SHAWNEE ASSESSMENT AREA

Volume 1: Geology

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Introduction: Influence of Geology and Soils on Ecosystem Development

Geology is . . . the original source of inorganic chemical nutrients for the biosphere and provides the abiotic physical environment of the biosphere. Through knowledge of rock type mineralogy, the geologist can predict the amount and variety of toxic or beneficial inorganic chemical nutrients present. . . . Geological processes modifying geologic materials create landforms that are commonly a basis for land unit hierarchies. Geologists can increase understanding of land unit hierarchies in ecosystem studies. . . . Geologists can be critical players in understanding ecosystems.[1]

The "Natural Divisions of Illinois" is a classification of the natural environments and biotic communities of Illinois based on physiography, flora, and fauna. . . . Factors considered in delimiting the 14 natural divisions are topography, soils, bedrock, glacial history, and the distribution of plants and animals.[2]

In the few areas of the Earth that have not been modified by human settlement, the patterns of vegetation and the animals that interact with vegetation are directly influenced by geologic factors. In fact, in undisturbed areas, surficial geology and, to some extent, bedrock geology can be mapped using inferences drawn from vegetation patterns observed on air photographs and satellite images and during field observations. For example, in the pristine terrains of northern North America, ecosystem variations were used to infer and eventually map underlying geologic conditions.

The geologic characteristics that most influence ecosystem development are soil moisture and composition, topography (including slope angle, slope direction, and local drainage), and texture of the parent material. In some places, geologic events such as earthquakes, glacial advances and retreats, and volcanic eruptions exert a strong control over the ecosystem. Even animal activities that are seemingly removed from geologic control are influenced by geologic factors such as availability of salt for migrating herds, availability of suitable vegetation for food, or—in the case of carnivores—suitable colonies of prey that congregate near geologically controlled food sources.

In uninhabited areas of the glaciated North American arctic, ridges of gravel (eskers) left behind by retreating glaciers served as transportation routes for early humans and animals alike. The ridges provided ease of footing, vantage points for hunters or the hunted,

[1] P. Hughes, A geologic response to the Seventh American Forest Congress and Round Tables: Environmental Geology 28 (1) July 1996, p. 52–53.

[2] Comprehensive Plan for the Illinois Nature Preserves System, Part 2, The Natural Divisions of Illinois, John E. Schwegman, principal author, 1984, Illinois Nature Preserves Commission, p. 3.

and protection from ravenous insects that prefer the calmer air of low-lying areas. Even in modern America, roads in New England are commonly constructed on these ridges. These examples clearly illustrate the dominant role local geologic factors can play in ecosystem development.

Before human settlement, a whole panoply of Illinois' ecological components was in equilibrium with the geology and climate of each region. The original ecological systems were closely attuned to the differences in near-surface conditions generated by the distribution of glacial deposits and by spatial variations in bedrock units.

The glacial moraines (arc-shaped ridges) in the northeastern part of the state provided well-drained soils for forest growth and refuge for forest-dwelling animals. The low, flat plains were sites where shallow lakes had been dammed between moraines; they became poorly drained seas of herbaceous plants whose luxuriant growth provided the biomass for the thick organic-rich soils that support so much agriculture. Illinois' soils developed on tills and thick loess that are mixtures of crushed bedrock particles. These soil parent materials, formed and homogenized by the grinding action of glaciers, supply abundant nutrients vital to the crops that are the basis of our modern agriculture.

The terrain, topography, soils, and vegetation are significantly different in the parts of the state never covered by glacial ice. In those areas, the composition of the soils is directly related to the composition of the immediately underlying bedrock from which they were formed by chemical and physical weathering. The contrasts in the ancient ecosystems can be imagined by observing the ways that modern society has adjusted to the differences in the soils of the glaciated and unglaciated parts of the state. For example, except on the alluvial plains of the major rivers, row crops are not a major source of income in the relatively small parts of the state that were never glaciated.

On our modern landscape, original ecosystems cannot be restored or maintained without respecting the geologic factors that generated the original complex interrelationships between plants and animals. For instance, attempting to reestablish a wetland consisting of acid-loving plants that require periodic drying will not succeed in areas where depressions are actively fed by groundwater that passes through alkaline glacial till. Similarly, reestablishing certain types of forest vegetation on an unstable terrain underlain by thick, easily erodible loess is likely to fail.

- *Land on a high terrace of the Illinois River, about 100 feet above the river channel, was purchased for wetlands restoration. The permanent water table was nine feet below the surface, and the sandy soils were highly permeable. Wetlands plants installed at the site died and were replaced naturally by upland plant species tolerant of the dry conditions. Had readily available information on geology and hydrogeology of the area been taken into consideration, it would have clearly indicated that this site was inappropriate as a potential wetlands compensation site. Given that the existence of wetlands depends on hydrology, and hydrology depends on* *geologic and geomorphic factors, such information identifies areas most favorable for the occurrence of wetlands or wetland mitigation.*

—Michael V. Miller, Illinois State Geological Survey

Hine's emerald dragonfly, a federally listed endangered species, is associated with seep areas that receive groundwater flows from dolomitic limestone formations. The exact habitat requirements of larvae and adults are still unclear.

—Illinois Natural History Survey Annual Report, 1995–1996, p. 10

Notice that these two examples of the interrelationships between geology and ecosystem elements illustrate the four geologic factors considered by the Illinois Nature Preserves Commission (Schwegman 1984) in delimiting the 14 natural divisions of the state: topography (high terrace of a river channel), soils (sandy permeable soils), bedrock (dolomitic limestone formations), and glacial history (the Illinois River channel's location and configuration are due largely to the area's glacial history).

Topography influences the biota of Illinois by controlling the diversity of habitats: generally, the more rugged the topography, the greater is the diversity of habitats. The type of bedrock grnerally is reflected by a characteristic topography (for example, sandstone is typically hard and resistant, forming bluffs and ledges, whereas shale is soft and erodible, forming smooth slopes). Bedrock also exerts a control on plant life because of the thin soils that commonly are developed in it. A crucial factor in controlling soil type is the geologic material in which the soil developed (parent material). The diversity of soil parent materials is partly responsible for the varied environments and biota within ecosystems. Glacial history has played a major role in shaping the topography of the landscape: the subdued, irregular topography characteristic of recently glaciated areas generally is poorly drained, resulting in an abundance of aquatic habitats (Schwegman 1984).

Another interesting example of the interrelationships between geology and ecosystems is an observation made at certain landfills in which the water table assumes a mounded shape within the landfill. Cattails have been observed to grow where the water table is high, and cattails help clean up the water by taking some of the pollutants out of the leachate.

—Keros Cartwright, Illinois State Geological Survey

The preceding examples all mention water as a crucial element. Water is also an inherent aspect of the four geologic factors used to delineate natural divisions: topography determines drainage, soil moisture is a function of soil texture, bedrock types determine resistance to erosion, and glacial materials, which range from clayey glacial tills (see Glacial and Surficial Geology section) to sands and gravels, vary widely in texture and moisture-holding capacity and their ability to yield moisture to plants (Schwegman 1984).

The geologic foundation of the Shawnee Assessment Area is bedrock and glacially derived, windblown sediments that lie directly beneath the soils and modern sediments at the land surface. Some of the bedrock layers contain mineral resources that are important to the region's economy. The rugged topography of the largely unglaciated bedrock surface affected the thickness and distribution of the overlying windblown and water-laid deposits. These deposits, and the bedrock, formed the parent materials of many of the region's soils and played a role in the development of wetland areas. These geologic and other factors together governed the development of the wide range of natural plant and animal communities found within the Shawnee Assessment Area.

Geologic factors also play a fundamental role in how humans use the land. For example, because the Shawnee Assessment Area was never covered by the thick sheets of ice that scraped across the rest of the state, the bedrock lies exposed or close to the surface throughout the area, and the rugged topography and thin soils in much of the area make row-crop farming difficult. The easy access to the bedrock in the area made underground and surface mining of fluorite, lead, zinc, and barite one of the most important industries in the region. These and many other geologic factors have played major roles in both in the human history of the region and in determining which plants and animals can thrive here.

Part 1 of this volume, The Natural Geologic Setting, is organized "from the bottom up"—that is, we begin by describing the bedrock geology, then work our way upward from the bedrock surface and describe the sediments and features that stack on top of each other until they reach the landscape on which we live. This approach may seem counterintuitive to many readers: why don't we begin at the surface, with the geology we can see, and work our way downward? We believe the opposite strategy is a more logical and natural approach for two reasons: (1) it reflects the chronological order in which geologic materials were emplaced, and (2) it better describes how the bedrock geology and surficial deposits influence each other and how they combine to create the geologic template upon which life exists on the surface.

Part 2 of this volume, Geology and Society, examines the use of geologic resources within the assessment area and some of the impacts related to resource extraction. It also describes some of the dominant natural and society-induced geologic hazards that can occur in the assessment area.

The following discussions and accompanying maps are generalized for the entire Shawnee Assessment Area (Figure 1) and cannot be used for site-specific purposes. Users needing more detailed information should contact the authors at

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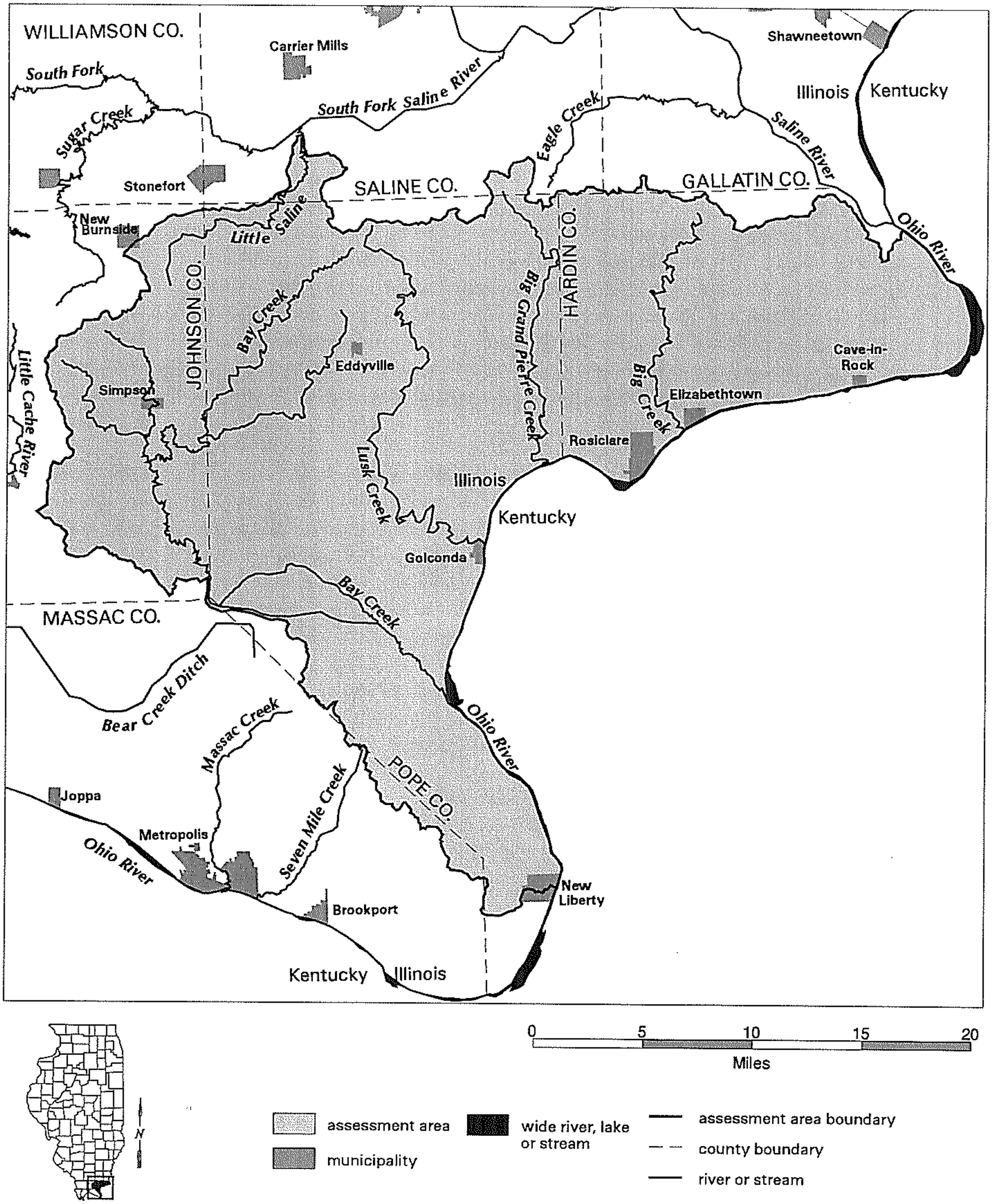

Figure 1. Shawnee Assessment Area

The maps reproduced in this volume are small-scale versions of preliminary work maps used by the authors in preparing their sections of the report. The level of detail in these maps is limited by the page size and type and quality of printing available for the reproduction of this report. In general, these maps are suitable for general planning and information purposes. Higher-detail and higher-resolution maps suitable for more specific applications and assessments can be consulted or obtained by contacting the authors at the Illinois State Geological Survey.

The databases used in this report are discussed in Appendix A.

The fact that Illinois is incorporating geologic data into this report on the Shawnee Assessment Area and into reports on other assessment areas in the state is an appropriate recognition of the necessity of integrating geologic and biological data into efforts to preserve our natural heritage.

Reference

Schwegman, J.E., principal author, 1984, Comprehensive Plan for the Illinois Nature Preserves System, Part 2, The Natural Divisions of Illinois: Illinois Nature Preserves Commission, p. 3.

Part 1: The Natural Geologic Setting

The nature of the geologic framework that lies beneath our feet is important in determining where flora and fauna prefer to grow, where streams flow, where humans build their homes, factories, and cities, and where land is set aside for parks and natural areas. Part 1 discusses the geologic framework of the Shawnee Assessment Area and, where possible, describes how the geology relates to ecosystems and habitat.

Bedrock Geology

Description of Materials

Bedrock within the Shawnee Assessment Area consists of sedimentary rocks of Devonian, Mississippian, Pennsylvanian, and Cretaceous ages (Figure 2). The outcrop patterns of these strata, except for the Cretaceous rocks, are heavily influenced by the complex structural geology of the area, specifically by Hicks Dome and several southwest-trending fault systems (inset map, Figure 3). Hicks Dome is a large, roughly circular uplift structure located in western Hardin County. The rock strata dip away from the center of this uplift in all directions. The dip of the strata generally causes successively younger rock layers to be exposed at the ground surface with distance away from the center of the dome. However, this general trend is interrupted in many places by faults that cut across and interrupt the bulls-eye pattern formed by Hicks Dome. Most of the faults trend northeast-southwest (Figure 3), but some arc around Hicks Dome and others extend radially from the center of the dome. Faults are numerous throughout much of the assessment area, except in the west-northwest part. In that area, the rocks are bent by several folds, including the McCormick and New Burnside Anticlines (upwarps) and the Bay Creek and Battle Ford Synclines (downwarps). In the eastern portion of the assessment area is an anticline, the Tolu Arch. Its axis (the crest of the arch) trends southeastward from near the apex of Hicks Dome. Unlike most of the folds in the area, the axis of the Tolu Arch is perpendicular to and intersects several faults.

