GEOLOGY FOR PLANNING IN ROCK ISLAND COUNTY, ILLINOIS

Richard C. Anderson

Illinois Institute of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY DIVISION, URBANA, ILLINOIS
Jack A. Simon, Chief

CIRCULAR 510
1980

COVER PHOTO: Aerial view of Barstow, looking northwest, April 27, 1973.

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ABSTRACT

Rock Island County contains a variety of geologic materials underlying floodplains, steep valley sides, and level uplands. The terrain and the underlying materials together determine the suitability of the land for specific uses. The northern part of the county consists of broad terraces and floodplains, underlain by sand, gravel, limestone, and dolomite, and uplands underlain by thick loess. Because the central, southern, and western parts of the county are more dissected than the northern part, steep valley sides intervene between the floodplains and uplands in these areas. Throughout the county, a consistent sequence of rock materials is apparent: (1) loess on the uplands, (2) glacial till on the valley sides where streams have cut through the loess, (3) Pennsylvanian shale on the floors of tributary valleys, and (4) Devonian limestone on the floors of the major streams, the Mississippi and Rock Rivers.

The mineral resources of Rock Island County include limestone, dolomite, sand and gravel, clay, and coal. In addition, both surface water and ground water are plentiful in most of the county. The soils of the county are fertile and are extensively cultivated on the uplands and floodplains. Although many of the valley sides are too steep for cultivation, particularly in the western part of the county, they support extensive stands of mixed hardwood forest. Floods and unstable slopes are the primary geologic problems in construction, waste disposal, and other land development. The county's rivers, forests, and dissected topography offer suitable sites for additional outdoor recreational facilities.

INTRODUCTION

Population growth and attendant expansion of urban areas in Rock Island County (fig. 1) are leading to increasingly intense use of the land and its resources. Although most of the land in the county is used for agriculture, most of the population—more than 80 percent—lives in urban areas. Urbanization, however, is in places restricted by natural limitations of the land; not all land is suited for the variety of human activities desired.

This report summarizes the available information on the geology, mineral resources, and hydrogeology of Rock Island County as it relates to land use and to regional planning. It is part of a program of environmental geology studies that was begun at the Illinois State Geological Survey in 1962 and that has included a number of previously published reports on geology for planning (fig. 2).

Physical setting

The physical setting of Rock Island County is dominated by the major streams which flow across it and along its borders (fig. 1). The Mississippi River extends for more than 60 miles (97 km) along its western border and is no more than 14 miles (22.5 km) distant from any point in the county. The Rock River forms the eastern boundary through a distance of almost 20 miles (32 km) before flowing westward across the county to join the Mississippi at the city of Rock Island. Meredosia Channel forms the boundary for about 16 miles (26 km) on the northeast, draining a broad, flat channel that was once occupied by the Mississippi River. Thus, about 70 percent of the boundary of the county is marked by streams flowing in major valleys.

The confluence of the Rock and Mississippi Rivers influenced trade and settlement long before the coming of the pioneers. This was the ancestral home of the Sac and Fox Indians; the site of Sauk-e-nuk, one of the largest Indian villages in the midwest; and the home of Black Hawk, the last of the great warriors of the Sac and Fox. The transportation afforded by the rivers and their valleys and rich bottomlands, significant mineral resources, scenic river-bluff topography, and fertile upland prairies combine to make Rock Island County a favorable setting for business and agriculture and to provide attractive residential and recreational opportunities for an expanding population.

Previous investigations

The geology and mineral resources of Rock Island County have been mapped and described several times during the

