographic map showing same area as figure 7*A*. Heavy solid lines indicate boundaries of Area 1 (alluvium), Area 2 (glacial outwash deposits), Area 3 (lake deposits), and Area 4 (loess-covered hills). (See fig. 2.) Many of the older roads, such as the Oak Hill Road through Lakewood Hills and the Old Boonville Highway northeast of Burkhart School, follow where possible higher ground of the loess-covered hills (Area 4). Evansville State Hospital is on a sand ridge, possibly capped by a few feet of windblown dune sand, along the inner edge of the glacial outwash deposits (Area 2). Probably this ridge represents the highest level reached by glacial meltwater in this area. From U.S. Geological Survey topographic quadrangle maps.

Figure 8*A*. Composite aerial photograph showing loess-covered hills and western part of Evansville. Small drainage channels are more closely spaced and more common in the hilly areas than in the flatter areas, which generally lack well-defined small drainageways. The hilly areas are mostly wooded. Many of the large light-toned areas (a) are bare ground at construction sites or are landfill sites. U.S. Geological Survey photographs of March 31, 1956.

Figure 8*B*. Composite topographic map showing same area as figure 8*A*. Heavy solid lines indicate boundaries of Area 1 (alluvium), Area 2 (glacial outwash deposits), Area 3 (lake deposits), and Area 4 (loess-covered hills). (See fig. 2.) Mine symbols show location of coal mine shafts as in figure 5. Topography of the loess-covered area is sufficiently hilly that the rectangular street pattern common on flatter areas cannot be used. Mapping shown here is more recent by several years than the photographs of figure 8*A*; considerable change in land use and some changes in roads and drainage are shown. From U.S. Geological Survey topographic quadrangle maps.

EXPLANATION FOR FIGURE 2

1

Area 1. Stream deposits on flat, low floodplains. Mostly silt and fine sand; minor amounts of gravel and organic materials. Thickness about 50 ft (15 m) along Ohio River, 5 to 20 ft (1.5 to 6 m) elsewhere. Unsuited to most kinds of urban use because of frequent flooding, poor foundation conditions, and soil wetness.

2

Area 2. Glacial outwash; high-level stream deposits, now in terrace-like remnants. Upper part is silt 10 to 20 ft (3 to 6 m) thick; sand and silt with some gravel are at depth. Total thickness about 150 ft (45 m). Part of area is subject to occasional flooding; otherwise well suited to urban use.

3

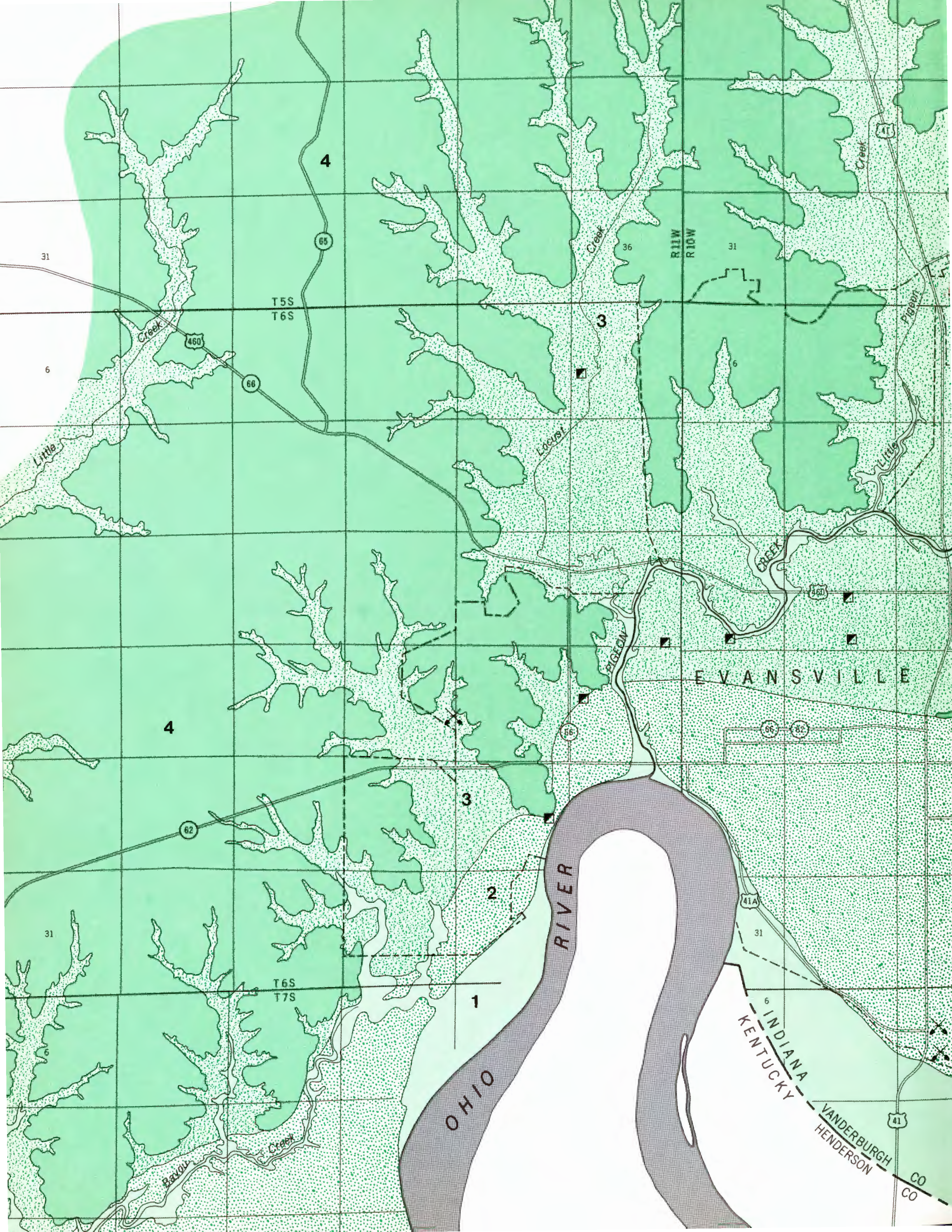
Area 3. Lake deposits; broad, low areas of former lake bottoms. Principally gray soft silt and clay. Thickness 40 to 100 ft (12 to 30 m) over most of area; thicker toward Ohio River, thinner toward uplands of Area 4. Poorly suited to urban use because of frequent flooding, poor foundation conditions, and soil wetness.