The Devonian strata, which consist of limestone and chert overlain by carbonaceous shale, are exposed only in the very center of Hicks Dome. Most of the bedrock of the assessment area is of Mississippian age. The Middle Mississippian (middle and upper Valmeyeran Series) rocks are dominated by thick limestones. The Upper Mississippian (lower and upper Chesterian Series) strata consist of limestones with interbedded layers of sandstone and shale. The Pennsylvanian strata in Illinois consist of many relatively thin layers of sandstone, siltstone, shale, limestone, and coal. Sandstone, siltstone, and shale are the dominant rock types (Figure 2). Within the boundaries of the assessment area, the Pennsylvanian strata are separated into two formations (Kosanke and others 1960, Willman and others 1967, Greb and others 1992) that are distinguished by differences between minor lithological components and the presence of key beds that mark the boundaries between the units. The oldest and lowermost Pennsylvanian formation exposed in the assessment area, the Caseyville Formation, is composed dominantly of sandstone. The Caseyville crops out along the Lusk Creek Fault Zone and within the Dixon Springs and Rock Creek Grabens in the northwestern part of the area and in northernmost Hardin County. The next oldest Pennsylvanian unit, the Tradewater Formation, consists mostly of sandstone, but is also characterized by the presence of thin, widespread limestones and coals. The Tradewater crops out in the northwestern part of the assessment area in Pope County and in northeasternmost Hardin County. Cretaceous

Era		Period or System and Thickness	Epoch	Age (years ago)	General Types of Rocks
CENOZOIC "Recent Life"	Age of Mammals	Quaternary 0–500'	Holocene	10,000	Recent; alluvium in river valleys
			Pleistocene Glacial Age	1.8 m	Glacial till, glacial outwash, gravel, sand, silt, lake deposits of clay and silt, loess and sand dunes; covers nearly all of state except northwest corner and southern tip
		Tertiary 0–500'	Pliocene	5.3 m	Chert gravel, present in northern, southern, and western Illinois
			Eocene	33.7 m; 54.8 m	Mostly micaceous sand with some silt and clay; present only in southern Illinois
			Paleocene	65 m	Mostly clay, little sand; present only in southern Illinois
MESOZOIC "Middle Life"	Age of Reptiles	Cretaceous 0–300'		144 m; 290 m	Mostly sand, some thin beds of clay, and, locally, gravel; present only in southern and western Illinois
PALEOZOIC "Ancient Life"	Age of Amphibians and Early Plants	Pennsylvanian 0–3,000' ("Coal Measures")		323 m	Largely shale and sandstone with beds of coal, limestone, and clay
		Mississippian 0–3,500'		354 m	Black and gray shale at base, middle zone of thick limestone that grades to siltstone chert, and shale; upper zone of interbedded sandstone, shale, and limestone
	Age of Fishes	Devonian 0–1,500'		417 m	Thick limestone, minor sandstones, and shales; largely chert and cherty limestone in southern Illinois; black shale at top
	Age of Invertebrates	Silurian 0–1,000'		443 m	Principally dolomite and limestone
		Ordovician 500–2,000'		490 m	Largely dolomite and limestone but contains sandstone, shale, and siltstone formations
		Cambrian 1,500–3,000'		543 m	Chiefly sandstones with some dolomite and shale; exposed only in small areas in north-central Illinois
		Precambrian			Igneous and metamorphic rocks; known in Illinois only from deep wells

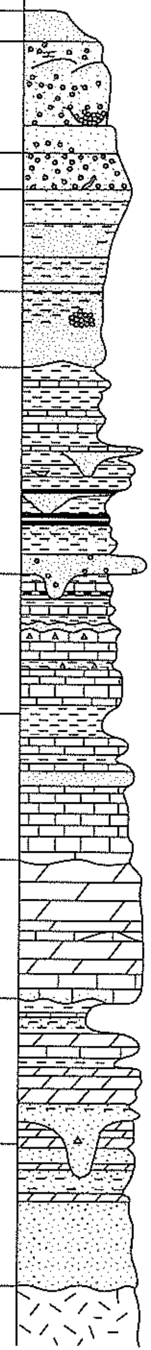

Figure 2. Generalized Stratigraphic Column for Illinois

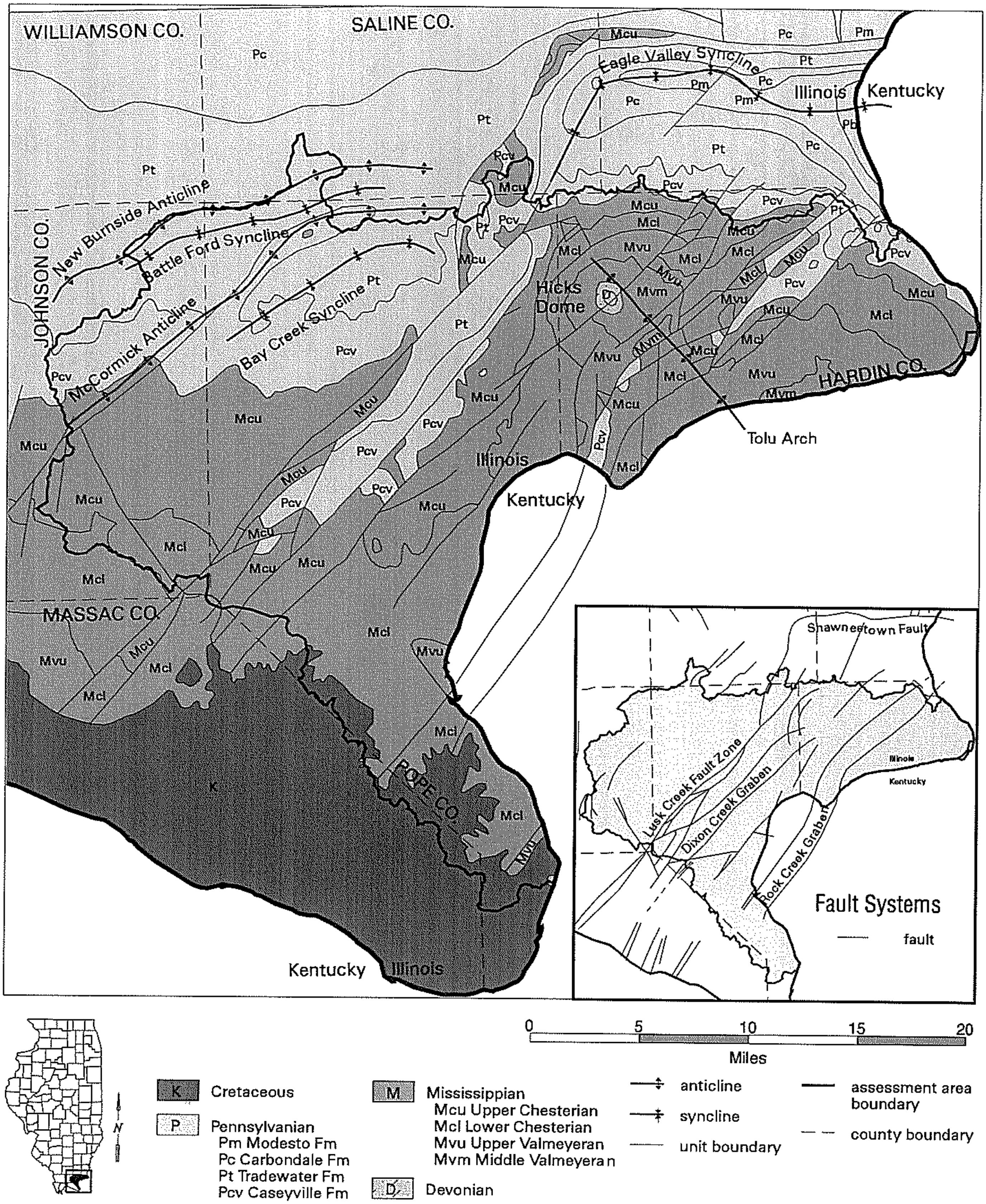

Figure 3. Bedrock Geology of the Shawnee Assessment Area (Willman et al. 1967 and Nelson 1995).

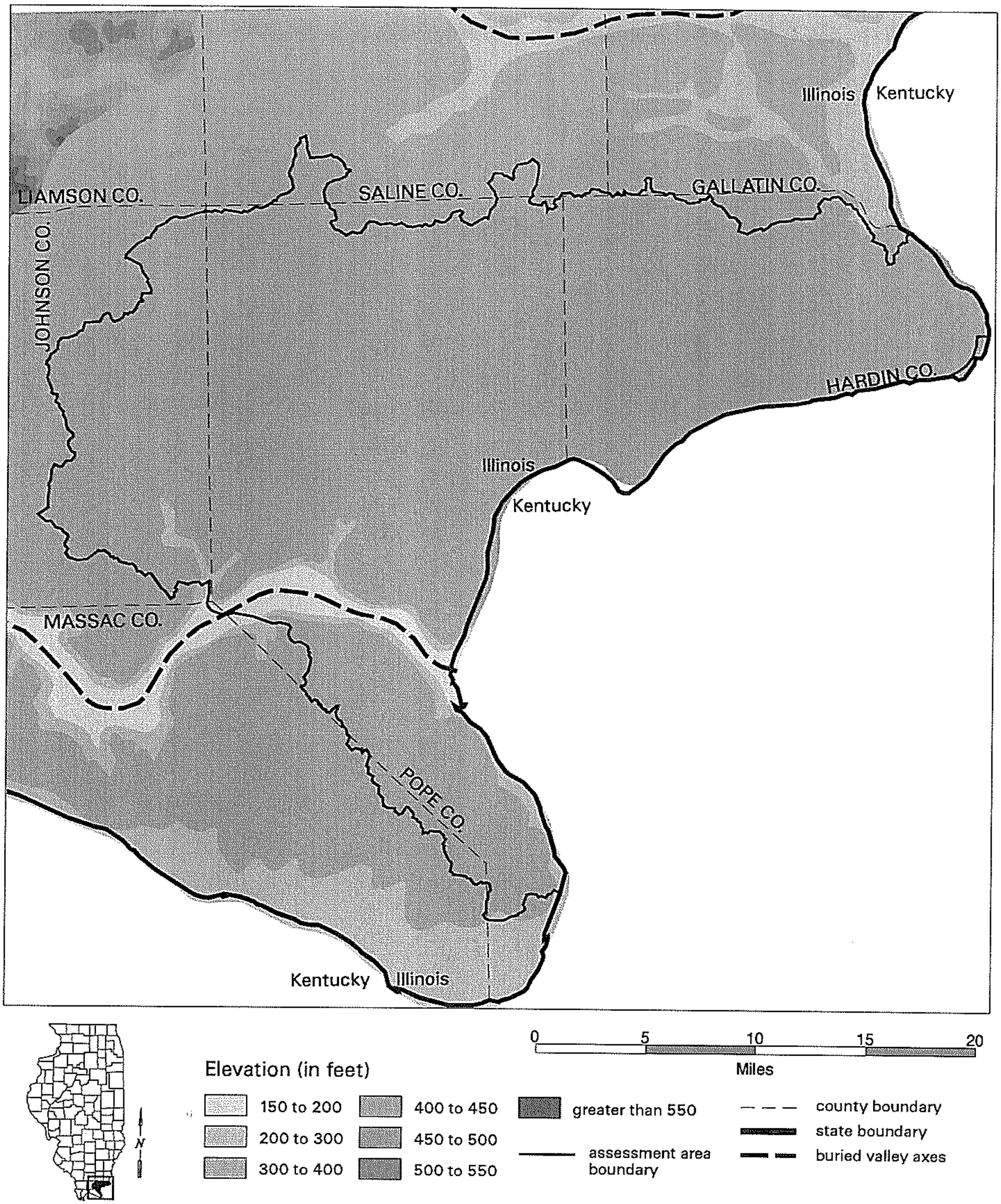

Figure 4. Bedrock Topography and Buried Valleys in the Shawnee Assessment Area (modified from Herzog and others 1994)

strata unconformably overlie Mississippian strata in the southern part of the assessment area, particularly along the border between Pope and Massac Counties. Cretaceous strata consist of poorly cemented sandstone along with silt, clay, and some thin, economically insignificant lignite beds.

Bedrock Topography

The topography of the top of the bedrock in the Shawnee Assessment Area is similar to the modern topography of the surface because most of the bedrock is either exposed or lies just below a relatively thin layer of Quaternary deposits (Figure 4). Most, if not all of the streams have eroded into bedrock. The Cache Valley (see section on Glacial and Surficial Geology), which traverses across the southern part of Pope County within the assessment area and continues westward through Massac County, eventually reaching the Mississippi River, is a buried, abandoned valley of the ancestral Ohio River (Horberg 1950). Within the assessment area, the valley is occupied by the lower part of Big Bay Creek, which flows eastward into the Ohio River. The Cache Valley is eroded into the bedrock and partially filled with significant amounts of Quaternary deposits (especially sand and gravel) that form an important, productive aquifer (Horberg 1945).

In areas where the bedrock comprises Mississippian rocks, karst topography has formed in many places (Weibel and Panno 1997). Karst consists of distinctive landforms and drainage patterns that are caused by the slow dissolution of limestone bedrock. Features that are typically found in karst include sinkholes, caves, and numerous springs. Relatively large interconnected conduits commonly occur in karst areas that allow rainwater and melted snow to infiltrate rapidly into and through the bedrock. The fractured, very permeable limestones present in karst areas commonly constitute locally important aquifers, but they are very susceptible to contamination from the surface.

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Willman, H.B., J.C. Frye, J.A. Simon, K.E. Clegg, C. Collinson, J.A. Lineback, and T.C. Buschbach, 1967, Geologic Map of Illinois: Illinois State Geological Survey, 1:500,000 scale.

Glacial and Surficial Geology

During the Pleistocene Epoch, or Great Ice Age, the continental glaciers advanced to within about five miles northwest of the Shawnee Assessment Area but not within the assessment area itself. Nevertheless, the influence of the glaciers reached well beyond the ice margin. This influence can be seen today both in the comparatively thin blanket of sediments that covers the bedrock in much of the area and also in the parts of the landscape that were modified by the meltwaters that flowed from the glaciers.

Description of Materials

In the assessment area, surficial sediments, the sediments that overlie the bedrock, fall into several categories: non-glacial chert gravels; glacially derived outwash, lacustrine (lake) deposits, and loess (windblown silt); and largely post-glacial alluvium (stream or river deposits). Collectively, the glacially derived sediments are called glacial drift. Knowledge about all of the surficial deposits is especially important because they strongly influence land use choices, ecosystem development, geologic processes that can affect ecosystems (see Modern Soils and the Landscape— Influences on Habitats and Agriculture section), and the effects of geologic hazards (Killey 1998).

Bedrock lies either at or very near the land surface in the Shawnee Assessment Area. Therefore, much of the area is mapped as non-Quaternary ("nq" in Figure 5). "Quaternary" is the term geologists use to refer both to the time period from the start of the Ice Age to the present and to the sediments that were deposited during that time. Although Quaternary sediments are present in much of the area, they are so thin that they have not altered the topography, which is determined largely by the shape of the bedrock surface.

The oldest surficial deposit in the area is a non-glacially derived deposit of brown chert pebbles, some quartz pebbles, and sand, called the Mounds Gravel ("mg" on Figure 5) by geologists. The Mounds is composed of moderately to well-rounded pebbles of chert, nearly all of which are coated and stained with brown iron oxide, and small amounts of red-colored sand. The Mounds Gravel seems to have been deposited on a series of river terraces, and the source of the pebbles is generally regarded to be the Tennessee River valley (Willman and Frye (1970). Although it forms a nearly continuous deposit across the uplands south of the buried Cache valley, the Mounds is recognized only from scattered pebbles to the north of the valley. The Mounds Gravel has been mined in a few areas for local use in construction, but the abundant chert makes the Mounds unsuitable for use as an aggregate in concrete.

Although the glaciers did not reach the assessment area, within about five miles to the northwest, sediments deposited directly by glaciers have been mapped as the Vandalia Till Member of the Glasford Formation ("gv" on Figure 5). Till is composed of a compact mixture of clay, silt, and sand particles that form a matrix that surrounds and supports larger grains, such as pebbles, cobbles, and boulders. The Vandalia Till represents the deposits laid down during the farthest glacial advance southward of all the glaciers to enter Illinois. The Vandalia was deposited during the Illinois Episode (Hansel and Johnson 1996) of the Pleistocene Epoch.

Another kind of sand and gravel deposit in the area is called outwash because it literally "washed out" from glacial ice in meltwater streams. The rock types represented in outwash are more variable than in the Mounds Gravel because of the great variety of terrain traversed by the glaciers from their origin in Canada. Outwash is also a potential resource for construction sand and gravel. These sand and gravel deposits are also porous and permeable and, when thick enough, can serve as excellent aquifers (see Aquifer Delineation section). Outwash occurs primarily in the Cache Valley and along the floodplain of the Ohio River near the southernmost tip of the assessment area. It is mapped as Henry Formation, Mackinaw facies ("hm"on Figure 5; Willman and Frye 1970).

A second glacially derived type of deposit is lacustrine (lake) sediments, which are silts and clays that settled at the bottoms of temporary lakes that often formed as glacial meltwater was dammed in valleys along the margin of the ice or backed up into tributary valleys when great surges of meltwater from melting glaciers to the north and northeast filled the main river valleys. Lacustrine sediments are often poorly drained and may cause water problems in construction projects. They are mapped as Equality Formation ("eq"; Willman and Frye 1970).

Indirectly derived from glaciers is windblown silt, or loess, which is of late glacial and post-glacial age. Loess blankets most of the Shawnee Assessment Area, and its importance lies in those properties that make it an excellent parent material for soils. Its origin is the floodplain sediments along the major meltwater valleys, such as the Mississippi, Ohio, and Wabash River valleys, which served as major meltwater outlets for melting glaciers to the north and northeast. Prevailing westerly winds picked up the finer sediments—silt, fine sand, and some clay—from the floodplain and blew them across the landscape. The loess actually consists of two units: the upper tan-brown Peoria Silt and the lower pinkish tan Roxana Silt (Willman and Frye 1970; Hansel and Johnson 1996). Because the two units share similar characteristics, such as the dominant silt size of its grains, they are generally mapped together as one unit ("prs" on Figure 5).

Bedded silts, clays, and sand and gravel deposited in floodplains and channels of modern streams and rivers are mapped as Cahokia Alluvium ("ca" on Figure 5; Willman and Frye 1970).

Regional Preglacial and Glacial History

Hundreds of records (logs) and samples of sediments are available from borings drilled throughout the assessment area. These logs and samples are stored and catalogued at mixture of clay, silt, and sand particles that form a matrix that surrounds and supports larger grains, such as pebbles, cobbles, and boulders. The Vandalia Till represents the deposits laid down during the farthest glacial advance southward of all the glaciers to enter Illinois. The Vandalia was deposited during the Illinois Episode (Hansel and Johnson 1996) of the Pleistocene Epoch.