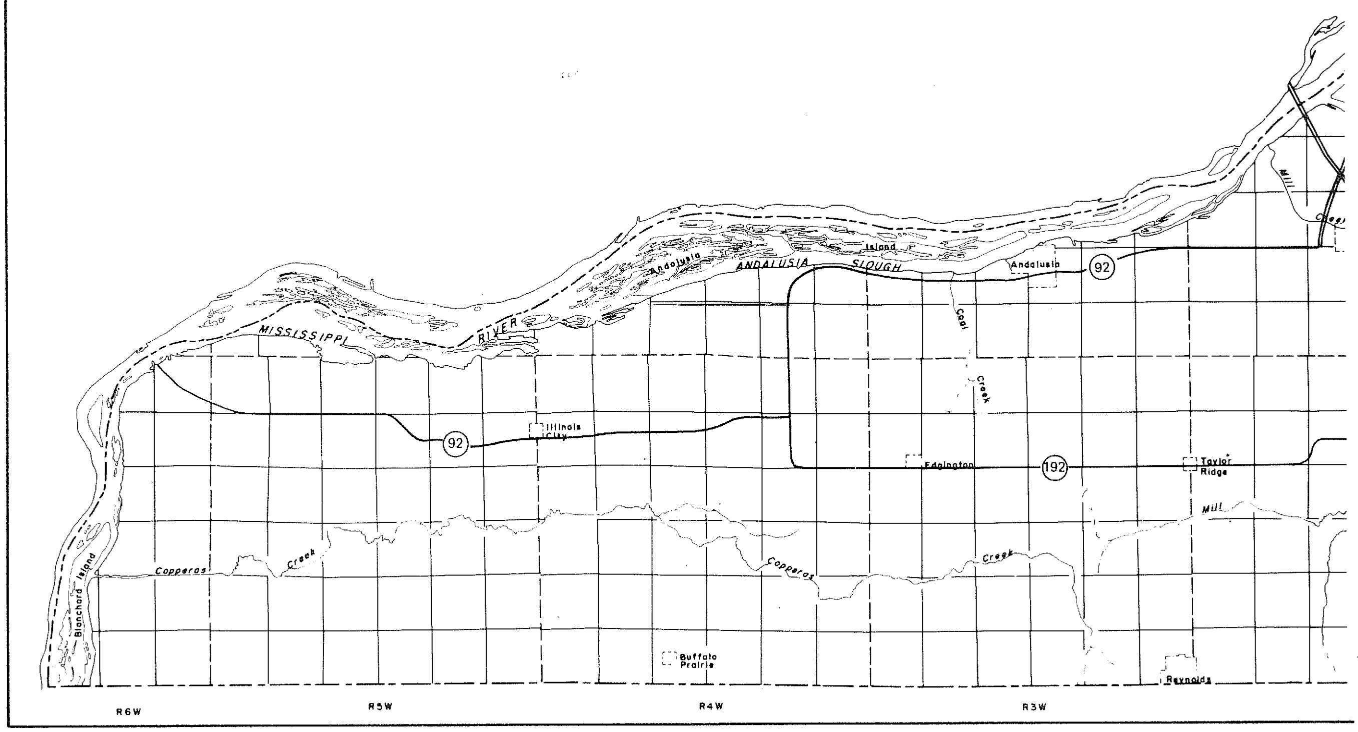
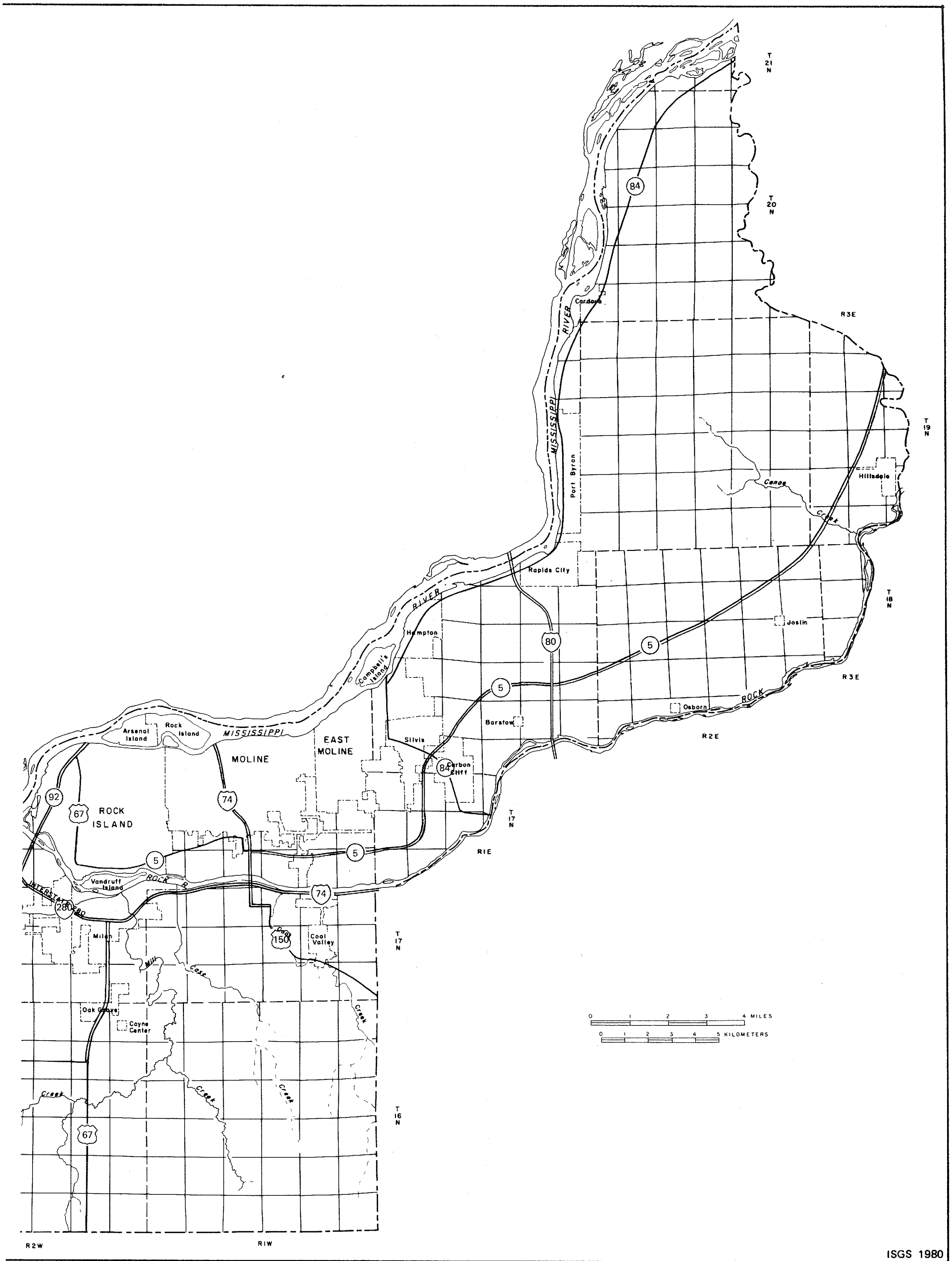