4

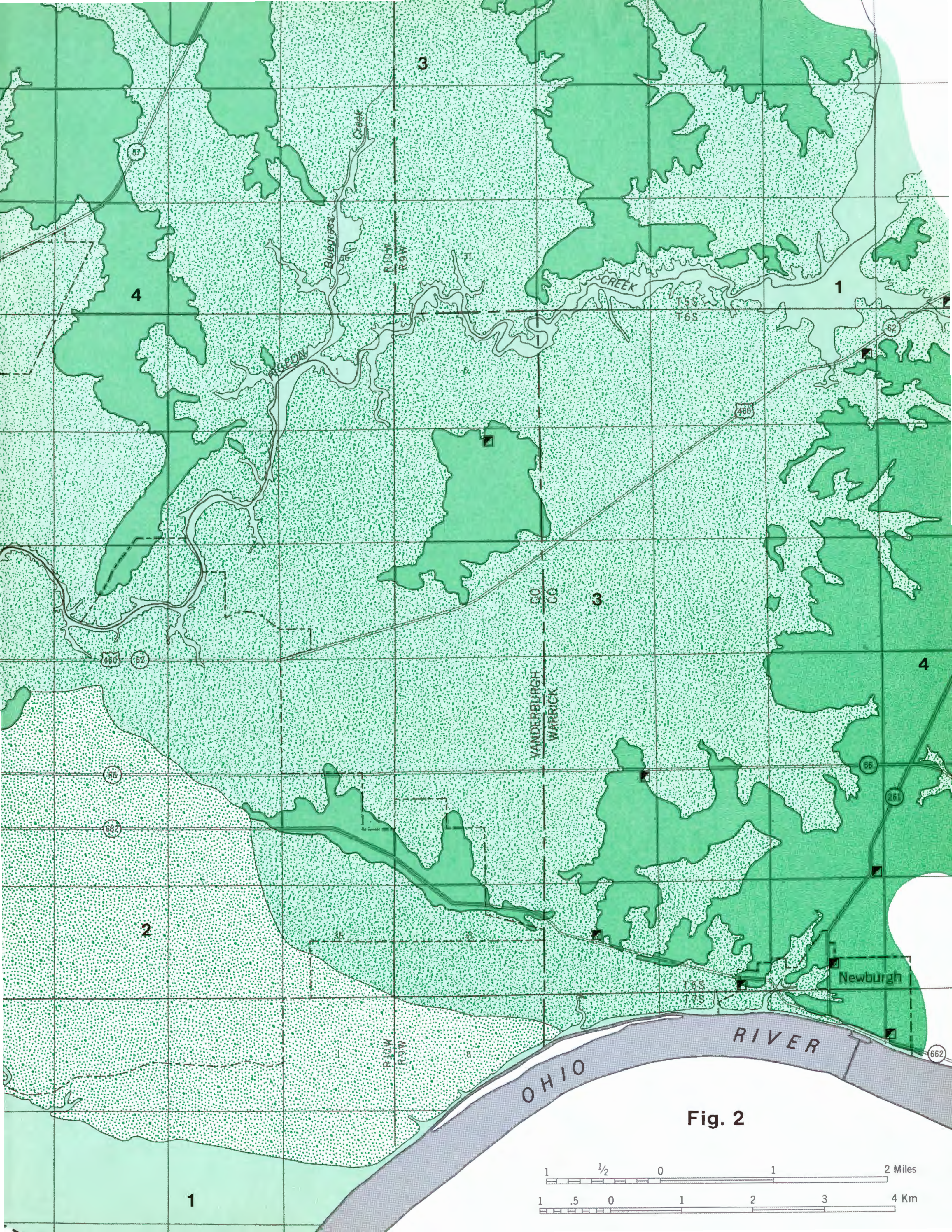
Area 4. Windblown silt deposits (loess) on low hills. Thickness 5 to 30 ft (1.5 to 9 m). Shale and sandstone are underlying materials. Well suited to urban use, although the hills are not well adapted to conventional rectangular urban street and utilities patterns.

Abandoned open pit for gravel, shale, or fill

Abandoned coal mine shaft
(See fig. 5 and table 1.)

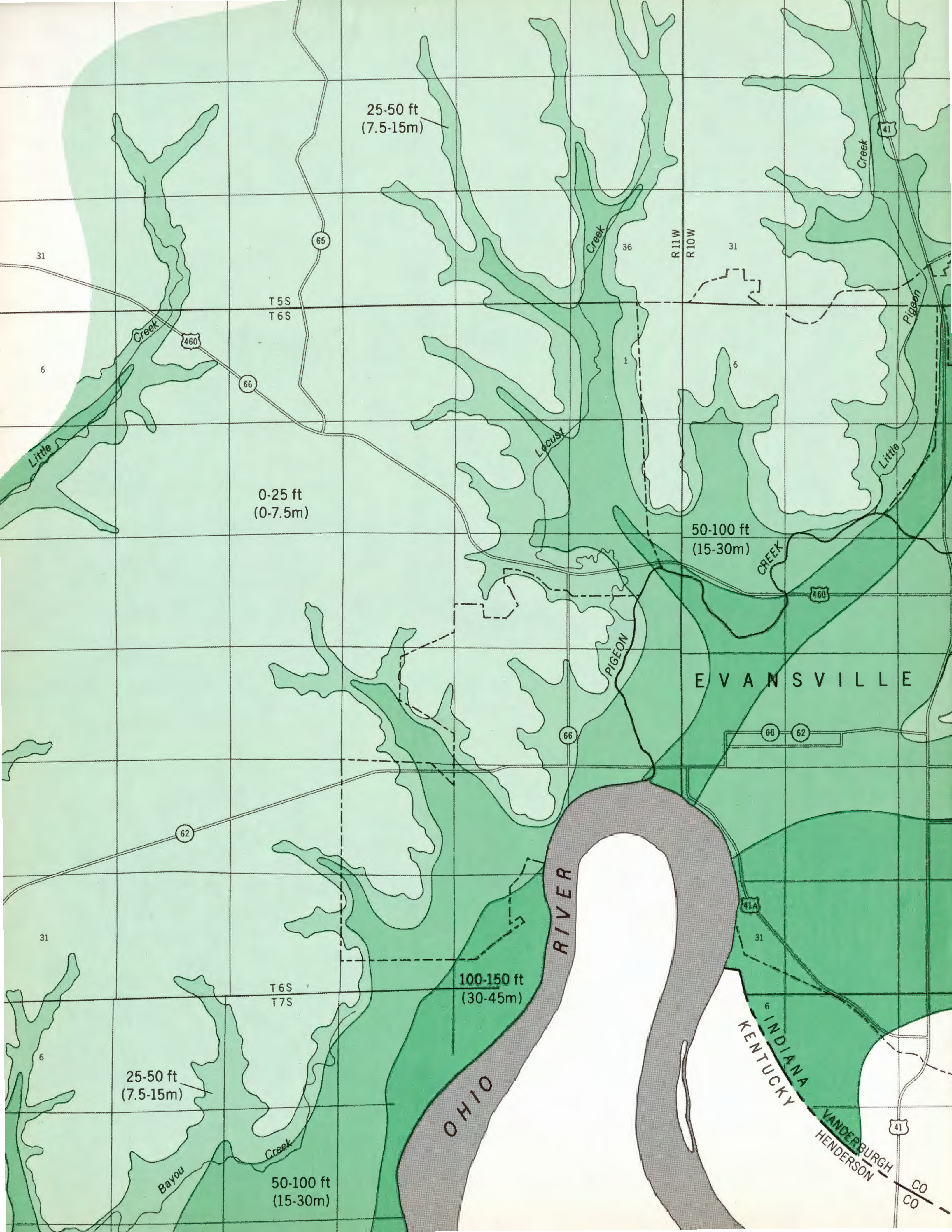


4
4
3
3
2
1
T5S
T6S
T6S
T7S
R11W
R10W
31
36
31
6
6
31
31
6
6
Little Creek
Creek
Locust
Creek
Pigeon
Little
CREEK
PIGEON
Bayou Creek
65
460
66
62
66
66
62
41
41A
41
460
EVANSVILLE
OHIO RIVER
INDIANA
KENTUCKY
VANDERBURGH CO
HENDERSON CO