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Regional Preglacial and Glacial History

Hundreds of records (logs) and samples of sediments are available from borings drilled throughout the assessment area. These logs and samples are stored and catalogued at the Illinois State Geological Survey. In much of the Shawnee Assessment Area, where bedrock is either exposed or covered with only a thin veneer of sediment, much of the preglacial and glacial history of the area can be deduced directly from examination of the sediments and rock at the land surface and from the landforms that can be seen in the assessment area.

The major rivers draining southern Illinois and adjacent regions were established before the beginning of the Pleistocene Epoch but flowed along somewhat different courses than they do now. Three river systems that existed in or near the assessment area were the ancient Ohio River, the ancient Cumberland River, and the ancient Tennessee River. The present-day Cache Valley, a prominent landscape feature that extends across the assessment area in Pope County and continues westward across southern Illinois, is an abandoned segment of the trunk portion of one of these major drainage systems (Reinertsen and others 1994). Geologists think that the Mounds Gravel is derived largely from the Tennessee Valley (Willman and Frye 1970) because it lacks the characteristic mineralogy of glacial outwash. The Mounds Gravel has been related to three terrace levels cut by the ancient river systems, but the interpretations and the exact drainage history are not precisely known. However, because the ancient Mississippi and Ohio Rivers drained all of the area eventually covered by glaciers from the Appalachian to the Rocky Mountains, the glaciers certainly had a profound influence on the history of these streams.

During the Ice Age's next-to-last major episode of glaciation, called the Illinois Episode (Figure 6), glaciers extended to within five miles of the assessment area. The drift left behind by this ice advance consists mostly of till and is mostly less than 25 feet thick, thickening only slightly toward the northwest to between 25 and 50 feet.

Although the last glaciers to enter Illinois (Wisconsin Episode glaciers; Figure 6) advanced only as far south as Shelbyville, their meltwaters strongly influenced the drainage of southeastern Illinois. Outwash carried by meltwaters draining down the Wabash River Valley aggraded (filled) the valley to the point that heavy surges of meltwater backed up into valleys tributary to the Wabash and formed slackwater lakes of sufficient duration that up to 20 feet of silts and clays settled to the bottoms of these temporary lakes. The extensive lake, called Glacial Lake Saline, that existed just to the north of the assessment area extended a short distance into the eastern part of the assessment area in both Pope and Hardin Counties (Figure 5; Frye and others 1972).

Loess was deposited during and after both the Illinois and Wisconsin Episodes of glaciation. Over much of the assessment area, the loess is less than 10 feet thick, and variability is considerable along the valley slopes in the area. The loess thickens to 15 feet or more near the Ohio River in easternmost Hardin County and is close to 10 feet thick in the southern part of the assessment area, as shown by the 10-foot contour lines in Figure 5.

Bedded silts, clays, and sand and gravel deposited in floodplains and channels of modern streams and rivers are mapped as Cahokia Alluvium ("ca" on Figure 5; Willman and Frye 1970).

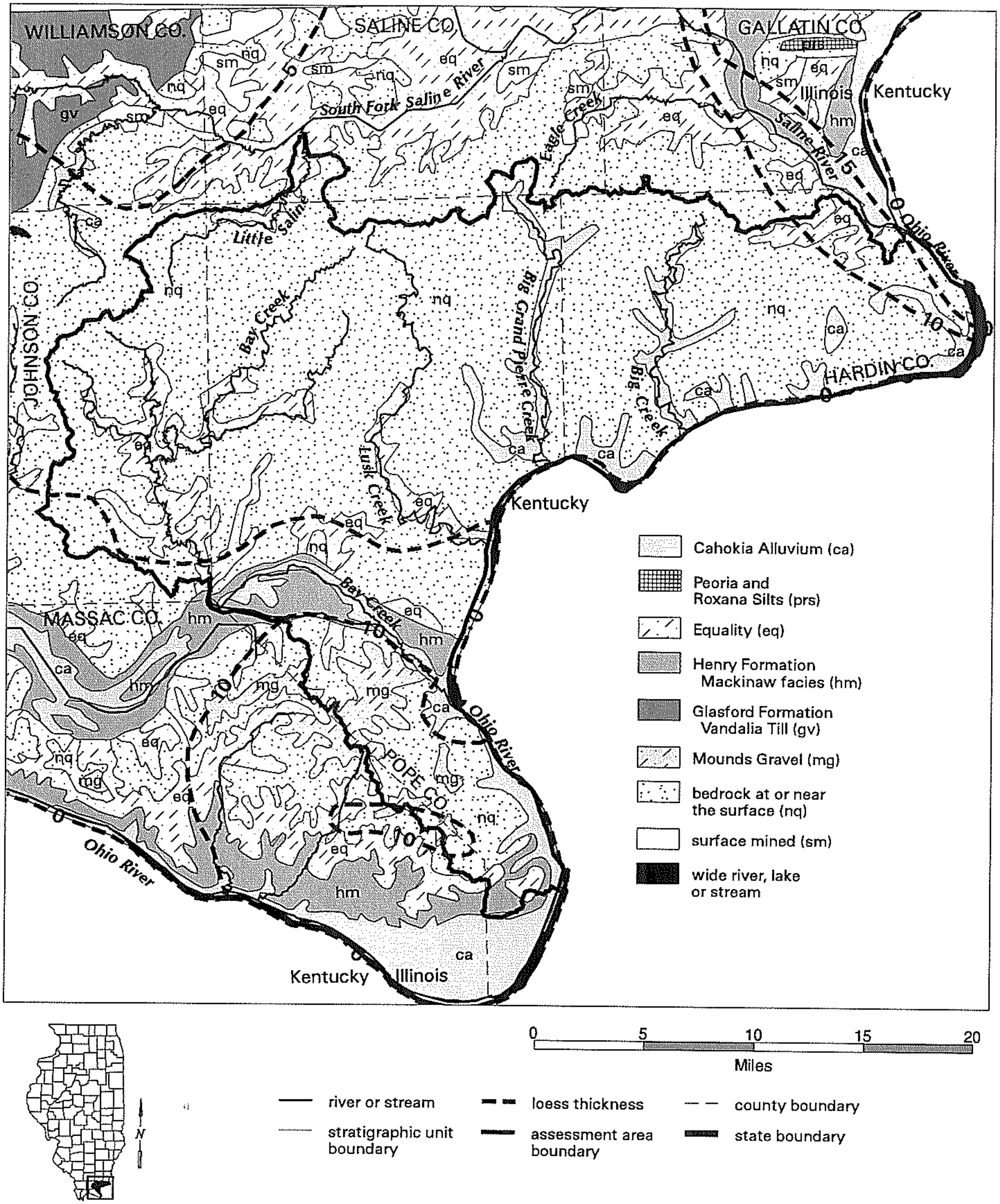

Figure 5. Surficial Deposits in the Shawnee Assessment Area

Years before present	Time-distance diagram of interglacial and glacial episodes	Sediment record	Dominant climate conditions dominant land-forming and soil-forming events
HOLO-CENE	interglacial episode	River, lake, wind, and slope deposits.	Warm; stable landscape conditions. Formation of modern soil; running water, lake, wind, and slope processes.
10,000	WISCONSIN (late) glacial episode; glacial ice	Till and ice-marginal deposits; outwash and glacial lake deposits; loess.	Cold; unstable landscape conditions. Glacial deposition, erosion, and landforming processes (e.g., formation of end moraines, outwash plains, valley trains, proglacial lakes, kettles), plus running water, lake, wind, and slope processes.
25,000	WISCONSIN (early and middle) glacial margin north of Illinois	Loess; river, lake, and slope deposits.	Cool; stable. Weathering, soil formation (Farmdale Soil and minor soils); wind and running water processes.
75,000	SANGAMON interglacial episode	River, lake, wind, and slope deposits.	Warm; stable. Weathering, soil formation (Sangamon Soil); running water, lake, wind, and slope processes.
125,000	ILLINOIS glacial episode	Till and ice-marginal deposits; outwash and glacial lake deposits; loess.	Cold; unstable. Glacial deposition, erosion, and land-forming processes, plus proglacial running water, lake, wind, and slope processes; possible minor soil formation.
300,000	YARMOUTH interglacial episode	River, lake, wind, and slope deposits.	Warm; stable. Long weathering interval with deep soil formation (Yarmouth Soil); running water, lake, wind, and slope processes.
425,000 – 1,800,000 and older	? PRE-ILLINOIS glacial and interglacial episodes ?	Till and ice-marginal deposits; outwash and glacial lake deposits; loess plus nonglacial river, lake, wind, and slope deposits.	Alternating stable and unstable intervals of uncertain duration. Glacial deposition, erosion, and land-forming processes, plus proglacial and interglacial running water, lake, wind, and slope processes; interglacial weathering and soil formation.

PLEISTOCENE EPOCH (not to scale)

Figure 6. Timetable of Events during the Ice Age in Illinois (Killey 1998)

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Modern Soils and the Landscape—Influences on Habitat and Agriculture

The Shawnee Assessment Area encompasses the southeasternmost part of the state, covering most of Hardin and Pope Counties and eastern Johnson County. It lies entirely outside the boundary of direct contact with glacial ice. The influence of geologic and topographic factors on soil development and habitat are discussed here. Geology, topography, and soil types combine to produce different types of habitats that are conducive to the development and survival of various natural plant and animal communities.

Geologic Factors

Loess, alluvium, lacustrine sediments, and bedrock are the dominant parent materials of the soils in this assessment area. These materials differ significantly in their permeability, erodibility, and physical and chemical characteristics. By affecting water table elevation, erosion, sedimentation, drainage development, and water chemistry, these differences create localized habitats. Soil texture, acidity, and other physical and chemical characteristics are very important in determining land use and land cover.

Windblown silt (loess) is the initial (uppermost) parent material for at least 80% of the soils in the Shawnee Assessment Area. The overall thickness and continuity of loess, in which modern soils have developed, vary considerably across the Shawnee Assessment Area. Also affecting soil development are the materials underlying the loess, which are especially important in this assessment area because of the influence these materials have on drainage, agricultural productivity, and erosion. Loess is thickest (10 to 15 feet) near the Ohio River bluffs but thins to about 1 to 5 feet over most of the assessment area. Sandy, silty, clayey, and gravelly alluvial sediments are found along the larger floodplains and may be more than 180 feet thick in places. Scattered areas of silty former lake (lacustrine) sediments occur along the Cache River and some smaller tributaries. Cherty limestone, sandstone, and shale bedrock occur at or near land surface in many areas.

Topographic Factors

Topographic influences (Figure 7) on drainage, erosion, and deposition are important to the long-term development of the landscape. Differences in the frequency, rate, and magnitude of surficial geologic processes have created many combinations of slope angle, slope length, and slope orientation that influence local drainage, erosion, and sedimentation. Modifications by human activities are also creating significant changes in surficial processes (discussed in Soil Erosion and Sedimentation).

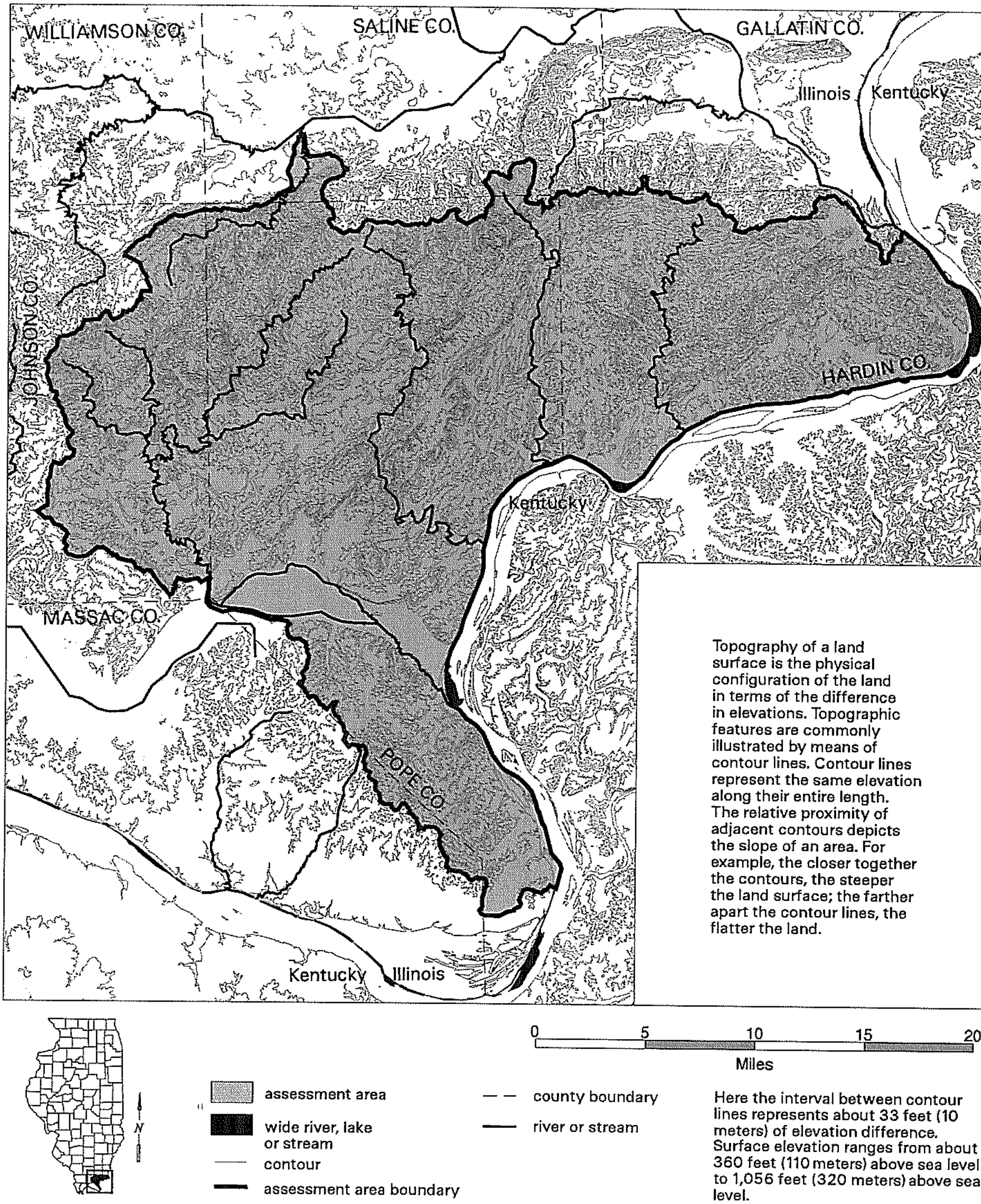

Figure 7. Topography of the Land Surface in the Shawnee Assessment Area

The upland areas between tributary drainages are commonly level and poorly to somewhat poorly drained. Generally, farmland is located in these areas, as shown by Figure 11. Downstream portions of each subbasin, however, commonly have greater amounts of pasture and forest cover because of a more rolling terrain. This increase demonstrates the effect topography and soil erosion have on land use. The Quaternary geology (Figure 5) and topography (Figure 7) maps of the Shawnee Assessment Area illustrate how soil development, vegetative cover, and land use are affected by these factors.

Soil Classification

The soils in the Shawnee Assessment Area are classified predominantly into the Alfisol soil order. Alfisols and Mollisols generally dominate most of Illinois and can be differentiated by the accumulation of organic matter in the upper soil horizon: Mollisols are rich in organic matter and have a darker soil color (black to dark brown). Alfisols are not as organic rich and have thinner upper soil horizons. In general, Mollisols have developed under natural prairie or marsh vegetation, whereas Alfisols have developed under forest vegetation. The climate of southern Illinois has favored the development of Alfisols. Poorly and very poorly drained Mollisols and Alfisols are common along drainages, floodplains, and flat upland areas and can be important in the development and maintenance of localized habitats.

Entisols and Inceptisols occur on floodplains and sandy outwash areas and along steeper, eroded uplands. Entisols and Inceptisols are soils with minimal soil horizon development. They occupy small total acreages in the area but are still significant because they help create niche communities (for example, where exceptionally sandy sediments exist).

Only seven soil associations are found in the Shawnee Assessment Area (Figure 8). The ubiquitous loess has provided relatively uniform parent materials, and the topography, associated with stream incision, has controlled the pattern of erosion and areas where bedrock occurs at land surface. The most widespread associations are the Grantsburg-Zanesville-Wellston and Hosmer-Zanesville-Belknap. These soils are affected by the presence of a subsurface soil horizon (fragipan) that is dense and brittle and can severely affect drainage and permeability and limit the usefulness of the soil for both agricultural and urban land use such as septic fields. The Goss-Alford-Baxter association is found where thin loess overlies cherty limestone bedrock along the Ohio River in Hardin County. The floodplain associations, which include the Beaucoup-Lawson-Darwin, Emma-Sexton-Martinsville, and Bonnie-Belknap-Piopolis, comprise soils formed in sediments ranging from clay to gravel in texture, depending on their depositional history. Floodplains exhibit a wide range of landforms and soil parent materials, including point bar deposits composed of sand and gravel, and ridge and swale topography where clays and silts alternate with sand. Variations in drainage and the variety of geologic parent materials help create a large number of biological habitats in floodplain areas.