Figure 1. Principal geographic features of Rock Island County, Illinois.


MISSISSIPPI RIVER
Cordova
Port Byron
Rapids City
Hampton
Campbell's Island
Arsenal Island
Rock Island
MOLINE
EAST MOLINE
ROCK ISLAND
Silvis
Carbon Cliff
Barstow
Hillsdale
Joslin
Osborn
ROCK R.
Vandruff Island
Milan
Coal Valley
Oak Grove
Coyne Center
Canoe Creek
Mill Creek
Case Creek
Creek
INTERSTATE 280
R2W
R1W
R1E
R2E
R3E
T 21 N
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ISGS 1980

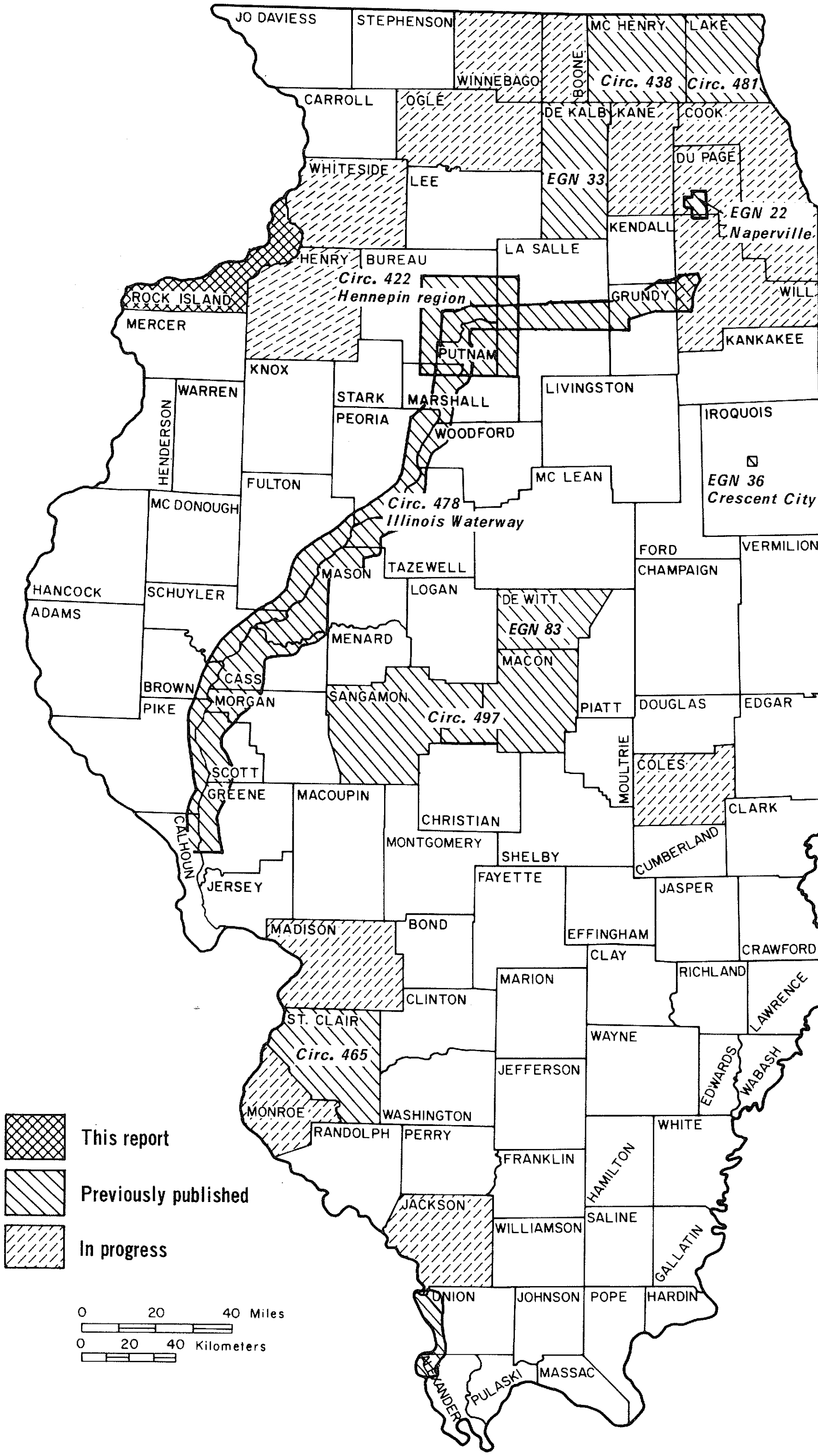


Figure 2. Areas included in environmental geology studies by the Illinois State Geological Survey.

past 100 years, each time in greater detail, to reflect the changing needs of a developing region.

The geology of Rock Island County was first described by A. H. Worthen (Worthen and Shaw, 1873) at a time when general principles were being formulated, upon which an understanding of the geology of the state could be based. By the end of the last century, the importance of Pleistocene glaciation in determining the landscape and surface materials of Illinois was widely recognized. These early studies of the glacial geology culminated in Monograph 38 of the U.S. Geological Survey by Frank Leverett (1899). The geology and mineral resources of the Milan and Edgington Quadrangles were later described in detail by Savage and Udden (1921). Recent studies reflect the need for more specific information: Parham (1961) described the clay resources of the county, and Brueckmann and Bergstrom (1968), the ground-water geology.

GEOGRAPHY

Topography

Rock Island County consists of relatively flat upland areas, ranging from 700 to 800 feet (213 to 244 m) above sea level, and river floodplains, which range from 580 feet (177 m) above sea level at the northeast end of the county to 540 feet (165 m) in the southwest. The Mississippi and Rock Rivers follow roughly parallel courses in the northern half of the county and are separated by a narrow upland tract, which itself is segmented by broad valleys connecting the Mississippi and Rock River floodplains (figs. 1 and 3). Thus, north and west of the Rock River valley, two distinct upland areas can be recognized: the Coe Upland, bounded by the Meredosia Channel on the northeast, the Mississippi River on the west, and Pleasant Valley on the south; and the Moline Upland, bounded by the Mississippi River on the north and west, the Rock River on the east and south, and Pleasant Valley on the northeast (Carman, 1909).