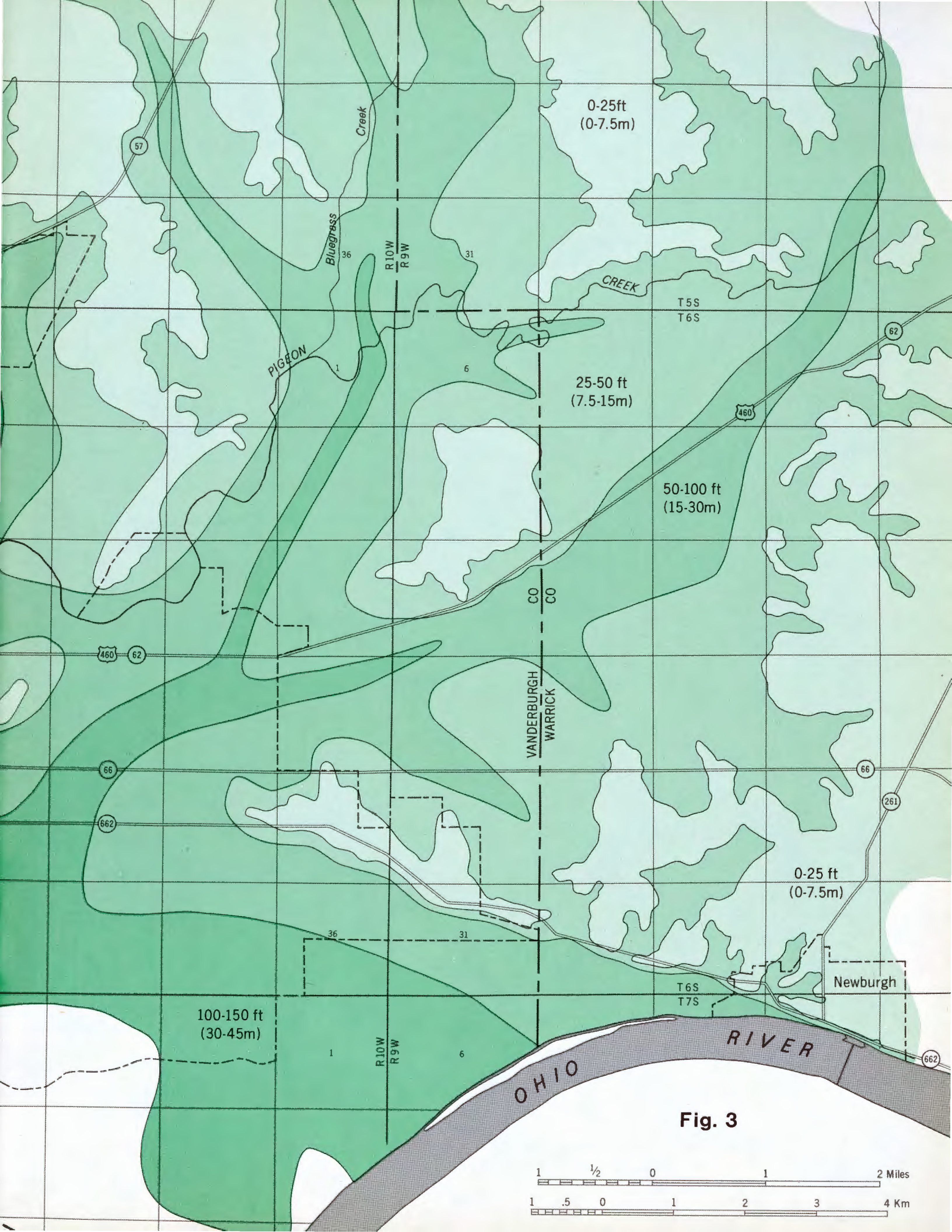


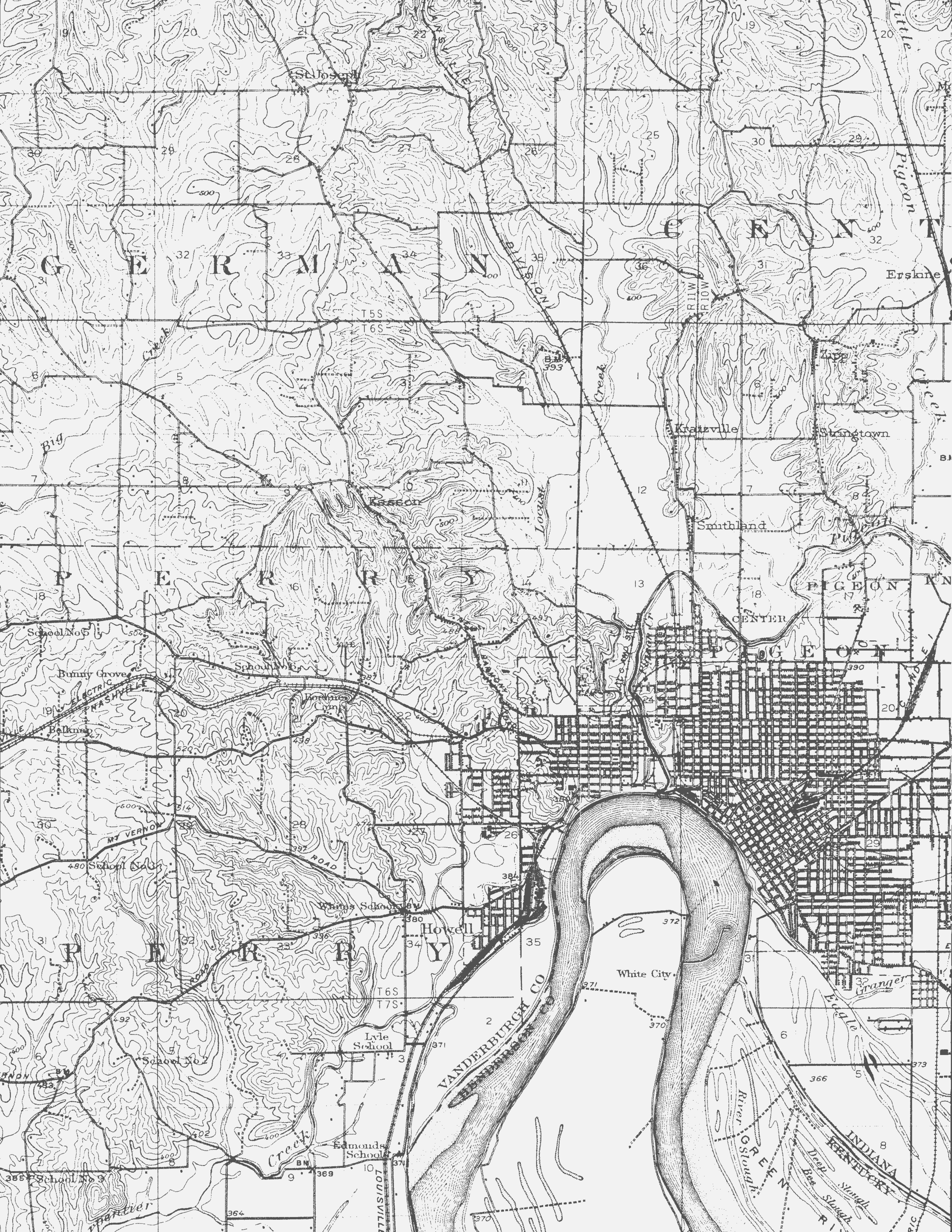
1
2
3
4
Bluegrass Creek
PIGEON CREEK
T5S
T6S
T7S
R10W
R9W
VANDERBURGH CO
WARRICK CO
Newburgh
OHIO RIVER
57
62
460
66
261
662
1 ½ 0 1 2 Miles
1 .5 0 1 2 3 4 Km