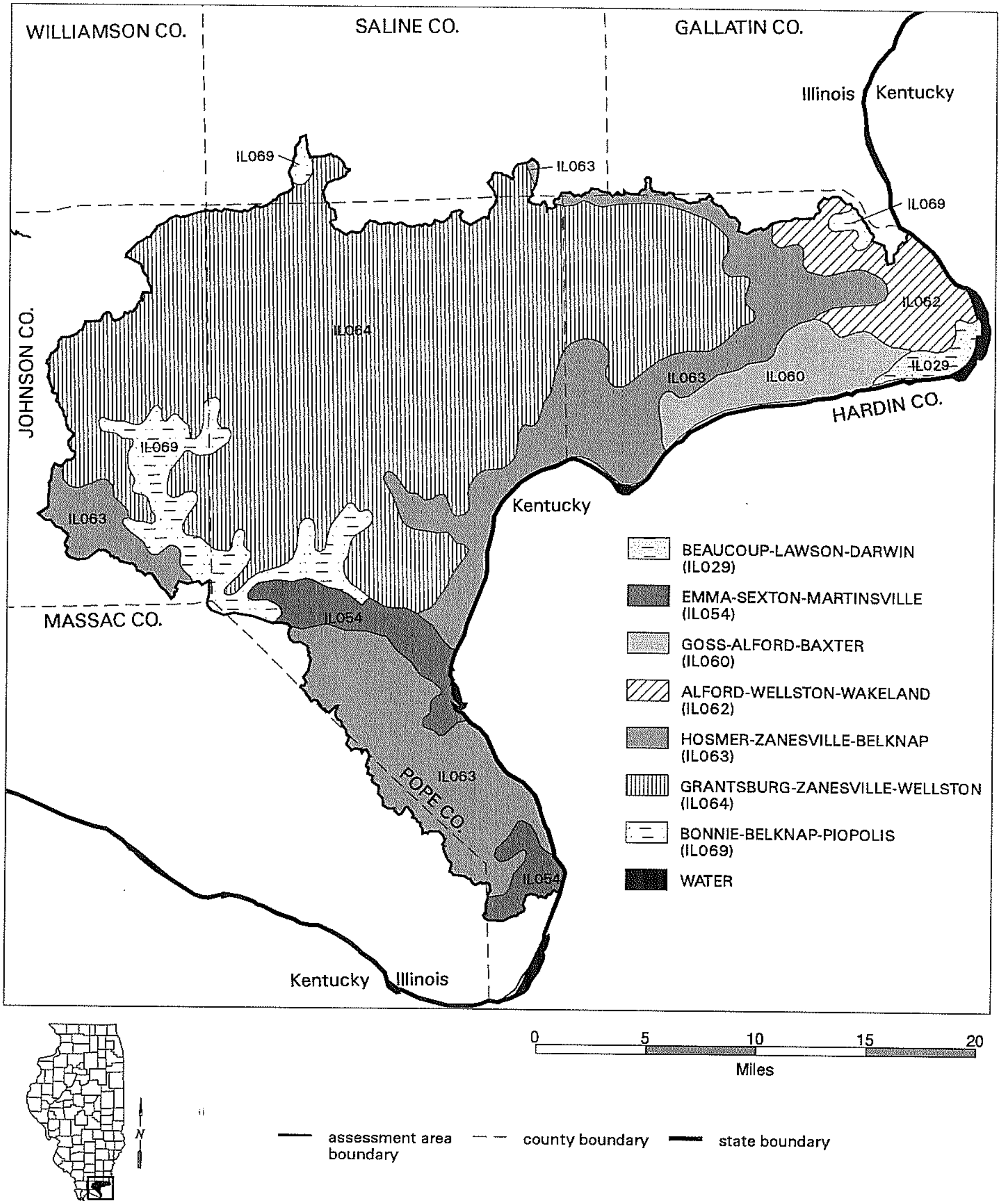

Figure 8. Soil Associations in the Shawnee Assessment Area

In general, soils classified within the same soil association behave similarly and can be treated as a single unit for general planning purposes. Differences in drainage class are the main reason for differences in soil characteristics on a local scale.

Soil Erosion and Sedimentation

In areas where slopes of less than 5% (5 vertical feet in 100 horizontal feet) predominate, the potential for soil erosion is generally low. The general lack of drainage dissection in parts of the flat upland and floodplain areas, however, combined with the slow permeability of the relatively fine-textured underlying sediments, makes high water tables, wet soils, severe stream and channel erosion, and sedimentation in streams and lakes a problem across the area. Flat upland and floodplain areas may be prime wildlife and wetland areas if they have not been cleared for cultivation or urban development.

The steeper slopes adjoining the floodplains of streams commonly are susceptible to severe soil erosion through sheetwash and the development of extensive gully networks. This eroded sediment generally is transported into small local channels and, ultimately, into the larger drainages. Uncontrolled erosion and sedimentation can seriously damage biologic communities that live in the channels or along stream banks by altering water tables, channel capacity, and channel geometry.

The distribution and thickness of loess across the assessment area further contribute to the erosion hazard. Loess is easily picked up (entrained) and carried by moving water or wind. When dry, loess has the consistency of talcum powder and, if unprotected, is easily transported by wind. Because of its low shear resistance, loess is also especially susceptible to erosion by running water. Flowing water incises rapidly into loess, developing a deeply dissected landscape characterized by numerous rills and gullies that are difficult to control. On topographic maps, this characteristic drainage pattern is shown by highly crenulated (sinuous) topographic contour lines (see Figure 7). Where loess overlies less permeable geologic materials such as weathered bedrock, the contrast in permeability and erodibility creates problems in land management, especially where the overlying loess unit is dissected or eroded and the less permeable underlying materials are exposed at or near the land surface.

Further increasing the erodibility of loess is the tendency for "pipes" to develop within the soil. Pipes can form where surface water penetrates to the subsurface and flows along macropores in the soil, such as open tube-shaped channels formerly occupied by roots or other natural fractures in the ground. These linear pipes may enlarge and ultimately collapse, causing the ground surface to subside and leaving small surface drainage channels. These newly formed surface channels then begin to collect and transport sediment and water as they are integrated into the local drainage system.

Areas with sloping, forested soils are especially susceptible to piping and are where hillside gullies commonly begin, even if the ground surface has not been disturbed by deforestation or cultivation. Once begun, these small rills and gullies can quickly enlarge, eroding upstream (headward), extending the drainage network and directing increased water and sediment into the existing drainage system. The increased water and sediment discharge can cause stream bank erosion and streambed changes that are detrimental to the biologic communities that inhabit the stream channels.

The widespread areas of grassland and forested land cover in the Shawnee Assessment Area generally indicate the difficulty of cultivating the steep, highly dissected landscape in the area. These grassland and forested areas contribute to the existing prime wildlife habitat in the region. Most of the eroded soils in the assessment area are located on slopes adjacent to stream channels, especially along the larger tributaries and in bluff areas near the Ohio River. The increase in slope angle and slope length in these areas creates a high potential for erosion.

Because of their low position in the landscape, wetland areas commonly receive much of the sediment eroded from adjacent upland areas that have been or are currently in cultivation or are in transition from undisturbed natural vegetation. This inundation of sediment can degrade wildlife food supplies and fill stream channels, decreasing their capacity to transport water and increasing the frequency of discharges of floodwater over the banks of streams. Pools along streams are especially prone to damage from sedimentation. Pesticides and other agricultural chemicals adsorbed to the sediment may also be deposited in channels and pools.

In some instances the sediment eroded from the uplands has accumulated quickly enough to bury part of the modern soil. Buried modern soils can be seen in some vertical soil profiles exposed along stream courses where a dark-colored former soil horizon lies beneath recently deposited, lighter-colored sediments. Such buried modern soils are evidence of accelerated erosion resulting from human activity and are environmental indicators of current and potential problems in a drainage system.

Land Management Practices

Sound land use and management practices are especially important in controlling erosion on loessial soils. Damaged land should be remediated quickly and appropriate erosion control measures implemented to prevent additional damage to the landscape. It is unlikely that severe erosion caused by gullying on hillslopes would repair itself quickly enough to prevent extensive damage to adjacent land. Gullies that develop in loess can quickly become too deep for farm equipment to cross and eliminate through tillage. Farming along narrow ridge tops is generally not advisable because of the absence of transition zones along field edges to keep water from running off the field and entering hillside drainage channels.

The moderately slow permeability of many of the soils in the assessment area creates conditions conducive to flooding and standing water during periods of high water table or heavy precipitation. Some of the soils in the assessment area respond well to tiling, and field drainage has increased the volume and rate of runoff from cultivated fields. The increased stream discharge that results from tiling, however, is less significant than drainage alterations associated with urbanization or other land-clearing activities. Rapid and high-volume runoff associated with water management may divert large volumes of water into drainages, causing extensive erosion problems through channel widening and bank failure along many areas. Lowland areas that once contained wetlands have been drained or have altered natural drainage have changed the wetland hydrology. Efforts to restore and protect isolated wetlands should be a major priority in this assessment area. Eroded areas that have had the overlying silt layer removed need to be addressed for revegetation to occur because it is unlikely these areas will be able to recover without some organized conservation and restoration program. The exposed sediments will be too difficult to vegetate naturally because of the altered soil climate and potential for erosion. Conservation practices such an contour plowing, minimum tillage, and other management practices are needed to help conserve soil moisture and tilth. The presence of a fragipan in many of the soils hampers soil drainage and runoff.

In summary, the potential for water erosion and the slow permeability of soil are the major management problems faced by land users in this area. The many potential problems created by the predominance of silty and clayey soil and variable topography can be alleviated by appropriate conservation practices and through the application of watershed-wide water management planning.

County Soil Survey Reports

The Shawnee Assessment Area incorporates most or parts of six counties. Modern soil survey reports are available for all of the involved counties. Many county soil survey reports are being updated and converted to digital format. Although this process will take some years to complete, interested individuals and groups should check with their local Natural Resources Conservation Service (NRCS) agent to learn what materials and information are available for their specific location. Digital soil surveys are in progress for Hardin, Pope, and Massac Counties and are being recompiled for Johnson County. The information from the digital survey is available to interested individuals by contacting the NRCS office in that county. Using the appropriate software, these digital products can provide increased versatility in applying soil characteristics in environmental planning. As always, individuals or groups seeking to plan environmental restoration or conservation projects should contact local federal, state, and county offices to determine the nature of the soils and consult other appropriate environmental databases.

The maps presented in this assessment report are too small in scale (not detailed enough) to provide for more than a cursory or reconnaissance level of interpretation and are only for general planning and information purposes. The individual soil maps presented in each county soil survey report are published at a scale of 1:15,840, or 1 inch on the map represents 1,320 feet (0.25 miles) on the ground. A smaller-scale soil association map is also included, typically at a scale of about 1:250,000, or 1 inch represents about 4 miles.

The scale of the soil association map is too small (contains too little detail) for site-specific planning and analysis, but the individual soil sheets are ideal for this purpose. Even these maps, however, lack the detail necessary for specific site assessments for construction, but they are valuable for most environmental-scale planning.

The large-scale soil maps in county soil survey reports are valuable sources of information about local conditions. Tabulated information within the report summarizes the capabilities and limitations of each soil series for various land uses as well as their physical and chemical characteristics. There are also tables with information concerning the suitability and capability of soils for supporting wildlife and woodland habitats.

In addition, the source materials used to produce this assessment area report generally are much more detailed than the information ultimately presented. Maps of a larger scale are used to assess the soil, geology, topography, drainage, and other landscape components. These maps may be of value to individuals and groups seeking information to support watershed activities. The Illinois State Geological Survey should be contacted for additional information and assistance.

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Landscape Features and Natural Areas with Geologic Features of Interest

Landscape Features

The landscape features of the Shawnee Assessment Area were formed primarily by erosional processes during the long stretch of geologic time between the deposition, lithification, and uplift of the sedimentary rocks that constitute the bedrock of the area and the effects of glaciation that took place to the north during the Great Ice Age. The assessment area is situated almost entirely within the Shawnee Hills Section of the Interior Low Plateaus Province (Figure 9; Leighton and others 1948). The Shawnee Hills Section is mostly a complexly dissected upland characterized by deep stream valleys that expose the bedrock in the valley walls. The small part of the assessment area that projects into Saline County along the Little Saline River crosses the physiographic boundary into the Mt. Vernon Hill Country of the Till Plains Section. The Mt. Vernon Hill Country comprises the southern part of the area that was covered by glacial ice during the Illinois Episode; it is characterized by topography of low relief. Landforms caused by glacial action are almost entirely absent, but a thin cover of Illinois Episode sediment overlies the bedrock surface.

Natural Areas with Geologic Features of Interest

According to available records maintained by the Illinois Natural History Survey (Illinois Natural Areas Inventory 1978), a total of 30 natural areas in or near the Shawnee Assessment Area contain features of geologic interest. One is in Gallatin County, 11 are in Hardin County, 1 is in Johnson County, 15 are in Pope County, and 2 are in Saline County. None is located in the tiny part of Gallatin County that lies within the assessment area. The names of these natural areas, the features of interest, and the type of ownership are listed in Table 1.

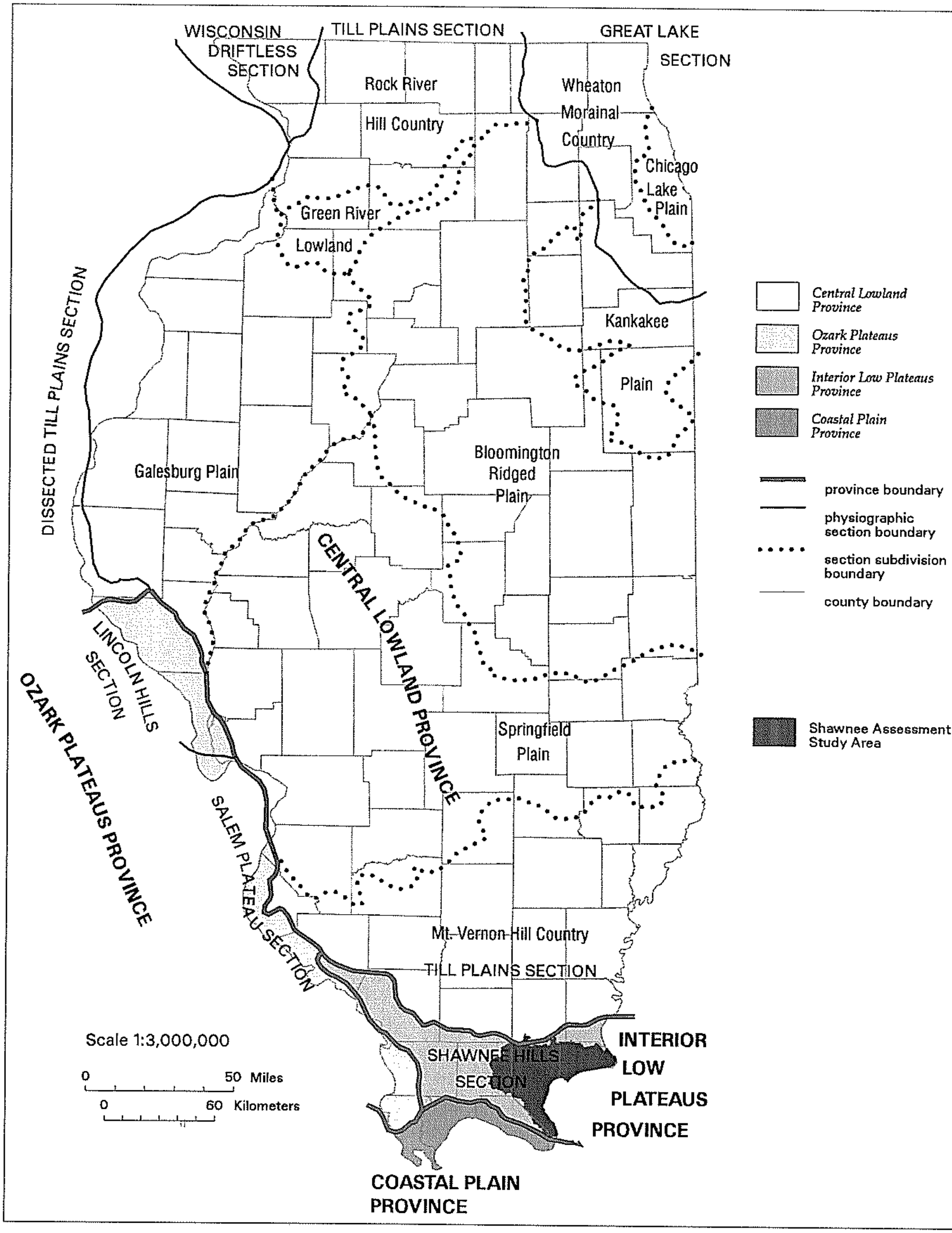

Figure 9. Physiographic Divisions of Illinois (from Leighton and others 1948)

Table 1. Natural areas with geologic features of interest, listed by county

Natural area name	*Description of geologic feature*	*Ownership type*
	Gallatin County	
Pounds Hollow	Sandstone cliff; exposure of the Caseyville and Tradewater Formations	Private and public
	Hardin County	
Collier Limestone Glade	Limestone exposure above glade	Private
Melcher Hill Limestone Glade	Limestone outcrop	Private
Orr's Landing Geological Area	Exposure of a dike of igneous rock	Private
Frailey's Landing Geological Area	Exposure of the Golconda Group (type section of the Frailey's Shale)	Private
Hicks Dome Plug Geological Area	Exposure of an explosion of breccia	Private
Hicks Geological Area	Exposure of the tilted rocks in the Hicks Dome structure	Private
Russell Cemetery area	Sandstone outcrop	Private
Layoff Cave	Cave	Private
Brown's Hole Cave	Cave	Public
Griffith Cave	Cave	Private
Panther Hollow	Sandstone cliff	Public
	Johnson County	
Split Rock Hollow	Sandstone cliff	Public
	Pope County	
Reddick Hollow	Sandstone outcrop	Public
Werner Tract	Sinkholes	Private
Little Grand Pierre South Glade	Limestone outcrops	Private
Abbott Geological Area	Exposure of breccia in Caseyville Formation (type section)	Private
Leisure City Glade	Limestone outcrop	Private and public
Lusk Creek North	Sandstone cliff	Public
Old Zion Cemetery Geological Area	Exposure of thrust fault	Private
Frieze Cave	Cave	Private and public
Jackson Hollow	Sandstone cliffs and overhangs	Public
Pine Hollow	Sandstone cliff along a fault	Private and public
Sand Cave	Sandstone cliff and overhang	Private and public
Gyp Williams Hollow	Sandstone cliff	Private and public
Bell Smith Springs	Sandstone natural bridge, sandstone chute and gorge, sandstone cliff and overhang	Private and public
Lusk Creek Canyon	Sandstone gorge, sandstone cliffs	Public
	Saline County	
Garden of the Gods	Caseyville Sandstone cliff and erosion of the cliff into unusual shapes	Public
Wamble Mountain	Limestone outcrop; sandstone outcrop	Private

References

Illinois Natural Areas Inventory, 1978: Department of Landscape Architecture, University of Illinois at Urbana-Champaign, and Natural Land Institute, Rockford, Illinois, 3 volumes.