Like the Meredosia Channel, Pleasant Valley is an abandoned river channel formed by the diversion of drainage by Pleistocene glaciers (Horberg, 1950; Anderson, 1968; McGinnis and Heigold, 1974). Both the Coe and Moline Uplands lie at elevations of about 700 feet (213 m). They are drained by short tributaries generally flowing in narrow valleys having gradients ranging from 30 to 100 feet per mile (5.7 to 18.9 m/km). Some of these streams flow on bedrock for a short distance, usually less than a quarter of a mile, before leaving the upland. Elevations exceed 700 feet (213 m) only in the northern portion of the Coe Upland where thick deposits of wind-blown silt (loess) occur as northwest-southeast trending ridges, called pahas, which rise to elevations as high as 740 feet (226 m).

The southern and western parts of the county, south of the Rock and Mississippi Rivers, consist of two narrow, generally east-west trending upland areas, ranging in elevation from 750 to 800 feet (229 to 244 m), intricately dissected by small streams, and separated from one another by the valleys of Copperas and Mill Creeks. These creeks, in common with most of the streams of western Illinois, display a striking east-west orientation—Mill Creek flowing east and Copperas Creek flowing west from a common source a few miles southwest of Taylor Ridge. The uplands are remarkably flat, but they merge almost imperceptibly with the shallow drainageways which mark the headwaters of innumerable tributary ravines surrounding the uplands on all sides. Local relief exceeds 250 feet (76 m) in many places along the Mississippi River bluffs, and steep slopes with extensive hardwood forests cover a sizable percentage of the total area. This is the northern portion of the Galesburg Plain, characterized by valleys which "are steep-walled, alluviated, and terraced," and by uplands "relatively high above base level, so that the minor valleys are numerous, deep, and youthful" (Leighton, Ekblaw, and Horberg, 1948).