Fig. 2



25-50 ft
(7.5-15m)
0-25 ft
(0-7.5m)
50-100 ft
(15-30m)
100-150 ft
(30-45m)
25-50 ft
(7.5-15m)
50-100 ft
(15-30m)
EVANSVILLE
OHIO RIVER
INDIANA
KENTUCKY
VANDERBURGH CO
HENDERSON CO
Little Creek
Locust Creek
Pigeon Creek
Little Pigeon Creek
PIGEON CREEK
Bayou Creek
T5S
T6S
T6S
T7S
R11W
R10W
460
66
65
62
41
41A
31
6
36
1

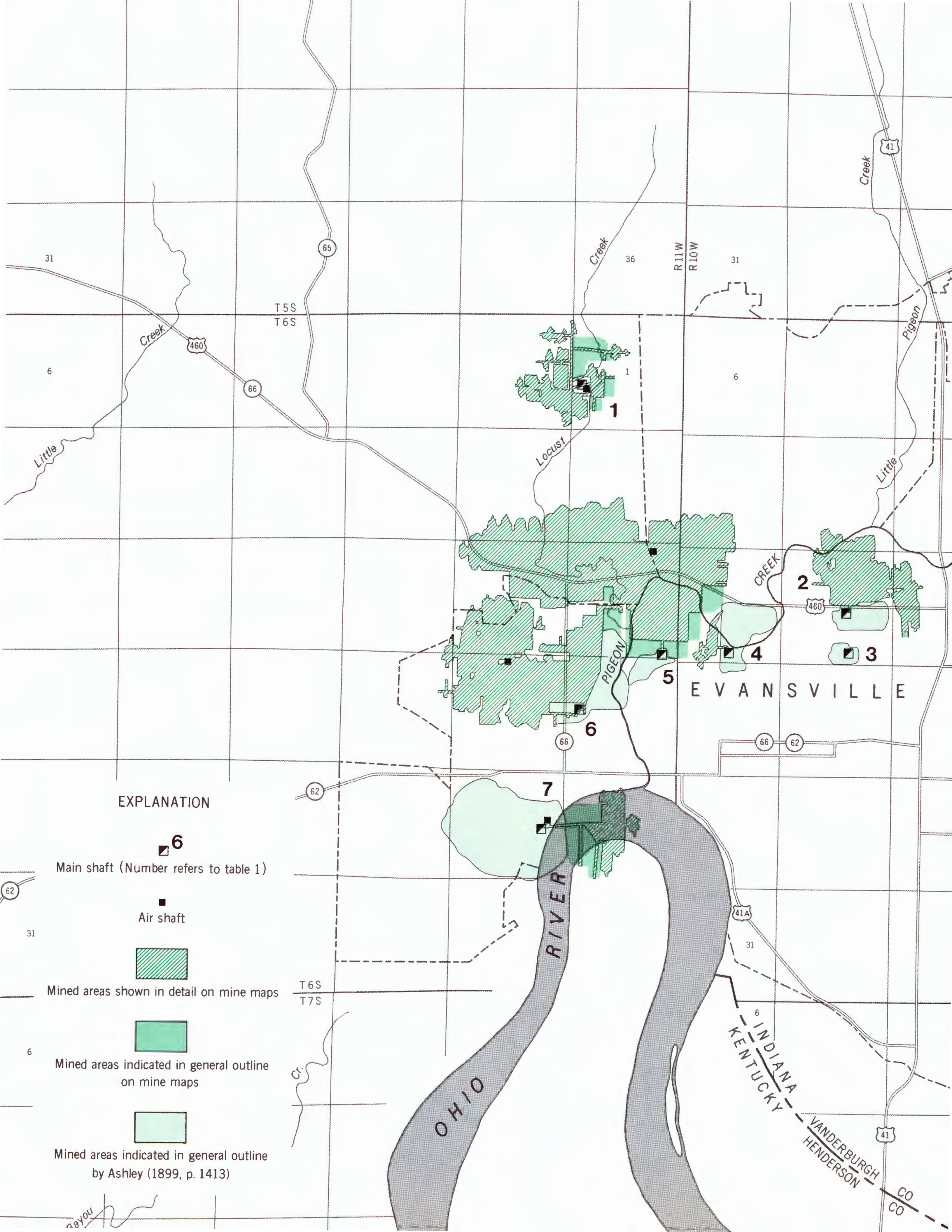

0-25ft
(0-7.5m)
25-50 ft
(7.5-15m)
50-100 ft
(15-30m)
100-150 ft
(30-45m)
0-25 ft
(0-7.5m)
Bluegrass
Creek
PIGEON
CREEK
R10W
R9W
T5S
T6S
T6S
T7S
VANDERBURGH
WARRICK
CO
CO
57
460
62
66
662
261
36
31
1
6
Newburgh
OHIO
RIVER
1
½
0
1
2 Miles
1
.5
0
1
2
3
4 Km
Fig. 3