Leighton, M.M., G.E. Ekblaw, and L. Horberg, 1948, Physiographic Divisions of Illinois: Illinois State Geological Survey, Reports of Investigations 129, 19 p.

Part 2: Geology and Society

Most of us live, work, and play on the surface of the Earth. But what we often fail to recognize is that beneath the office building or factory where we work, beneath the home where we live, or beneath the park where we play is a framework of geologic materials and a series of ongoing, interlinked processes that support our lives on the surface. The geologic materials supply the mineral resources that are the raw ingredients of most of the manufactured materials that furnish our homes, offices, and playgrounds; the geologic framework also provides the water that flows freely from the faucets that we turn on and off daily. At the same time, contamination of water resources, slumping of embankments along our roadways, or damage from earthquakes are hazards that we don't think about until they happen—let alone realize that the geologic framework and the interlinked natural processes control why and where these hazards occur.

The interrelationships between geology and human society are so intimate and intricate that they are easily ignored and little understood by most people. Nevertheless, to understand and wisely use the natural heritage we value, we must consider the geologic factors that affect our daily lives. Some of the most important ways that geologic materials (resources) and geologic processes affect modern society are discussed in this part.

Mineral Resources

Mineral commodities and fossil fuels are important foundations of a modern industrialized society. Fluorite, lead, zinc, crushed limestone, and sandstone have been or are currently being mined in the Shawnee Assessment Area. Until recently, mineral mining and processing were major contributors to the economic vitality of the region.

Fluorite, Lead, and Zinc

Production of the mineral fluorite (calcium fluoride, CaF_2) was first recorded in southeastern Illinois as early as 1842 and continued in Hardin and Pope Counties until the last mine closed in December 1995. Illinois once produced more fluorite than any other state, and the mineral remains the official state mineral. The mineral is used as a flux in the smelting of steel and aluminum, in the manufacture of glass, and as the source of the element fluorine, which is essential in the manufacture of many chemicals, especially refrigerants (Gillson and others 1960). All U.S. needs for fluorite are now met by imports from China, Mexico, and elsewhere.

Galena (the ore of lead) and sphalerite (the ore of zinc) were the main targets of the first miners in southeastern Illinois, and the abundant fluorite that came out of the mines with these ores was mostly discarded as waste material (called "gangue"). Once fluorite's many uses were discovered in the late nineteenth century and later, fluorite became the primary target of the miners and the comparatively small amounts of galena, sphalerite, and barite (a barium ore) quickly became by-products that provided added revenue for the fluorite mines and mills in the area. From mills and concentrating plants at Rosiclare, Elizabethtown, and Cave-in-Rock on the banks of the Ohio River, barges hauled fluorite up and down the waterways to the steel mills near Pittsburgh and Gary, chemical plants near Baton Rouge, and the glass factories near Ottawa, Illinois.

In the mid-1960s, when production was still strong, three major companies operated 17 mines and 5 ore-processing plants in the assessment area, and there were three small companies operating independent mines that sold their production to the bigger mills (Bradbury and others 1968). Figure 10 shows the areas in Hardin and Pope Counties where the fluorite ore bodies and the mines were most heavily concentrated. Although fluorite ores undoubtedly remain in the area, new mines probably will not be opened unless there is a major disruption in U.S. access to the supply of low-cost fluorite from other countries.

Limestone and Sandstone

Table 2 lists the five limestone quarries and one sandstone quarry known to be operating in the area as of 1997, and Figure 10 shows their locations. Data on production and

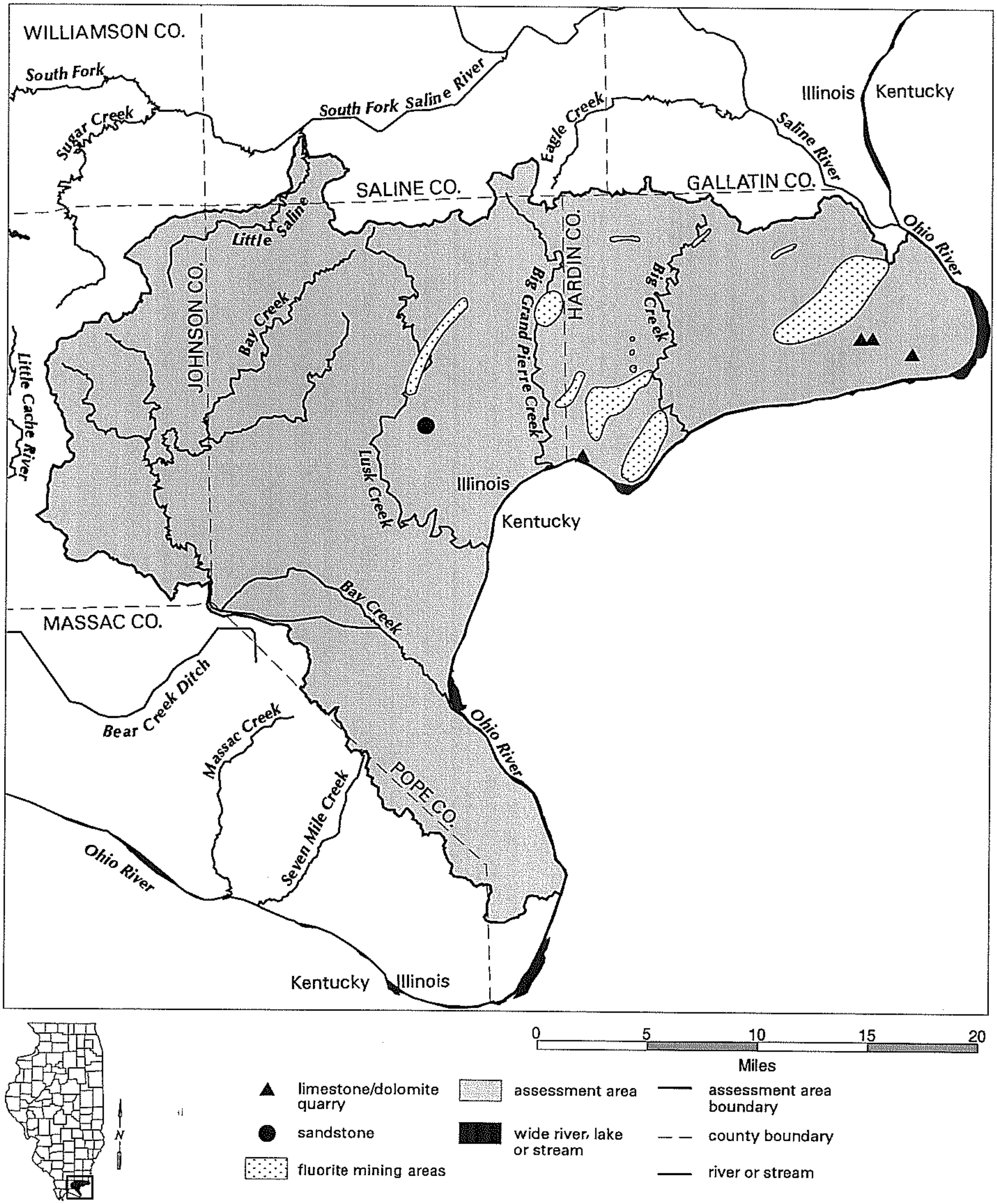

Figure 10. Fluorite Mining Areas and Active Limestone and Sandstone Quarries in the Shawnee Assessment Area

Table 2. Active mineral producers in the Shawnee Assessment Area as of 1997.

Hardin County
Limestone Quarries

Hastie Mining and Trucking Co.
R.R. 1, Box 55
Cave-in-Rock, IL 62919
NW Sec. 3, T12S, R9E
Mississippian Ste. Genevieve Limestone and Aux Vases Sandstone

Quarry # 1
Martin Marietta Aggregates Co.
River Central District
125 Augusta Pl., Suite C
Paducah, KY 42003
SE Sec. 1, T12S, R9E
Mississippian Ste. Genevieve Limestone

Quarry # 2
Martin Marietta Aggregates Co.
River Central District
125 Augusta Pl., Suite C
Paducah, KY 42003
SW Sec. 1, T12S, R9E
Mississippian Ste. Genevieve Limestone

Quarry # 3 (Williams)
Martin Marietta Aggregates Co.
River Central District
125 Augusta Pl., Suite C
Paducah, KY 42003
SE Sec. 35, T12S, R7E
Mississippian Ste. Genevieve Limestone

Cave-in-Rock Quarry
(leased from LaFarge Corp.)
Martin Marietta Aggregates Co.
River Central District
125 Augusta Pl., Suite C
Paducah, KY 42003
Sec. 8, T12S, R10E
Mississippian Ste. Genevieve Limestone

Pope County
Sandstone Quarry

Harley Emerson Quarry
Jan Stone Enterprises, Inc.
R.R. 1
IL 146, 4 miles south of Eddyville
Golconda, IL 62938
NE Sec. 27, T12S, R6E
Pennsylvanian Caseyville Sandstone

employment at individual mines or for the assessment area as a whole are not available. In 2001, the average price of construction sand and gravel was $4.41 per ton, and that of crushed stone was $5.35 per ton, but transporting these bulk commodities a few tens of miles by truck can double their delivered cost. Because these commodities are vital for construction, nearby sources generally are needed to keep construction costs down. The comparatively low cost of shipping by barge along the Ohio and Mississippi Rivers has allowed one or more of the quarries in Hardin County to sell their stone in locations as far away as Louisiana, where there are no sources of high-quality crushed limestone for use in making concrete highways. Some of the limestone quarries in this area have layers that are exceptionally pure and highly reactive to the sulfur oxides in power plant flue gases. These properties make the limestone especially suitable for use in flue gas scrubbing units of coal-fired power plants. If mine-mouth power plants are developed in southern Illinois, the high-purity limestone needed to operate the scrubbing units of these power plants could be an important product of some of the quarries in the region (Harvey and others 1974; Lamar 1959).

The unusually hard crushed sandstone produced at the Harley Emerson Quarry in Pope County and the Hastie Mining and Trucking Co. Quarry in Hardin County have been marketed as a skid-resistant aggregate for asphalt pavement.

Coal

As shown in Figure 11, a few coal mines have operated in Pope and Johnson Counties within the boundaries of the assessment area. None is currently operating, however. The only rocks in the area that contain significant amounts of coal are in the Tradewater Formation (see Figure 3) of the Pennsylvanian System. However, the coal seams in these rocks are thin and discontinuous, unlike the seams in the overlying Carbondale Formation that are extensively mined in Saline, Gallatin, and other counties to the north. Because the Carbondale Formation is absent from the assessment area, and most of the coal resources in other units have already been exploited, any remaining coal resources are not likely to be developed.

The coal mine directory for Johnson County lists 25 mine sites, of which 23 were surface mines, 2 were drift mines that extracted the coal from an exposure in the side of a hill or in the high wall of a surface mine, 1 was a slope mine that reached the coal seam underground through a sloping shaft, and 1 was a shaft mine that extracted the coal through a vertical shaft. The mines exploited the New Burnside, Reynoldsburg, and Mt. Rorah Coal Members of the Tradewater Formation. Total coal production in the county is 314,325 tons, of which 72,781 came from the surface mines (Samson 1994). Of the 25 mines listed in the directory, only 6 were located within the boundaries of the Shawnee Assessment Area. Most of the mines were clustered in the vicinity of the village of New Burnside, just outside the northwest boundary of the assessment area.

The directory for Pope County lists 23 mines, of which 8 were drift mines, 5 were surface mines, and 10 were of unknown type. The mines exploited the Bidwell, Willis, Smith, and Reynoldsburg Coal Members of the Tradewater Formation. Total coal production in the county is 36,266 tons, of which 34,704 tons came from the surface mines (Samson 1994).

The directory for Hardin County lists only one mine site, located in the eastern part of the county near the confluence of the Saline River with the Ohio. Available production records indicate that only 40 tons of coal have ever been produced in the conty.

Mine directories may be downloaded free of charge (http://www.isgs.uiuc.edu/servs/pubs/county-coal-maps/coalmine_for.htm).

Potential Mineral Resources

As noted in the section on bedrock geology (Figure 3), much of the Shawnee Assessment Area, especially the southern and eastern part, is underlain by rock units of the upper and middle Valmeyeran Series that generally contain thick limestones. Where these units are present at the bedrock surface, there may be a significant potential for opening a limestone quarry (Figure 12). However, the low population density of the region strongly limits the total market, and a newly opened quarry would face strong competition from the existing quarries in the region. Where the Caseyville Sandstone is strongly cemented