The extensive floodplains of Rock Island County are not restricted to areas immediately adjoining the major rivers. Although areas within the Meredosia Channel at the northern end of the county and Pleasant Valley in the central part of the county are subject to flood, they are not, in a strict sense, a part of either the Mississippi or Rock River floodplains. Their location, however, makes them subject to floods from either of these rivers. River terraces, former bottomlands which now lie above the reach of flood waters because new bottomlands have been formed at a lower level as a result of downcutting by the stream, are common in the valleys of the major rivers as well as in the abandoned channels. Though not as broad as the floodplains of the Mississippi and Rock Rivers, the floodplains of Copperas and Mill Creeks are well-defined and display most of the characteristics of those of the master streams, but on a smaller scale. In general, the valleys of the smaller tributaries are narrow and without floodplains.

Climate

Rock Island County has a typical continental climate with warm summers, cold winters, and a precipitation maximum in summer. From 1939 to 1978, mean monthly temperatures ranged from 21.5°F (-5.8°C) in January to 75.2°F (24.0°C) in July, and the mean annual range was 53.7°F (12.1°C). Extremes have ranged from -26°F (-32°C) in January 1974 to 106°F (41.1°C) in July 1936 (U.S. Department of Commerce, 1978). Mean annual temperature is 50.0°F (10.0°C). From 1939 to 1978 mean annual precipitation was 35.55 inches (903 mm); and 26.27 inches (668 mm) fell during the warm half of the year. During this period snowfall averaged 30.7 inches (780 mm) per year. Since 1938, mean annual temperature has ranged from 47.6°F (8.7°C) in 1978 to 52.6°F (11.4°C) in 1938, and annual precipitation, from 20.20 inches (513.1 mm) in 1956 to 56.36 inches (1431.5 mm) in 1973.