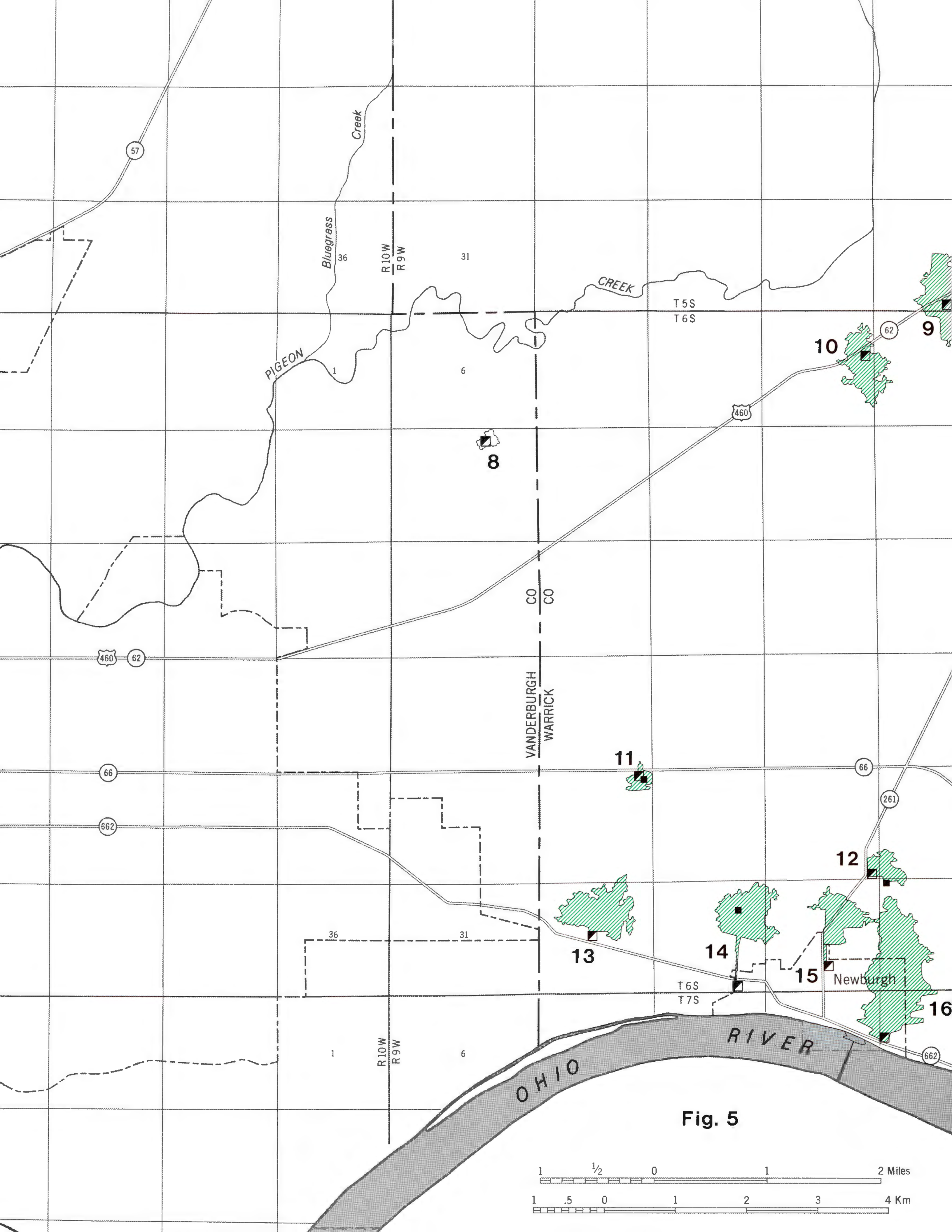
St Joseph
G E R M A N
C E N T
Erskine
T5S
T6S
Zipp
Kratzville
Stringtown
Kasson
Locust
Creek
Smithland
Big
P E R R Y
PIGEON
CENTER
P I G E O N
School No 5
Bunny Grove
School No 6
Belknap
Boehnes Cem
School No 3
Whites School
Howell
White City
MT VERNON
ROAD
P E R R Y
T6S
T7S
Lyle School
School No 2
VANDERBURGH CO
HENDERSON CO
Edmonds School
School No 3
Pigeon
Little
Eagle
Granger
River
GREEN
Deep Slough
Bee Slough
INDIANA
KENTUCKY

Cutchanville
Iglehart
McCutchan
Evansville and Indianapolis R.R.
Bluegrass
Barnes
Branch
Creek
Pigeon
Locust
Creek
R10W
R9W
T5S
T6S
T6S
T7S
KNIGHT
CENTER
OHIO
Vanderburgh Co.
Warrick Co.
Stevenston
Southern R.R.
Evansville Div.
Evansville
Woodmere
Evansville Suburban and Newburg R.R.
Evansville Electric
Staser
Newburg
Lodge School
Ditch
Threemile Island
OHIO
SCALE 1:62500
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

Fig. 4



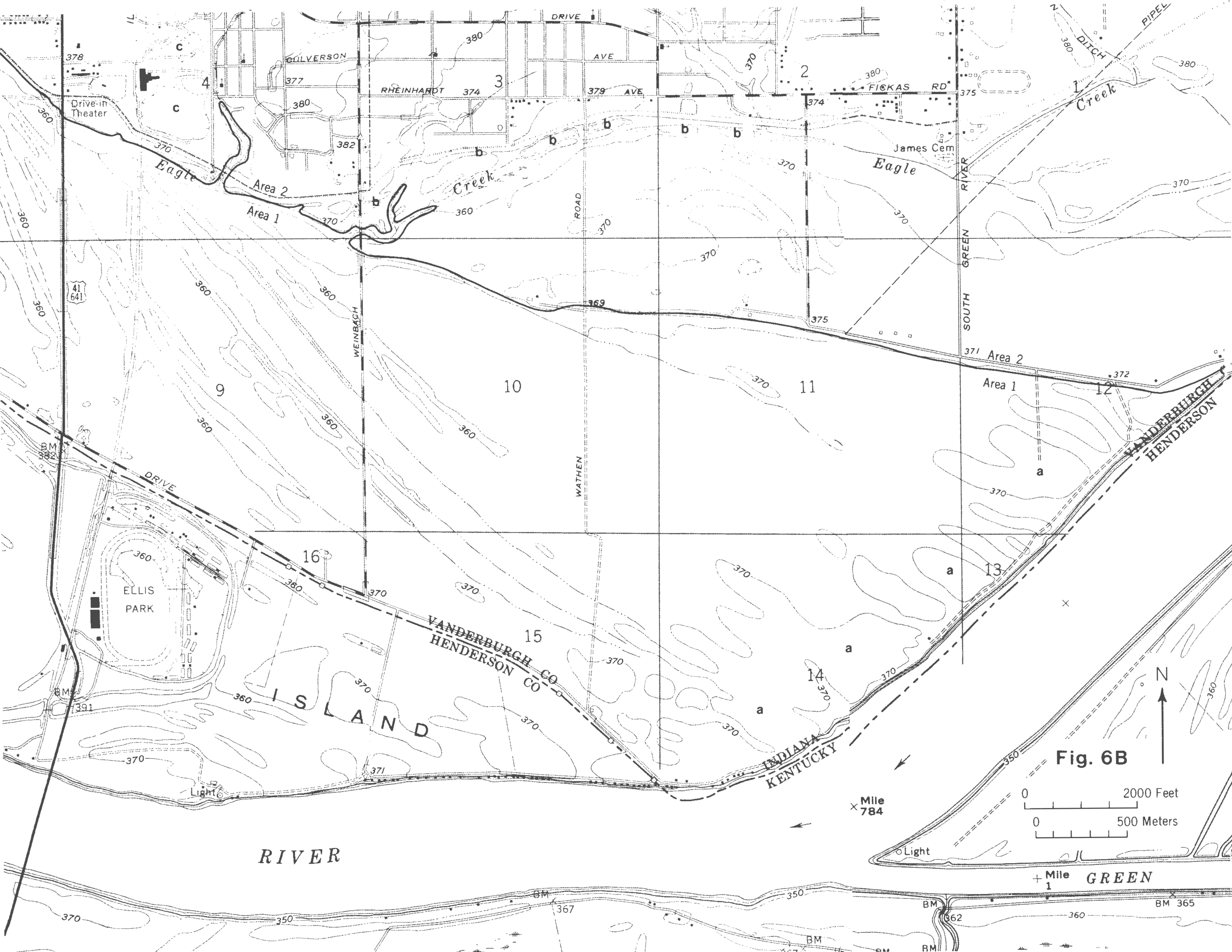
EXPLANATION
6
Main shaft (Number refers to table 1)
Air shaft
Mined areas shown in detail on mine maps
Mined areas indicated in general outline on mine maps
Mined areas indicated in general outline by Ashley (1899, p. 1413)
EVANSVILLE
OHIO RIVER
PIGEON
CREEK
Little Creek
Locust Creek
Pigeon Creek
Little
Cr.
Bayou
T5S
T6S
T7S
R11W
R10W
INDIANA
KENTUCKY
VANDERBURGH CO
HENDERSON CO
1
2
3
4
5
6
7
31
36
6
1
41
41A
460
65
66
62