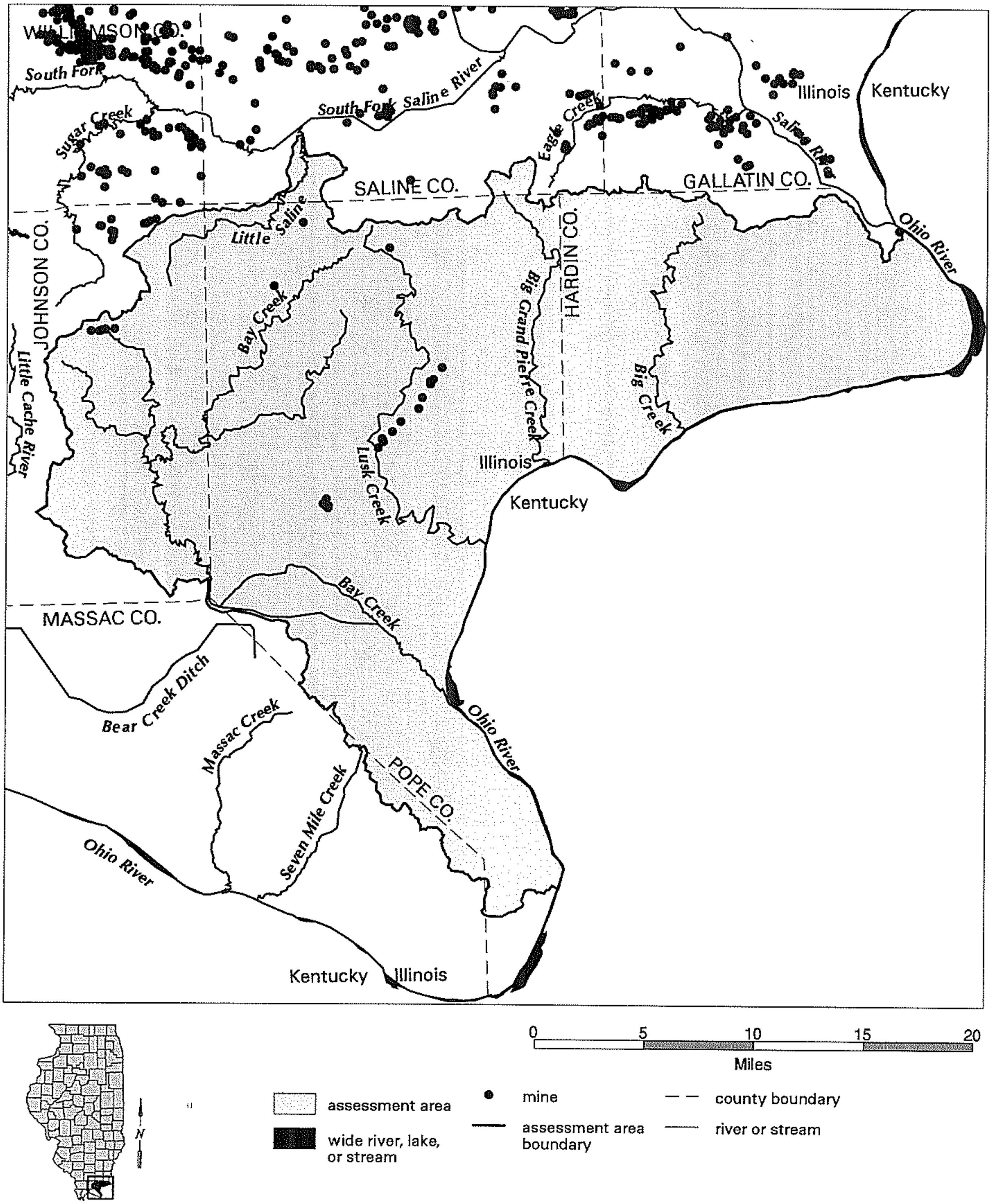

Figure 11. Coal Mines in the Shawnee Assessment Area

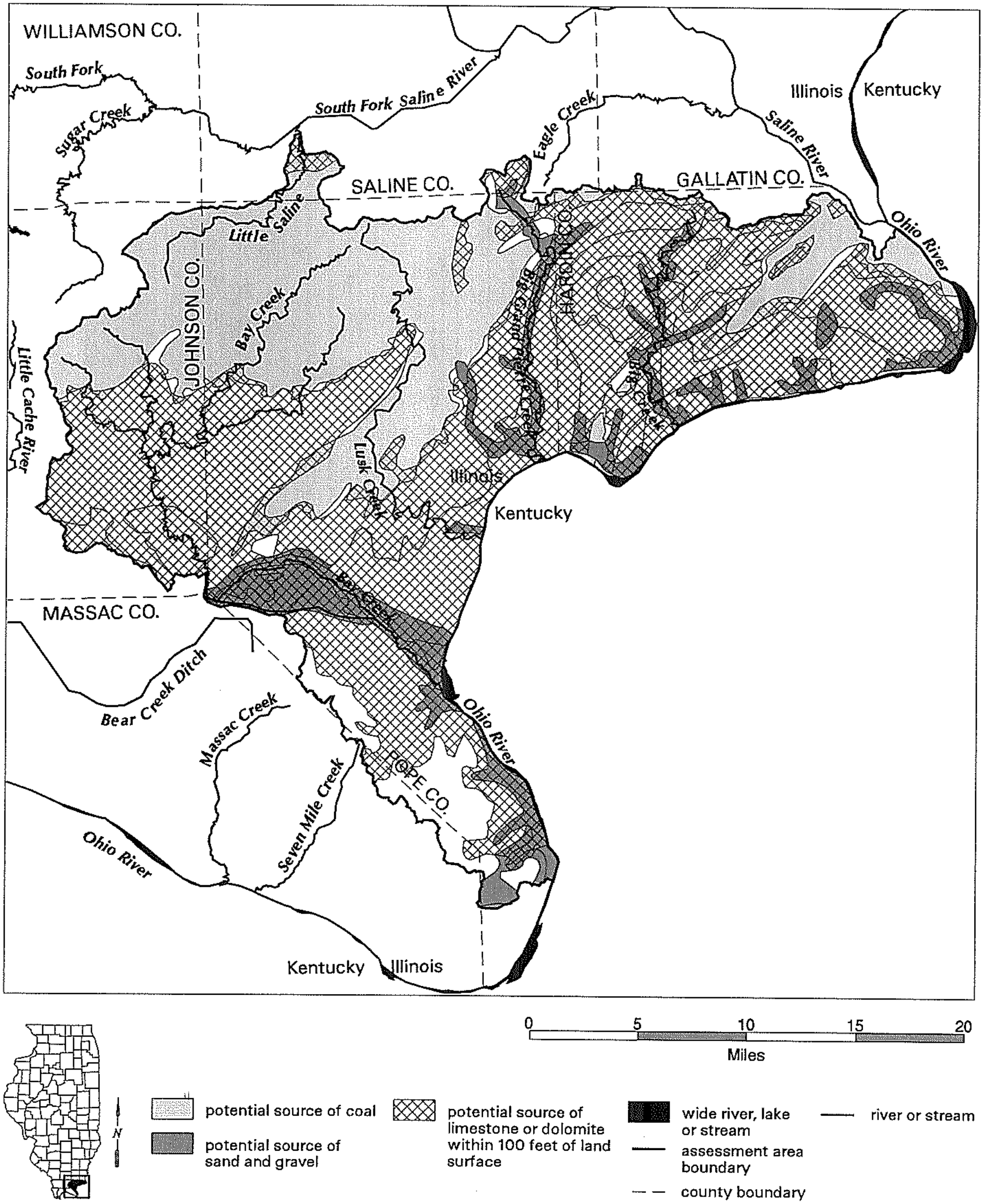

Figure 12. Potential Mineral Resources in the Shawnee River Assessment Area

or, where sandstone layers in the Upper Valmeyeran Series rocks are present, it might be possible to develop a quarry producing aggregate materials from the sandstone. However, these materials may be marketable only locally.

Figure 12 shows that the areas with the greatest potential for finding new deposits of sand and gravel for production of aggregate materials lie in the valleys of the Ohio River and its tributary streams. The Bay Creek valley, which approximately coincides with the deep bedrock valley eroded by the ancestral Ohio River, almost certainly contains significant resources of sand and gravel laid down by the large river that once flowed through the area. However, in most places, those deposits may be buried beneath a thick cover of fine-grained alluvium and, therefore, would be difficult to obtain. Similarly, the tributary streams that drain toward the Ohio River from the uplands to the north in Hardin and eastern Pope Counties may contain sand and gravel deposits that could be useful sources of aggregate materials, at least for local use as fill, although these deposits, too, may be covered by fine-grained modern alluvium derived from the thick loess deposits in the region. As noted in the Aquifer Delineation section, areas where tributaries enter the Ohio River are most likely to contain coarse-grained, porous sand and gravel deposits. Exposures of the Mounds Gravel, which are present in a few scattered areas in the uplands of southeastern Pope County, also may be a local source for gravel and for decorative stone for landscaping. Because the Mounds is composed mostly of chert pebbles, it does not meet Illinois Department of Transportation standards for use in making concrete pavement. *The Directory of Illinois Mineral Producers* for 1997 (Masters and others 1997) lists no producers of sand and gravel for any of the counties in the Shawnee Assessment Area.

The Carbondale Formation, which contains most of the thick coal seams that are extensively mined in the counties just to the north, is not present in the Shawnee Assessment Area. Of the Pennsylvanian rocks present in the assessment area, only the Tradewater Formation contains coal beds, but they are generally thin and discontinuous, so there is little prospect that economically important coal resources will be discovered in the area. The small total amount of coal produced from the mines that have operated in the area indicates that extensive, thick coal seams simply are not present in the area.

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Aquifer Delineation

An aquifer is a body of water-saturated earth materials capable of yielding sufficient groundwater to a spring or well for the intended use of the water. Aquifers in the glacial drift of Illinois generally are composed of loose, unlithified sand and gravel. The aquifers in the bedrock at shallow depths in Illinois generally are composed of dolomite, at intermediate depths of dolomite or sandstone, and, at greatest depths, of sandstone. Fine-grained earth materials, such as silt, clay, or till in the glacial materials and shale, claystone, or unfractured limestone or dolomite in the bedrock, generally restrict the flow of groundwater through and between aquifers and are therefore called aquitards.

Bedrock aquifers in the assessment area tend to be relatively uniform in thickness and laterally continuous. These aquifer materials generally formed in widespread marine environments, and the units may be traced over many miles. Equally widespread aquitards restrict the vertical movement of groundwater between bedrock aquifers.

The bedrock layers that are now aquifers generally were laid down in widespread marine environments and, therefore, tend to be relatively uniform in character laterally. Successive layers in the bedrock commonly were deposited in quite different environments, however, so the character of the bedrock layers varies more vertically than laterally from place to place. In most of Illinois, bedrock aquifers are composed either of fractured and weathered dolomite and limestone or of sandstone. In the Shawnee Assessment Area, the bedrock aquifers that lie at relatively shallow depths are composed of sandstone or fractured and creviced limestone (see Figures 2 and 3). The bedrock aquifers that are present at intermediate and greater depths generally consist of limestone, dolomite, and some sandstone, but they typically yield water that contains fairly large concentrations of dissolved minerals. Interbedded layers of fine-grained shale and dense, unfractured dolomite or limestone restrict the vertical movement of groundwater between bedrock aquifers.

Aquifers in Illinois are replenished (recharged) by downward-percolating water from precipitation that originally falls on the ground surface. The rate of recharge of an aquifer depends mostly on the permeability of the succession of glacial deposits and bedrock layers that immediately overlie it. As groundwater moves slowly downward and laterally through the glacial drift and rocks, it dissolves the mineral grains in the rocks, slowly absorbing more and more chemicals. Consequently, the water withdrawn from deeper rock layers generally is more mineralized than the water in layers closer to the surface. Given the right type of permeable glacial deposits, less mineralized water moving downward into these permeable deposits can "flush out" more highly mineralized water.

Bedrock Aquifers

In Illinois, the concentration of minerals dissolved in groundwater (mineralization) commonly increases with depth. In addition, the amount of recharge that reaches the intermediate and deep aquifers is limited in areas where Devonian and Ordovician age shales overlie the older rocks. The degree of mineralization in the groundwater in an intermediate or deep aquifer may be reduced where these shales are absent, and recharge can dilute the mineralization of the groundwater. Although water may be available in the deeper bedrock formations (Cambrian through Devonian age), it is generally not utilized because of its very poor quality. An exception to this situation is the very small area around Hicks Dome where Devonian bedrock is exposed at the surface. In this vicinity, the water quality in the Devonian and underlying Silurian aquifers may be adequate for consumption.

Rocks of the Mississippian System are present at the bedrock surface across a large part of the Shawnee Assessment Area (Figure 3). Groundwater supplies have been developed from rocks in the Middle Mississippian (middle and upper Valmeyeran Series) and Upper Mississippian (lower and upper Chesterian Series). The Valmeyeran rocks are composed mostly of thick limestones with some sandstones, siltstones, shales, and dolomites. Because of the presence of several southwest-trending fault systems and Hicks Dome (Figure 3), the limestones can be extensively fractured and creviced. In these areas, wells are capable of producing moderate water supplies with yields from a few gallons per minute to several hundred gallons per minute that are suitable for domestic, farm, and municipal use (Brower and others 1989). These aquifers are generally present in a large part of Hardin County and in southern Pope County where the Valmeyeran limestones are at the bedrock surface or are overlain by thin Chesterian Series rocks. However, where the cover of loess and soil materials is thin, the recharge from the surface can carry contaminants such as animal wastes, seepage from septic systems, and agricultural chemicals into the limestone aquifer. Solution of the limestone bedrock by normally acidic rainwater can enlarge the cracks and crevices, forming caves, sinkholes, and sinking streams that are typical elements of karst topography (Weibel and Panno 1997).

The interlayered sandstones and limestones that make up the Chesterian Series (Figure 3) provide groundwater supplies for domestic and farm purposes in the southern two-thirds of Pope County and adjacent areas of Johnson and Hardin Counties where they are present at the bedrock surface. Additionally, in a narrow strip a few miles downdip (generally northward) from the southern margin of the Pennsylvanian rocks, domestic groundwater supplies may be obtained from the Chesterian sandstones and limestones that underlie the Pennsylvanian rocks. As with the Valmeyeran Series aquifers, yields of wells that tap limestone aquifers in the Chesterian Series are enhanced by cracks and crevices in faulted rocks and by solution openings in these limestones. However, the principle water-yielding units in the Chesterian Series are the sandstones (Student and others 1981). Reported yields to wells range from very small to moderate, approximately 1 to 70 gallons per minute (gpm) (Brower and others 1989); most yields are less than 15 gpm.

Within the assessment area, sandstone is the dominant lithology in the basal Pennsylvanian Caseyville and Tradewater Formations. These rocks are at the bedrock surface in the northern half of Pope and Johnson Counties and in northeasternmost Hardin County and are a source of groundwater for domestic and farm use. Potable water has been found in the thick, permeable Pennsylvanian age sandstones at depths up to 900 feet in a relatively narrow band 8 to 15 miles wide downdip (northward) from the southern edge of the Pennsylvanian system. Yields of 40 to 75 gpm have been reported for water wells that tap the Pennsylvanian rocks in the assessment area (Brower and others 1989), but yields much less than 40 gpm are more typical.

Clastic rocks of the Cretaceous McNairy Formation are present in the assessment area in the far southern portion of Pope County adjacent to the Ohio River and along the border with Massac County. The unit is composed of sand and some gravel, silts, clays, and small amounts of lignite-grade coal. The availability of groundwater within these Cretaceous rocks can be characterized as scattered and discontinuous. Availability is dependent on the variable permeability of the sediments and whether the sand layers are drained to hillsides in the upland areas. Large-diameter wells dug in the fine sands and silts may be used in some places for small domestic supplies, but such wells may be undependable during droughts.

Overlying the Cretaceous rocks in far southern Pope County is a small area where the Tertiary age Mounds Gravel is present (see Figure 5). These sediments, which are composed of brown chert pebbles and sand, generally are located only in upland areas and are drained to the hillsides. Because of this, the Mounds is not generally considered a dependable source of groundwater in this area.

Glacial and Younger Alluvial Aquifers

Sediments laid down directly by glacial ice are entirely absent in the Shawnee Assessment Area. However, sand and gravel aquifers composed of glacially derived outwash and younger alluvium are present in the Cache and Ohio River valleys and in tributary valleys. Because these sediments generally have little or no surface cover, they are more vulnerable to surface contamination than aquifers that are more deeply buried.

Glacial outwash mapped as the Henry Formation and Cahokia Formation alluvium (Figure 5) can be dependable aquifers in areas where they are thick, porous, and permeable. These aquifers occur in the Cache Valley, the ancient bedrock valley eroded by the ancestral Ohio River that trends east-west across southern Pope County into Massac County and in the valley of the modern Ohio River in southernmost Pope and Hardin Counties. In the Cache Valley, the potential for large yields of groundwater is greatest from the coarse-grained sediments deposited in areas occupied by the former main stream of the ancestral Ohio River in the bedrock valley. In the present-day valley of the Ohio River, sediments that can supply large yields of groundwater are most likely to occur in scattered areas where the floodplain is wide and tributary streams empty into the Ohio River.

Water Quality

The quality of groundwater available from bedrock aquifers in the assessment area is generally good at shallow depths, but the amount of mineralization of the groundwater increases with depth. The quality of the water from the glacially derived and younger alluvial aquifers is generally good. Although the total dissolved solids content of the groundwater in these aquifers is generally fairly low, the iron content and hardness locally can be fairly high.

Summary

In summary, water from the deeper sedimentary rocks of Cambrian, Ordovician, Silurian, and Devonian rocks generally is too highly mineralized for human consumption, with the possible exception of a small area around Hicks Dome where these rocks are exposed.

The primary aquifers throughout the assessment area are in the Mississippian Chesterian Series and Valmeyran Series. Thick limestones of the Valmeyeran Series and sandstones and limestones of the Chesterian Series underlie the entire area except for a small area around Hicks Dome. These aquifers provide water of suitable quality and in quantities sufficient for domestic use in all but about the northern one-third of Pope County. In this part of the assessment area, domestic water supplies may be found in the thick permeable sandstones of Pennsylvanian age that constitute the bedrock surface there. In localized areas, the Mississippian or Pennsylvanian aquifers may yield enough groundwater to support a town.

Domestic yields are obtained from glacially derived sand and gravel aquifers in the Ohio and Cache Valleys and from alluvial sand and gravel in tributary valleys. Larger groundwater yields are available only in the thicker sand and gravel deposits in the buried bedrock Cache Valley and in a discontinuous band of variable width along the Ohio River in Pope and Hardin Counties.