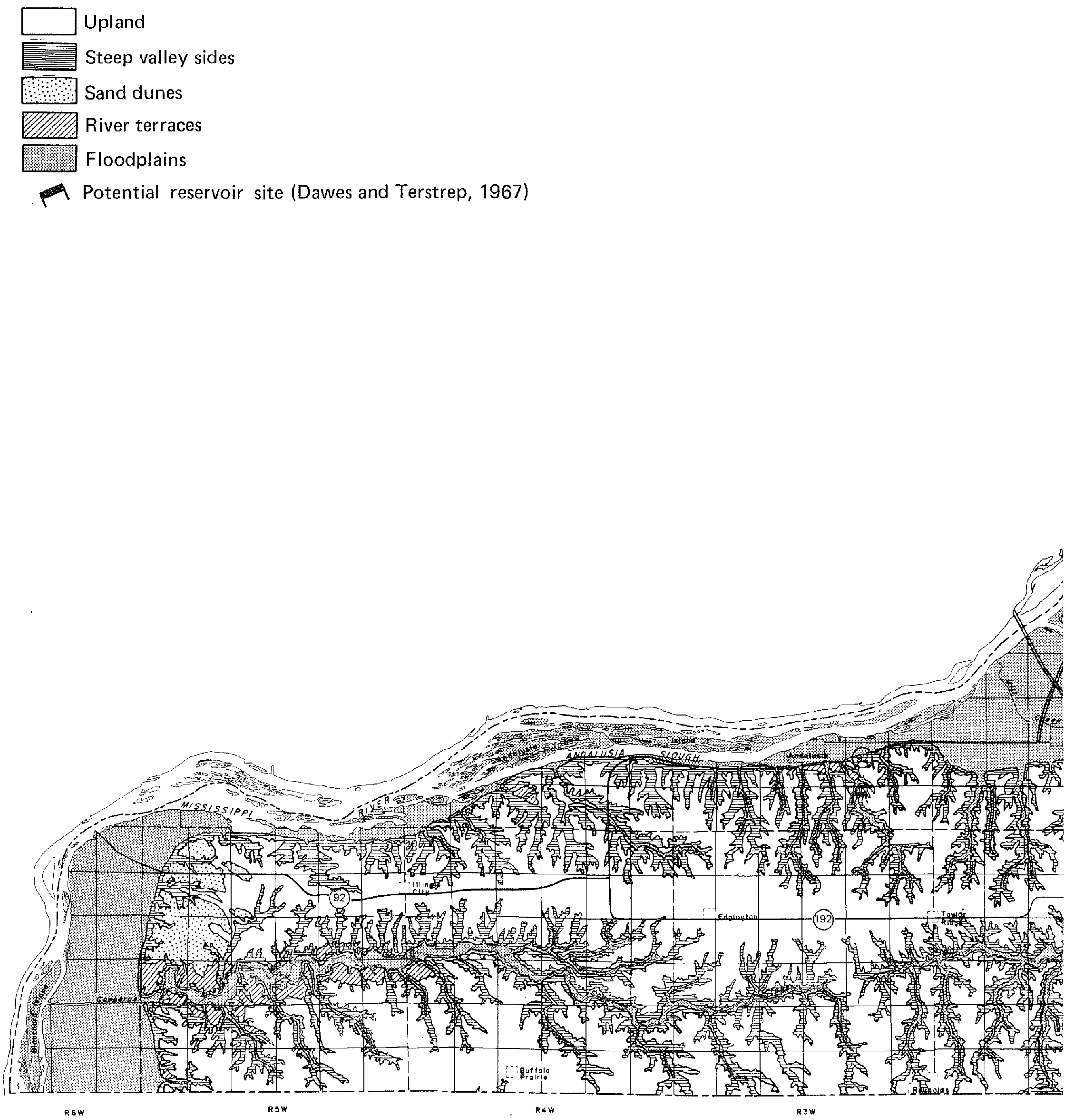
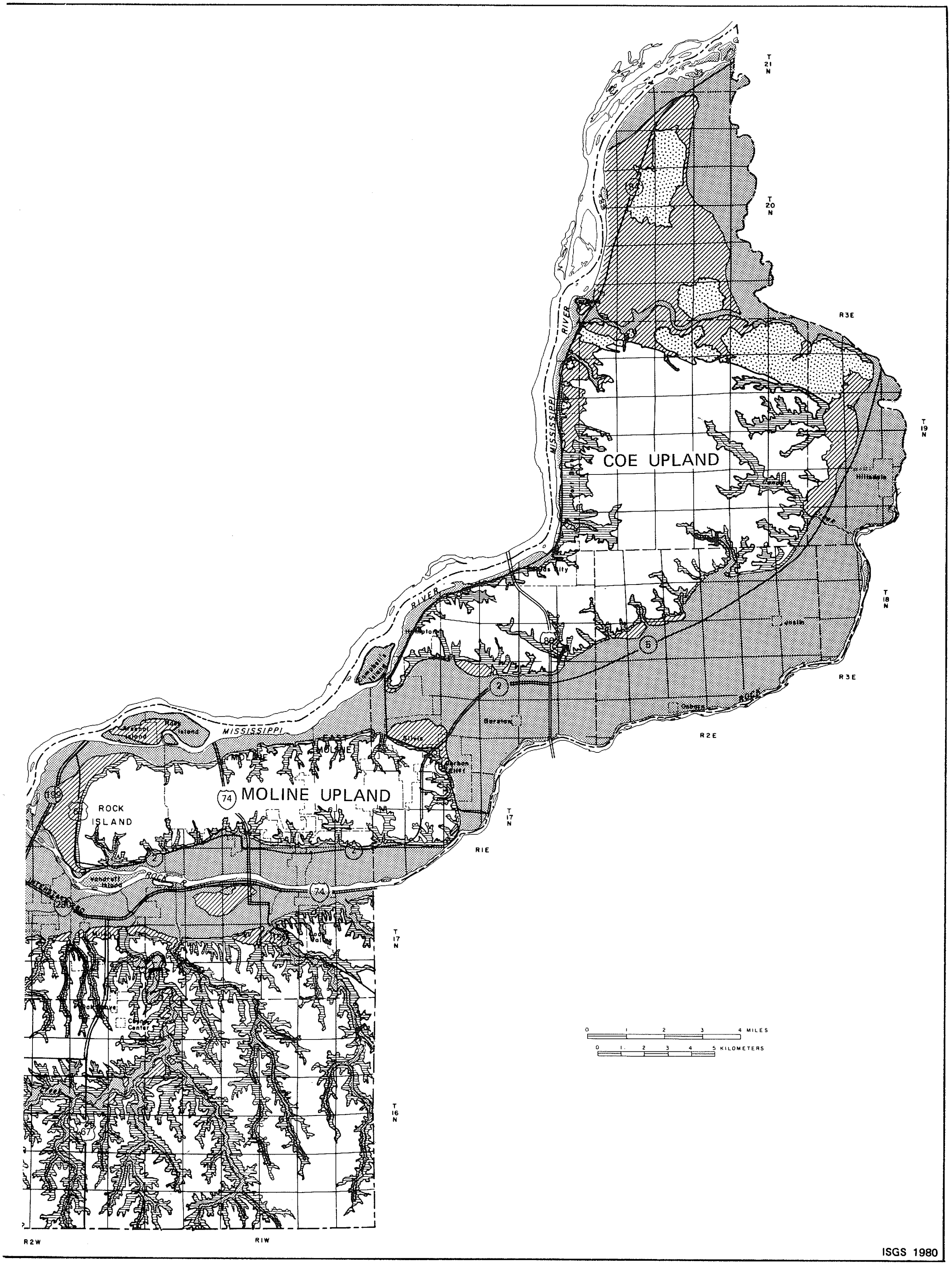


Figure 3. Terrains of Rock Island County, Illinois.