57
Bluegrass
Creek
36
R10W
R9W
31
CREEK
T5S
T6S
PIGEON
1
6
62
9
10
460
8
460
62
CO
CO
VANDERBURGH
WARRICK
11
66
66
261
662
12
13
14
15
Newburgh
16
36
31
T6S
T7S
1
R10W
R9W
6
OHIO
RIVER
662
1
½
0
1
2 Miles
1
.5
0
1
2
3
4 Km

Fig. 5


N
Fig. 6A
0 2000 Feet
0 500 Meters


DRIVE
CULVERSON
AVE
RHEINHARDT
AVE
FICKAS
RD
Drive-in Theater
James Cem
Eagle
Creek
Area 2
Area 1
WEINBACH
ROAD
WATHEN
SOUTH GREEN RIVER
DITCH
PIPEL
ELLIS PARK
ISLAND
VANDERBURGH CO
HENDERSON CO
VANDERBURGH
HENDERSON
INDIANA
KENTUCKY
RIVER
GREEN
Light
Mile 784
Mile 1
N
0 2000 Feet
0 500 Meters
41
641
BM
382
391
367
362
365
Fig. 6B

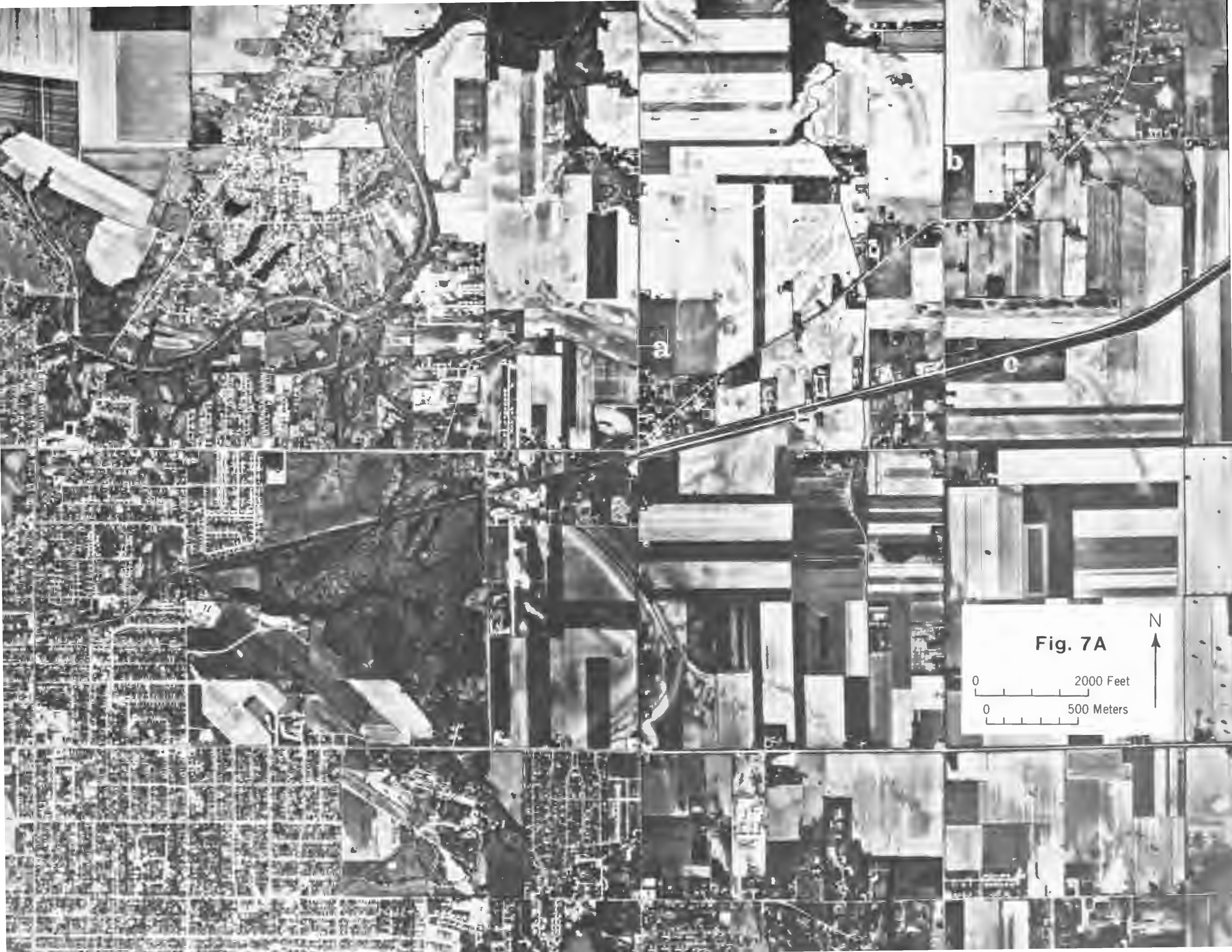


Fig. 7A

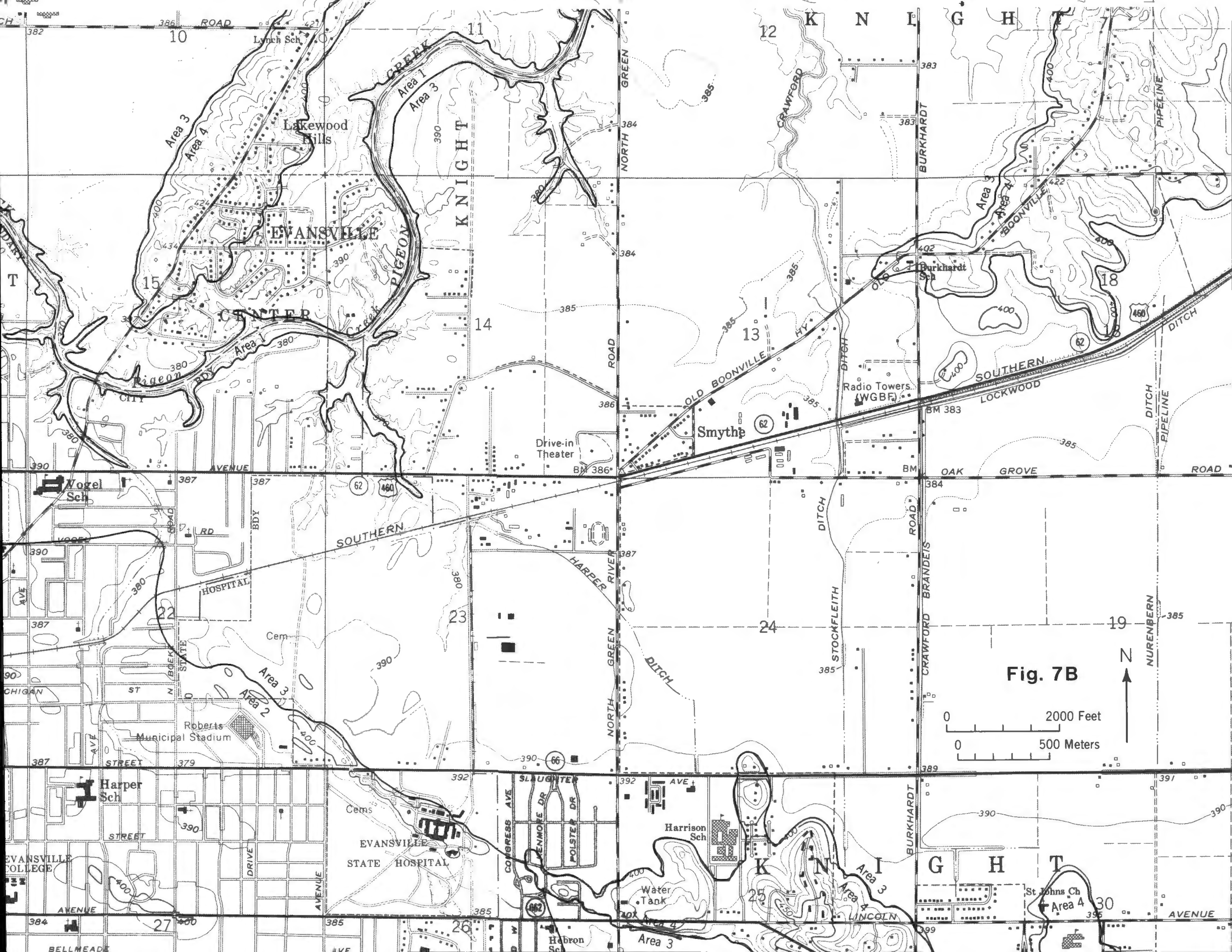
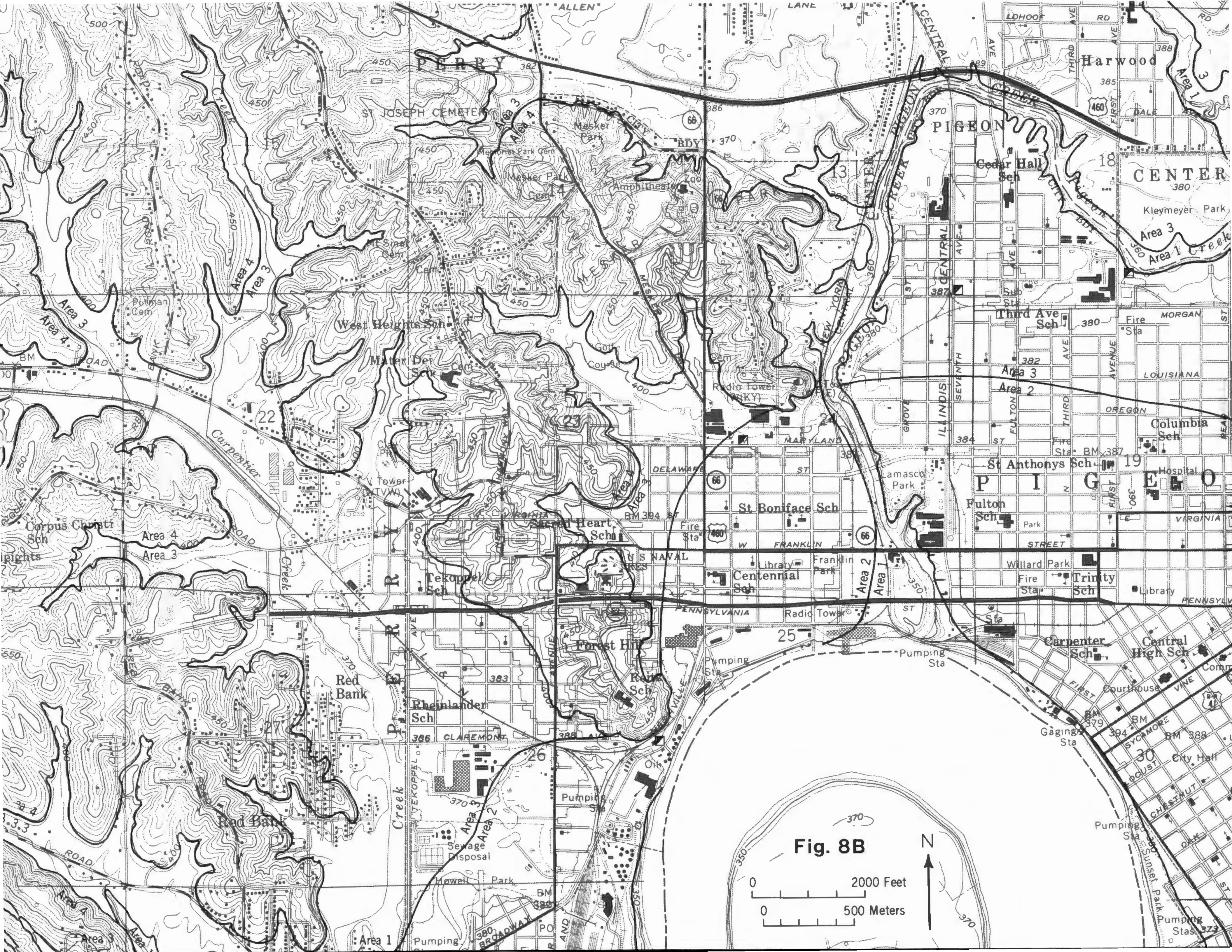