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Potential for Geologic Hazards

Determining appropriate land use in the Shawnee Assessment Area requires an understanding of the potential natural and society-induced geologic hazards inherent to the area. Geologic hazards develop through interactions between geologic materials and natural forces and can be influenced by human activities. This section explains to readers some of the potential geologic hazards, including groundwater contamination, that can occur in the assessment area. Site-specific geologic conditions or hazards are not comprehensively discussed. For a broader view of geologic hazards and the measures to take when they occur, consult *The Citizen's Guide to Geologic Hazards* (Nuhfer and others 1993). Prepared by the American Institute of Professional Geologists, this publication covers hazards that arise from naturally occurring geologic materials (such as radon and asbestos) and from geologic processes (such as earthquakes, landslides, and flooding). In addition, its appendixes list sources of help from professional geologists and insurance professionals. The publication may be ordered by contacting

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Potential for Contamination of Groundwater Resources

Groundwater contamination can arise from many sources. These sources are generally grouped into two classes, point or non-point, on the basis of the size of the area where a chemical is applied or spilled or a waste material is deposited. Point sources of contamination include many types of facilities and activities, such as landfills, chemical storage tanks (both above and below ground surface), individual septic systems, homeowner disposal of unwanted chemicals (for example, paint or used motor oil), the over-application of lawn fertilizers and pesticides at individual residences, and the facilities of pesticide and fertilizer dealers or applicators.

The primary non-point source of potential contamination in Illinois is the agricultural use of pesticides and fertilizers. Urban and suburban sources of groundwater contamination, such as septic systems and overuse of lawn fertilizers and pesticides, can also become non-point problems if a significant concentration of these sources occurs in a subdivision or other area.

Groundwater contamination can be defined as the presence of a chemical in the groundwater at or below the water table at a concentration that exceeds federal or state acceptable levels. The natural flow of the groundwater is the means of transporting these dissolved contaminants away from their source. Responsible chemical use and prompt cleanup of spills can prevent the degradation or contamination of groundwater. In addition, it can be helpful to restrict or closely monitor activities that can contribute to groundwater contamination, particularly when the activities are conducted in or near the setback zone around a public water supply well. The Illinois Environmental Protection Agency provides information on the delineation of setback zones for public water supply wells and the activities that are controlled or prohibited within these areas (Cobb and others 1995).

The potential for groundwater contamination depends on a complicated combination of hydrogeologic properties, environmental processes, and the quantity and nature of the contaminant in question. In general, as depth to the top of the uppermost aquifer increases, the sensitivity to contamination of that particular aquifer decreases. Greater depth below the ground surface (greater thickness of overlying earth materials) affords an aquifer greater protection due to the increased opportunity for adsorption, microbial degradation, and dilution of a spilled contaminant before it can reach the aquifer. The validity of this generalization, however, depends on several other factors. The effects of these various factors on contaminant fate and transport are discussed next.

Effects of Climatic Variables on the Fate of Contaminants

Four climatic variables (precipitation, temperature, humidity, and wind speed) help determine the fate of subsurface chemicals through their impact on several different processes. The total amount and intensity of rainfall during a storm help to determine the amount of runoff from the soil surface and, consequently, the amount of water infiltrating the soil surface. Temperature, humidity, and wind speed also influence water infiltration rates and the movement of chemicals and groundwater through their effects on the processes of evaporation, transpiration, volatilization, and condensation.

Evaporation of water from the soil and transpiration of water from plants both reduce the amount of water in the soil that percolates downward to the water table. Depending on the depth of the water table and the depth and distribution of plant roots, plants can even remove water from below the water table.

Volatilization is the process by which a chemical in a liquid state is heated enough to convert it to a gaseous state. Gasoline is one example of a chemical that can volatilize at temperatures normally found in the soil during Illinois summers. Condensation is the process by which gaseous chemicals are cooled into a liquid state. Once condensed, the chemical may become dissolved in water and leach to the groundwater system. Thus, chemicals that have been volatilized and remain trapped as gases in soil can condense back to a liquid form and leach to groundwater.

Effects of Quantity and Chemical Characteristics on the Fate of Contaminants

The quantity and nature of a chemical spill or application, as well as the chemical properties of the contaminant, also help control whether groundwater contamination occurs and the amount of groundwater that becomes contaminated. The larger the quantity of contaminant that is released, the more likely it is that some fraction of the chemical will leach to the groundwater system. In addition, the depth from the land surface to the aquifer and the area of land exposed to the chemical also affect the likelihood of groundwater contamination. For example, a herbicide applied to the land surface at a rate of 3 pounds per acre over 640 acres has a much smaller likelihood of causing significant groundwater contamination than a leaking gasoline storage tank that is buried 15 feet below land surface.

Several chemical properties affect the fate of a chemical in the subsurface. These properties include, but are not limited to, the water solubility of the chemical (the amount of a chemical that can dissolve in water) and the adsorption coefficient (a measure of the tendency for a chemical to stick to the outside of soil particles). Many chemicals applied to agricultural fields are removed by runoff and soil erosion during rainfalls. The water solubility of a chemical controls how readily the chemical mixes with or dissolves in water. Less soluble compounds generally do not move as rapidly as more soluble compounds. Adsorption is the process by which a molecule of a chemical sticks to the surface of a soil particle. Like solubility, adsorption is important in helping to control the rate of chemical movement in the subsurface. Many organic chemicals found in pesticides or used in solvents are strongly adsorbed by the organic matter or clay minerals in soil, which slows their flow to groundwater resources. Nitrate, however, does not adsorb to soil particles and thus moves much more rapidly in groundwater than do pesticides.

In addition to solubility and adsorption characteristics, potential contaminants are also characterized by their half-life. The half-life of a chemical is a measure of the speed with which it can be degraded by microbial organisms, sunlight, or other natural processes. In general, these processes break the chemical down into smaller compounds that may be less toxic or even nontoxic.

Effects of Geologic Materials on the Fate of Contaminants

Whether groundwater becomes contaminated also depends heavily upon the hydrogeologic characteristics of the area. Groundwater flow is largely controlled by the hydraulic conductivity of the geologic materials and the hydraulic gradient of the system. Hydraulic conductivity is a measure of the ability of water to flow through a geologic deposit. For example, sand and gravel deposits generally have high hydraulic conductivity values, and clayey diamictons generally have low hydraulic conductivity values. Some geologic materials are fractured, and, depending on the size and spacing of the fractures, hydraulic conductivities in these units can be much greater than unfractured materials and may be much greater in one direction than another.

Hydraulic gradient is the difference in the groundwater pressure between two points. Under a large hydraulic gradient (or a large difference in pressure), water and dissolved contaminants will move more quickly through a given geologic material than under a small hydraulic gradient. Because the measurement of hydraulic conductivity and hydraulic gradient requires significant commitments of time and money, other methods have been developed to estimate the potential for groundwater contamination.

Potential for Groundwater Contamination and Aquifer Sensitivity

Most discussions of groundwater contamination do not distinguish between groundwater contamination and aquifer contamination, but this distinction can have very important practical consequences. Technically, any time a chemical reaches the water table at a concentration above a level established by a state or federal agency, the groundwater has been contaminated. In most of Illinois, however, contamination of shallow groundwater at the top of the zone of saturation (the water table) would not necessarily result in contamination of the uppermost aquifer because the uppermost aquifer commonly lies deeper than 20 feet from the surface. Most water supplies that use groundwater rely on the water in aquifers for that supply. For this reason, most concerns regarding groundwater quality generally refer to protection of the water quality in aquifers rather than all groundwater.

In regions without aquifers, private water supplies may have to draw water from nonaquifer materials with low hydraulic conductivities by using large-diameter dug or bored wells. Residents of these regions must be concerned with the contamination of any groundwater.

The contamination potential of shallow aquifers has been estimated in much of the state using information on the occurrence and depth of shallow aquifers and on the relative contaminant-leaching characteristics of mapped soils (Keefer 1995). Although well suited to areas with a mantle of glacial deposits covering the bedrock units, the method is not well suited to areas such as the Shawnee Assessment Area where bedrock is at or near land surface.

When assessing the sensitivity of shallow aquifers in the Shawnee River Assessment Area to possible contamination, several factors that distinguish this area from other parts of Illinois must be taken into account.

- The rocks of the Shawnee Assessment Area are heavily faulted and structurally deformed. In these faulted and folded areas, the porosity and hydraulic conductivity values of the bedrock can be expected to vary widely and unpredictably within short distances.
- Even away from the fault zones, the hydraulic conductivity of the Middle and Late Mississippian limestones and sandstones is expected to be quite variable and unpredictable. The rocks are jointed and fractured, and the number of fractures in a given area and their degree of connectedness are highly variable.
- Much of the region contains prominent karst features where aquifers in shallow, cavernous limestone layers have flow rates that are extremely large; many surface streams flow into sinkholes in these areas and disappear, re-emerging

at springs at lower elevations. The contamination potential of such aquifers is extremely high, resembling that of surface water systems more than typical groundwater systems.

- In the layers of sandstone that are prevalent in the Late Missippian, Chesterian Series rocks, the amount of cement that has formed in the pores of the rocks varies widely from place to place. Depending on the porosity that remains, these layers can provide sustainable water supplies for domestic purposes in some areas but not in other areas.

- The many deep valleys and cliffs within the assessment area (large local relief) and the folding and faulting of the bedrock units can allow much of the infiltrating rainwater to discharge as seeps or into nearby streams. This tendency for local discharge of groundwater from the bedrock serves to protect deeper aquifers from surface contamination by reducing the quantity of shallow groundwater that makes it to the deeper groundwater system.

These factors, together with the distribution of aquifers detailed in the section on Aquifer Delineation, have been used to interpret the potential for contamination of shallow aquifers in the Shawnee River Assessment Area.

Throughout much of Hardin County and southern Pope County, aquifers within the Middle Mississippian, Valmeyeran Series are at land surface or are buried by a thin cover of rocks of the Upper Mississippian, Chesterian Series. The Valmeyeran aquifers are dominated by thick limestone deposits that are heavily jointed and vulnerable to dissolution and karstification in many areas. These carbonate rocks are the most productive aquifers in the assessment area but also the most vulnerable to contamination.

Aquifers within the rocks of the Chesterian Series are located mostly in the southern two-thirds of Pope County and much of Hardin County. These aquifers are composed mostly of sandstone with some interlayered thin limestone and dolomite beds, but they typically have hydraulic conductivities that are significantly lower than Valmeyeran aquifers. Because of their tendency for lower hydraulic conductivities and the predominance of variably cemented sandstones within these rocks, Chesterian aquifers typically have the lowest vulnerability to contamination in the assessment area. The variable nature of the cementation in the sandstones and the fracturing of the carbonate rocks suggest that the potential for contamination of these aquifers will be greater where they are more productive. In locations where the sandstones in the Chesterian rocks are tightly cemented and the limestones are only slightly fractured, they may not provide enough water to drilled wells to be considered aquifers.

Aquifers within the Pennsylvanian, Caseyville, and Tradewater Formations are predominantly composed of sandstone. These deposits are fairly reliable aquifers for domestic supplies within 8 to 15 miles northward from the southern edge of their exposures at the bedrock surface. Beyond this distance, these Pennsylvanian rocks are buried so deeply that the water in them is too saline for consumption. These aquifers have a moderate potential for contamination.

These descriptions are based on the average condition of the rocks. In areas near major faults or fault zones, the aquifers are likely to have a relatively larger potential for contamination because of the increased fracture porosity and resultant hydraulic conductivity in all of the rocks around the faults.

In the immediate vicinity of Hicks Dome, in west-central Hardin County, the faulting and folding bring some older bedrock formations close to land surface. In this area, limestone of the Devonian System outcrops at or near the land surface, and the underlying rocks of the Silurian System may be present at relatively shallow depths. These deposits are known to be productive aquifers in this small area, but it is likely that their highly fractured nature would cause them to have a relatively high potential for contamination.

Regional Earthquake History

People living in the Shawnee Assessment Area will not be surprised to learn that this is "earthquake country." Nearly four dozen small earthquakes, many of them at least felt by residents, have been reported in this area since 1872 (Figure 13). Many larger earthquakes that occurred in places just outside the Shawnee Assessment Area also have been felt, and some of these have caused damage. Small to moderate earthquakes can be expected to continue in and near the assessment area on a regular basis. Earthquakes with magnitudes of 5.0 or greater might be expected every few decades. These quakes could cause minor damage throughout the Shawnee Assessment Area. Stronger quakes, with magnitudes of 6.0 to 6.5, are less likely to occur within the Shawnee Assessment Area, but because it lies close to the New Madrid Seismic Zone, strong earthquakes in that zone can be expected to cause damage in the Shawnee study area. There is a significant likelihood that an earthquake of magnitude 6.0 to 6.5 will occur somewhere in the New Madrid Seismic Zone within the next 15 years. An earthquake of that magnitude in the northeastern end of the New Madrid Seismic Zone could cause significant damage to structures in the assessment area. In the winter of 1811–1812, three very strong earthquakes occurred in the New Madrid Seismic Zone. The absence of large human settlements in the region meant that few people or humans were affected, but the seismic waves from at least one of those earthquakes caused church bells to ring as far away as Boston, Massachusetts. The evidence for estimating recurrence rates of such large earthquakes in the New Madrid Seismic Zone is quite limited, but it seems likely that they occur only once every 600 to 1,200 years. Therefore, the probability of one occurring within the next 50 years is considered to be very low.

Landslides

When most people think of landslides, they usually envision a massive body of boulders, gravel, sand, and dirt crashing down a hillside, destroying everything in its path. Rightly so, for this type of "mass wasting," as geologists call it, often occurs in landscapes dominated by very high, steep slopes. Several such landslides that have caused hundreds of thousands of dollars in property damage have been documented in Illinois, and they have caused hundreds

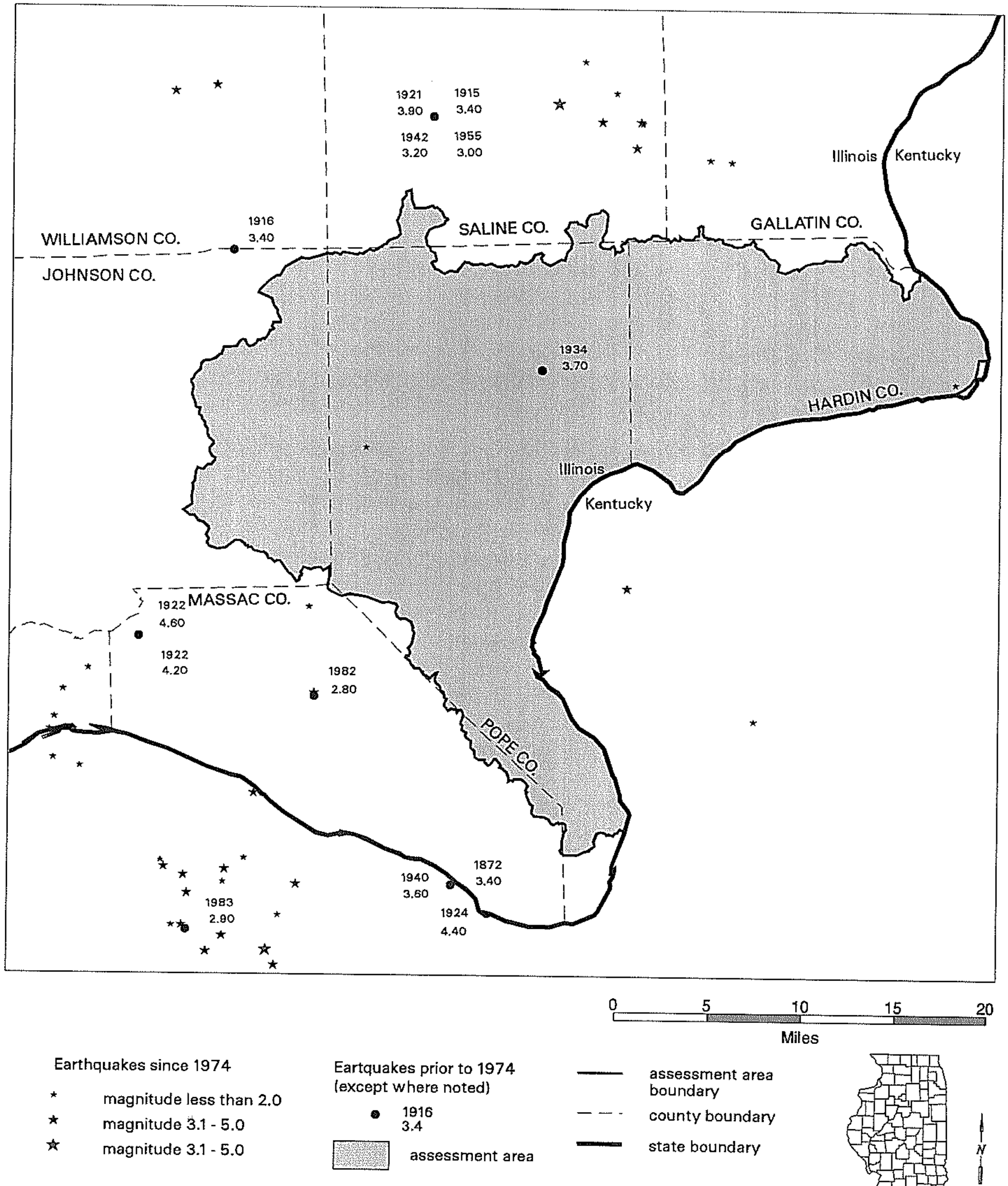

Figure 13. Earthquakes in and near the Shawnee Assessment Area (St. Louis University Earthquake Center Database 1996)

of thousands of dollars in property damage. In the relatively young, low-relief, glacially sculpted landscape common to most of Illinois, more subtle mechanisms of mass wasting can be just as threatening and costly as their more extreme but less common counterparts.