COE UPLAND
MOLINE UPLAND
ROCK ISLAND
MISSISSIPPI
MISSISSIPPI RIVER
RIVER
EAST MOLINE
MOLINE
ROCK
T 21 N
T 20 N
T 19 N
T 18 N
T 17 N
T 16 N
R3E
R2E
R1E
R2W
R1W
0 1 2 3 4 MILES
0 1 2 3 4 5 KILOMETERS
ISGS 1980

Population

According to the 1970 census, Rock Island County had a population of 166,734, an increase of 10.4 percent since 1960. By 1985, population is expected to increase by 20 percent (Bi-State Metropolitan Planning Commission, 1968), with the largest increase occurring in the young adult age group. Of the total population in 1970, 85.7 percent resided in urban areas, primarily in the central urbanized area of Rock Island, Moline, East Moline, and adjoining smaller communities.

Economy

The most important economic activities in the county are manufacturing and agriculture. Manufacturing accounted for 40 percent of the employed persons in 1965 (Bi-State Metropolitan Planning Commission, 1967); the manufacture of farm implements was of primary importance. Trade and services employed 25 percent of the labor force in 1965.

GEOLOGY

Rock materials

The exposed rocks of Rock Island County can be conveniently classified as either bedrock (mainly dolomite, limestone, and shale) or unconsolidated deposits[1] (glacial deposits, river deposits, and loess). The bedrock consists of sedimentary strata of Paleozoic age which underlie the unconsolidated deposits of Quaternary age (table 1). Because the bedrock is a great deal older than the unconsolidated deposits and was extensively eroded prior to the deposition of the latter, the contact between them is irregular, in places exposed at the surface and in other places deeply buried. The geologic map (plate 1) shows the distribution of these materials at the earth's surface, and the map of bedrock topography (fig. 4) shows the elevation and configuration of the top of the bedrock, the surface now largely buried beneath the unconsolidated deposits. The thickness of the unconsolidated deposits, which cover most of the county, is shown on figure 5. Bedrock is exposed only where erosion has removed the unconsolidated deposits, primarily along streams and the lower slopes of valley walls.

Bedrock

The bedrock of Rock Island County—described in considerable detail by Savage and Udden (1921), Buschbach (1965), and Brueckman and Bergstrom (1968)—consists of about 4,000 feet (1220 m) of sedimentary rock, ranging

[1]The term "unconsolidated deposits" is used in this report in a general sense for all the overburden materials above the firm, layered bedrock.

TABLE 1. Geologic column of Rock Island County.

TIME-ROCK UNITS		ROCK UNITS			
SYSTEM	SERIES	GROUP	FORMATION	THICKNESS ft. (m)	DESCRIPTION
QUATERNARY	Pleistocene			0-250(76)	Loess, glacial till, silt, clay sand and gravel
PENNSYLVANIAN	Desmoinesian	KEWANEE	Spoon	0-200(61)	Shale and sandstone with thin coals and limestone
	Atokan	McCORMICK	Abbott		
	Morrowan		Caseyville		
DEVONIAN			Cedar Valley Limestone	0-140(43)	Limestone, dolomite
			Wapsipinicon Ls.	0-60(18)	
SILURIAN	Niagaran		Racine	300(91)	Dolomite
			Marcus	40(12)	
	Alexandrian		Sweeney	45-65(14-20)	Dolomite
			Blanding	35-50(11-15)	
ORDOVICIAN	Cincinnatian	MAQUOKETA	Brainard Shale	75-90(23-27)	Shale
			Fort Atkinson	15-20(4.5-6)	Dolomite, shale
			Scales Shale	120(37)	Shale
	Champlainian	GALENA	Wise Lake	110(34)	Dolomite
			Dunleith	130(40)	Dolomite, cherty
			Guttenberg	20(6)	Dolomite, shale
		PLATTEVILLE		85-130 (26-40)	Limestone, dolomite
		ANCELL	Glenwood	5(1.5)	Sandstone, silty
			St. Peter	70-160 (21-49)	Sandstone
	Canadian	PRAIRIE DU CHIEN	Shakopee	207(63)	Dolomite
			New Richmond	50(15)	Sandstone
			Oneota		Dolomite
CAMBRIAN	Croixan		Eminence	60(18)	Dolomite, sandy
			Potosi	166(51)	Dolomite
			Franconia	180(55)	Sandstone, dolomite, shale
			Ironton-Galesville	130(40)	Sandstone
			Eau Claire	300(91)	Sandstone, siltstone, shale
			Mt. Simon	1250(381)	Sandstone
PRECAMBRIAN					Igneous (granite)