KNIGHT
CENTER
EVANSVILLE
Lakewood Hills
Lynch Sch
Pigeon Creek
PIGEON
Area 1
Area 2
Area 3
Area 4
NORTH GREEN ROAD
BURKHARDT ROAD
CRAWFORD BRANDEIS ROAD
NURENBERN
PIPELINE
DITCH
CRAWFORD
STOCKFLEITH DITCH
HARPER RIVER DITCH
OLD BOONVILLE HY
SOUTHERN
LOCKWOOD
OAK GROVE ROAD
Burkhardt Sch
Radio Towers (WGBF)
Smythe
Drive-in Theater
BM 386
BM 383
Vogel Sch
HOSPITAL
Cem
Roberts Municipal Stadium
Harper Sch
EVANSVILLE COLLEGE
Cems
EVANSVILLE STATE HOSPITAL
Harrison Sch
Water Tank
Hebron Sch
St Johns Ch
SLAUGHTER AVE
KENMORE DR
POLSTER DR
CONGRESS AVE
LINCOLN AVENUE
BELLMEADE
0 2000 Feet
0 500 Meters
N

Fig. 7B


Fig. 8A
N
0
2000 Feet
0
500 Meters



PERRY
ST JOSEPH CEMETERY
Mesker Park
Amphitheater
Zoo
CITY BDY
Harwood
PIGEON
CREEK
Cedar Hall Sch
CENTER
Kleymeyer Park
Area 1
Area 2
Area 3
Area 4
West Heights Sch
Mater Dei Sch
Putman Cem
Golf Course
Radio Tower (WIKY)
Third Ave Sch
Columbia Sch
St Anthonys Sch
Hospital
Lamasco Park
Fulton Sch
St Boniface Sch
Sacred Heart Sch
US NAVAL
Centennial Sch
Library
Franklin Park
Willard Park
Trinity Sch
Corpus Christi Sch
Carpenter Creek
Tekoppel Sch
Forest Hill
Radio Tower
Pumping Sta
Carpenter Sch
Central High Sch
Courthouse
Gaging Sta
City Hall
Red Bank
Rheinlander Sch
Red Sch
Sewage Disposal
Howell Park
Sunset Park
DELAWARE ST
MARYLAND
FRANKLIN STREET
PENNSYLVANIA ST
VIRGINIA
LOUISIANA
OREGON
MORGAN
CLAREMONT
BROADWAY
FIRST
SYCAMORE
VINE
LOCUST
CHESTNUT
OAK
DALE
LOHOOF RD
ALLEN
LANE
0 2000 Feet
0 500 Meters
N

Fig. 8B

Table 1. Coal mines in Evansville area[1]

No.	Name of mine	Company	Sec.	T.	R.	Thickness of coal in feet (meters)	Depth to coal in feet (meters)	Year begun	Year abandoned	Area mined in acres (hectares)
			Vanderburgh County							
1	Crescent No. 2	Crescent Fuel Co. Evansville Coals, Inc. Crescent Mining Co.	1	6 S	11 W	4.0 (1.2)	256 (78)	1937	1946	256 (104)
2	Diamond	Diamond Coal & Mining Co.	17	6 S	10 W	4.0 (1.2)	257 (78)	Before 1891	1925?	340 (138)
3	Union	Evansville Union Coal & Mining Co.	17	6 S	10 W	4.0 (1.2)	242 (74)	1892	1905?	25 (10)
4	First Avenue	Banner Coal Co. C. Thomas Coal Co. H. A. Lozier Coal Co. First Avenue Coal Co.	18	6 S	10 W	4.0 (1.2)	265 (81)	Before 1891	1913	140 (57)
5	Crescent No. 1 Unity Sunnyside No. 2 Unity	Crescent Coal Co. Crescent Coal Co. Sunnyside Coal & Coke Co. Sunnyside Coal & Coke Co.	13	6 S	11 W	4.0 (1.2)	256 (78)	Before 1891	1936	1,276 (516)
6	Sunnyside No. 1	Sunnyside Coal & Coke Co.	24	6 S	11 W	4.0 (1.2)	255 (78)	Before 1891	1936	826 (334)
7	Ingleside	Gibson & Moore Coal Co. John Ingle Coal Co.	26	6 S	11 W	4.2 (1.3)	260 (79)	1858	1918	665 (269)
8	Black Crow	Banner Coal Co.	7	5 S	9 W	4.0 (1.2)	160 (49)	1934	1939	11 (4)
			Warrick County							
9	Chandler	Chandler Coal Co. Joe A. Bryan Coal Co. (1911) Chandler Coal Mining Co. (1940)	35	5 S	9 W	4.4 (1.3)	120 (37)	1904	1940	131 (53)
10	Castle Garden Castle Garden No. 6	Castle Garden Coal Co. J. Woolley Coal Co. (1908)	3	6 S	9 W	4.0 (1.2)	80 (24)	1906	1923	100 (40)
11	Allen Gay	Allen Coal Co., Inc. Gay Mining Corp. (1944)	29	6 S	9 W	4.0 (1.2)	150 (46)	1937	1950	21 (8)
12	Rose Hill	Rose Hill Coal Co.	27	6 S	9 W	4.2 (1.3)	130 (40)	1940		42 (17)

13	Epworth	Epworth Coal Co. Staser-Epperson Coal Co. (1911) Newburgh Coal Co. (1914) Epworth Coal Co. (1925)	32	6 S	9 W	4.0 (1.2)	114 (35)	1908	1927	130 (52)
14	Brizius Star No. 2 Burke Sargeant No. 2	William Robertson J. Archbold Coal Co. (1899) Ohio River Coal Co. (1904) Worsham Coal Co. (1906) Worsham-Newburg Coal Co. (1913) Sargeant Coal Co. (1913) Shaw McConnell Coal Co. (1928) Schimmel Coal Co. (1933)	33	6 S	9 W	4.0 (1.2)	128 (39)	1897	1934	125 (50)
15	Sargeant No. 1	Sargeant Coal Co. Shaw McConnell Coal Co. (1928)	34	6 S	9 W	4.0 (1.2)	96 (29)	1909	1931	87 (35)
16	Star No. 1 Red Shaft	John Archbold Coal Co. Fisher & Goldbank Coal Co. (1909) Red Shaft Coal Co. (1931) Red Shaft Mining Co. (1934)	2	7 S	9 W	4.5 (1.4)	100 (30)	1893	1935	310 (125)

[1] All mines are abandoned underground mines in the Springfield Coal Member (V).