Nearly 60% of the landslides documented thus far in Illinois have been classified as "slumps" (Killey and others 1985). A slump is a mass of rock or earth (glacial material) that moves downhill along one or more underground surfaces or slip planes within the mass or along the contact between the bedrock and the overlying glacial material. Slump-type landslides may be recognized by one or more of the following characteristics:

- A sharp cliff (also called a "scarp") found at the top of the slide that can be several inches or feet high that results from the initial downward movement;
- One or more additional scarp faces resulting from successive slump movement;
- Ponding of water or marshy, wet areas in the landslide due to large blocks of earth tilting back toward the slope;
- Tilting of trees, fence posts, and utility poles; and
- Earth bulging and rolling over the original ground surface at the base of the landslide.

Most landslides in Illinois are caused by stream erosion or road construction that removes the lower part of the slope, triggering the landslide by, effectively, steepening the slope. Construction of a road or a building near the top of a slope also can trigger a landslide by adding weight to the unstable mass of soil and rock. Drainage from downspouts or seepage from a septic system also can supply enough moisture to a nearby slope to cause the rock and soil in the slope to fail by adding weight to the unstable mass and by lubricating the slide plane.

Information on landslides in Illinois is contained in *Landslide Inventory of Illinois* (Killey and others 1985), produced by the Illinois State Geological Survey in cooperation with the United States Geological Survey. This publication contains historical photos of landslides that have occurred in Illinois and provides information on landslide classification, factors contributing to landslide potential, and what can be done to stabilize slopes. This publication can be purchased from the Illinois State Geological Survey at (217) 333-ISGS or isgs@isgs.uiuc.edu.

Despite the presence of steep slopes, large rock outcrops, and near-vertical rock cliffs in many parts of the assessment area, no landslides that have caused significant property damage were recorded when the ISGS compiled the statewide landslide inventory. However, the absence of records of damaging landslides should not be taken to mean that landslides do not occur in the region. Rather, it is more an indication of the limited number of roads and the low population density in the assessment area. A walk below a cliff almost anywhere in the assessment area is almost certain to reveal large boulders that have crashed down from above and may even reveal the lighter-colored escarpment left by a recent fall from the cliff face. The rugged topography across the region means that local officials and individual property owners must be mindful of the potential dangers from landslides whenever they are considering sites for constructing public facilities, building roads, installing water or sewer lines, or considering a home site.

Mine Subsidence and Acid Mine Drainage

Fluorite Mining

Fluorite has been extensively mined in several areas in Hardin and Pope Counties (Mineral Resources section). The mines included both undergound and surface mines, but most either were underground mines that followed nearly vertical veins or room-and-pillar mines that followed deposits of fluorite formed in nearly horizontal layers that followed the bedding in the limestone that was the host rock, the "country rock," of the mineral deposits. During the more than 150 years of fluorite mining in the area, numerous small mines and prospect pits were opened and operated briefly to supply some ore to the mills and processing plants operated by the major companies at Cave-in-Rock, Rosiclare, and Elizabethtown. As of July 1967, Bradbury and others (1968) reported that 5 ore-processing mills and 18 mines were operating in the mining district. The extensive mining activity in the region, which continued for almost 150 years, has almost certainly left many dangerous openings. In some instances, near-vertical vein mine shafts following ore vein (called stopes) may have reached nearly to the land surface, but the only evidence of this may be little more than a narrow crack in the ground, hidden by weeds and brush. The irregular shaft below may extend downward several hundred feet. Many exploration pits or "dog holes" dug into the sides of hills may still stand open, forming attractive "caves" for children to explore. Although the Abandoned Mined Land Reclamation Division of the Office of Mines and Minerals, Department of Natural Resources, has worked at various times to eliminate open mine shafts and workings in the area, the records available for the mining district are limited, and "daylighted stopes" (mine workings that have bored upward to the ground surface), exploration "dog holes" (small pits and tunnels dug to search for ore veins), and other potentially dangerous mine openings likely remain in the area. Dangerous mine openings encountered in the area should be reported to the Abandoned Mined Land Reclamation Division at its Marion field office (618) 997-9495.

The host rock of the fluorite mineralization is limestone, composed mostly of the mineral calcite, with the chemical composition calcium carbonate ($CaCO_3$). Several sulfur-rich minerals, especially galena (lead sulfide, PbS), sphalerite (zinc sulfide, ZnS), and barite (barium sulfate, $BaSO_4$) are associated with the fluorite ore and are present in the mine dumps along with pieces of the host rock and fragments of fluorite (calcium fluoride, CaF_2). Weathering of the sulfide minerals, sulfate minerals, and fluorite in the mine dumps would be expected to form sulfurous and sulfuric acid (H_2SO_3 and H_2SO_4) and hydrofluoric acid (HF). All of these are strong acids that could be expected to seriously damage the ecology of nearby streams. However, the abundant limestone in the mine dumps provides a strong base that should react to neutralize any acids formed by the weathering of the ore minerals. Thus, rain that falls on the mine dumps is not expected to form strongly acidic drainage. As noted in the section on Aquifer Delineation, the groundwater in the fluorite mining area has the composition typical of groundwater in areas where the bedrock is mostly limestone.

Coal Mining

The coal mining industry has long been an important component of the Illinois economy. Mine locations and coal mine maps, catalogued by county, are available at the ISGS. Its county-based maps at a scale of 1:100,000 (or 1 inch represents about 1.6 miles), which show the general outlines of the mines, are another source of this information. Paper copies of the maps can be obtained at the ISGS, and electronic versions can be found on the ISGS Web site (http://www.isgs.uiuc.edu/) under Publications and Coal Mine Maps. Each map is accompanied with a county directory, which lists company names, mine names, mine numbers, type of mining method used, years of operation, coal seam mined, and mine location (Mineral Resources section and Figure 11).

Mine subsidence (the sinking of the land surface as a result of planned mining activities or an unplanned failure in the mine opening underground) has not been documented over the coal mines in this area. Most of the underground coal mines were fairly shallow, and mine subsidence probably would take the form of pits. Where underground mining was deep and the room-and-pillar mining method was used, failure of stability of the pillars of coal left underground to hold up the mine opening can produce a depression on the ground surface that is hundreds of feet across and 1 to 3 feet deep near the center. Two essential publications for land-use planners and homeowners who want to learn more about coal mine subsidence are *Planned Coal Mine Subsidence in Illinois, A Public Information Booklet* and *Mine Subsidence in Illinois: Facts for Homeowners*. These booklets contain information on coal-mine reserves in Illinois, coal-mining methods, the history of subsidence in Illinois, what to do if subsidence occurs, and sources for additional information. Contact the Illinois State Geological Survey at (217) 333-4747 or isgs@isgs.uiuc.edu to request these free publications.

Because of the very limited amount of coal mining that has occurred in the Shawnee Assessment Area, mine subsidence and acid drainage from coal mine wastes are not likely to have significant impacts, except in localized areas.

Karst Terrain

Areas of the Shawnee Assessment Area where the bedrock is composed mostly of limestone or dolomite (see Figures 2 and 3) are likely to have the suite of landscape features that are collectively called karst or karst terrain (Panno and others 1997). Characteristic karst features include numerous round or irregularly shaped closed depressions called sinkholes or "dolines," surface streams that vanish underground by flowing into sinkholes (sometimes called swallow holes), numerous caves, and springs and seeps. These features characteristically form in areas where a water-soluble bedrock such as limestone is present at the land surface or covered by less than 15 meters (50 feet) of overburden, and where steep topography allows the surface streams that flow into the limestone to escape through springs and be drained away. Figure 14 shows the parts of the assessment area underlain by soluble carbonate bedrock, the locations of springs and caves, and the upland areas where sinkholes are especially abundant.

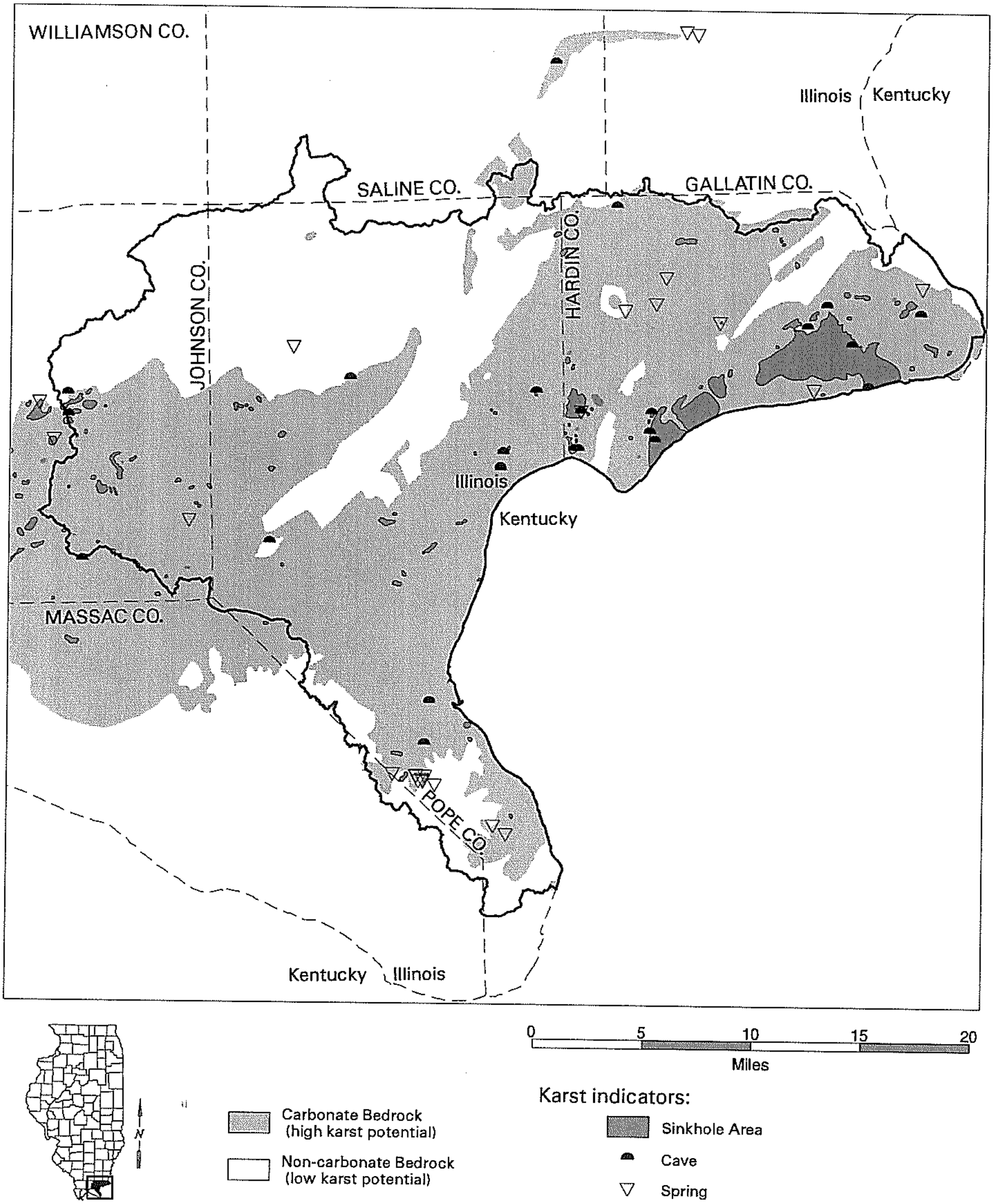

Figure 14. Karst Terrain in the Shawnee Assessment Area

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Appendix A: Overview of Databases

Illinois Wetlands Inventory

This digital database contains the location and classification of wetland and deep water habitats in Illinois. Following U.S. Fish and Wildlife Service definitions, the Illinois Natural History Survey (INHS) compiled the information from interpretations of 1:58,000-scale high-altitude photographs taken between 1980 and 1987. Identifiable wetlands and deep-water habitats were represented by points, lines, and polygons on 1:24,000-scale U.S. Geological Survey (USGS) 7.5- minute quadrangle maps. These data were digitized and compiled into the Illinois Wetlands Inventory. Because no wetland or deep-water habitats smaller than 0.01 acres were included, many farmed wetlands are not in the database. This database is appropriate for analysis on a local and regional scale; because of the dynamics of wetland systems, however, boundaries and classifications may change over time. For detailed explanation of wetland classification in Illinois, see *Wetland Resources of Illinois: An Analysis and Atlas* (Suloway and Hubbell 1994).

Quaternary Deposits of Illinois

Originally automated in 1984, this database is the digital representation of the 1:500,000-scale map *Quaternary Deposits in Illinois* (Lineback 1979). Because these data, modified by Hansel and Johnson (1996), represent a generalization of the glacial sediments that lie at or near the land surface, this database is most appropriate for use at a regional scale. For further information about surficial deposits in Illinois, see *Wedron and Mason Groups—Lithostratigraphic Reclassification of the Wisconsin Episode, Lake Michigan Lobe Area* (Hansel and Johnson 1996).

Thickness of Loess in Illinois

This database contains polygons delineating glacial and stream materials throughout the state; thicknesses range from less than 25 feet to greater than 500 feet. The data were originally automated in 1986 from the 1:500,000-scale map in *Glacial Drift in Illinois—Thickness and Character* (Piskin and Bergstrom 1975, plate 1). This database is most appropriate for use at a regional scale.

Thickness of Surficial Deposits

This database contains polygons delineating glacial and stream materials throughout the state; thicknesses range from less than 25 feet to greater than 500 feet. The data were originally automated in 1986 from the 1:500,000-scale map in *Glacial Drift in Illinois—Thickness and Character* (Piskin and Bergstrom 1975, plate 1). This database is most appropriate for use at a regional scale.

Noncoal Mineral Industry Database

Compiled by the ISGS from Illinois Office of Mines and Minerals permit data and information from the ISGS Directory of Illinois Mineral Producers, this database contains the locations of mineral extraction operations (other than coal, oil, and gas producers) in Illinois. The database contains both active and inactive sites and is updated every year. The 1996 data include 7 active underground mines and 449 active surface pits and quarries. This point database is appropriate for analysis on a local to regional scale. For more information on the current locations of non-coal mineral extraction sites or on the location of potential non-coal mineral resources, contact the Industrial Minerals Section of the Illinois State Geological Survey.

1:100,000-Scale Topography of Illinois

Depicting the general configuration and relief of the land surface in Illinois, this database was compiled by the ISGS from 1:100,000-scale digital line graph (DLG) format data files, originally automated by the USGS from USGS 1:100,000-scale 30- × 60-minute quadrangle maps. The USGS collected the land surface relief data for Illinois from stable-base manuscripts, photographic reductions, and stable-base composites of the original 1:100,000 map separates using manual, semiautomatic, and automatic digitizing systems. The contour interval of these topographic data is 5.0 meters (16.4 feet). These digital data are useful for the production of intermediate- to regional-scale base maps and for a variety of spatial analyses, such as determining the slope of a geographic area. The DLG format topographic data are available from the USGS

(http://edcwww.cr.usgs.gov/glis/hyper/guide/100kdlgfig/states/Il.html).

A full description of the DLG format can be found in the *Digital Line Graphs from 1:100,000-Scale Maps—Data Users Guide 2* produced by the USGS. These data are also available from the ISGS in ARC format.

State Soil Geographic (STATSGO) Database for Illinois

The Illinois STATSGO was compiled by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The database is the result of generalizing available county-level soil surveys into a general soil association map. If no county survey was available, data on geology, topography, vegetation, and climate were assembled along with Land Remote Sensing Satellite (LANDSAT) images. Soils of like areas were studied, and the probable classification and extent of the soils were determined. The data were compiled at 1:250,000-scale using USGS 1- by 2- degree quadrangle maps. This database was designed to be used primarily for regional, multistate, state, and river basin resource planning, management, and monitoring. It is not intended to be used at the county level. Illinois STATSGO data are available in DLG, ASCII, or ARC format and can be downloaded (http://www.il.nrcs.usda.gov/).

The data are also available from the ISGS in ARC format. For more information, visit the USDA Web site or contact the Natural Resources Conservation Service, 2118 W. Park Court, Champaign, IL 61821; telephone (217) 353-6600.

Land Cover Database of Illinois

Compiled for the IDNR Critical Trends Assessment Project by the INHS, the land cover database is intended as a baseline for assessment and management of biologic natural resources in Illinois. Twenty-three major land cover classes were defined using Thematic Mapper (TM) Satellite data. Dates of the imagery range from April 1991 to May 1995. Ancillary data used to interpret the TM imagery include the 1992 Topologically Integrated Geographic Encoding and Referencing System (TIGER) line files, the Illinois Wetlands Inventory, NRCS county crop compliance data, 1988 National Aerial Photography Program (NAPP) photography, and USGS transportation and hydrography data. This database is most appropriate for use at medium and regional scales. For more information on land cover in Illinois see *Illinois Land Cover—An Atlas* (1996).

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