in age from Cambrian to Pennsylvanian, lying on granitic rock of Precambrian age (table 1). The characteristics of these sedimentary rocks and their enclosed fossils indicate that they were deposited on the beaches, reefs, deltas, and offshore areas of shallow seas.

At the base of the sedimentary section, sandstone predominates; almost 1,900 feet (580 m) of sandstone occurs between the base of the Mt. Simon Sandstone and the top of the Franconia Formation (table 1). Dolomite and shale are minor elements in this lowest part of the section. In contrast, dolomite and limestone make up the bulk of the next 1,800 feet (549 m), from the base of the Potosi Dolomite to the top of the Devonian System. Within this interval, however, are several sandstones, the most important of which is the St. Peter, a significant source of ground water. In addition, shale of the Maquoketa Group occurs near the top of this dolomite-limestone sequence. The shale is relatively impermeable and restricts the vertical movement of liquids and gases.

The Racine Formation (Silurian System) is the oldest rock exposed at the surface in Rock Island County (S in plate 1). Consisting of brownish-yellow to gray, porous, crystalline dolomite, it occurs in beds ranging in thickness from a few inches to several feet. Whereas in general the strata in this part of the state are inclined gently southward, the Racine Formation displays marked local departures from this regional trend as a result of initial deposition on the flanks of coral reefs which were common in the warm, shallow seas of the Silurian Period. The cores of the reefs are composed of coral and a variety of other invertebrate fossils. The cores generally are poorly stratified and very porous. Such structures can be observed in the Midway Stone Company quarry (SW¼ Sec. 16, T. 18 N., R. 2 E.), the Cordova quarry (SE¼ Sec. 1, T. 19 N., R. 1 E.), and in numerous outcrops along the Mississippi River bluffs between Rapids City and Cordova. Caves and solutional openings, common in the Racine Formation, are particularly conspicuous along the south bluffs of the Meredosia Channel in the northern part of the county (Bretz and Harris, 1961).

The Wapsipinicon and Cedar Valley Limestones of Devonian age (D in plate 1) overlie the Racine Formation (fig. 6) and are found at the surface in Rock Island County along the Mississippi River between East Moline (Campbells Island) and Andalusia and along the Rock River in the vicinity of Milan. The older of the two Devonian units, the Wapsipinicon Limestone, is fine-grained, light gray limestone, in places dolomitic. Beds are generally uniform and from 0.5 to 3.0 feet (0.15 to 0.9 m) thick. Fossils are rare, but thin laminations of algal origin (stromatolites) are common. Breccia is also common.

The Cedar Valley Limestone overlying the Wapsipinicon Limestone can be distinguished by its shaly, thin-bedded character and by its abundance of fossils. In addition, it contains no dolomite or dolomitic limestone and is medium to coarse grained. Although both of these formations are relatively dense, they readily transmit water along horizontal bedding planes and vertical joints. Solution openings, however, though not conspicuous in outcrops, are occasionally encountered in engineering borings on the floodplains of both the Mississippi and Rock Rivers. Caves in the Devonian limestones which have been filled with Pennsylvanian shale are common (fig. 7) and in places, such as on Vandruff Island in the lower Rock River valley, cave fillings may constitute an important percentage of the total volume of rock, possibly as much as 10 percent.

The uppermost, hence youngest, bedrock of Rock Island County is shale, sandstone, and coal of the Pennsylvanian, Caseyville, Abbott, and Spoon Formations (see plate 1 and table 1). These rocks crop out in the floodplains and valley walls throughout the county south and west of the southern portion of the Coe Upland, though they are best exposed along the Mississippi River bluffs downstream from Andalusia. Whereas the exposed rocks of Silurian and Devonian age are rather uniform in character and composition, the rocks of Pennsylvanian age are diverse. The most common rocks are gray to black, structurally weak claystone, shale, and siltstone; but sandstone—in places as much as 20 feet (6.1 m) thick—and coal are also important constituents. Sulfides, particularly iron sulfides (FeS), and their oxidation and hydration products are disseminated throughout.

The sediments that formed the Pennsylvanian rocks were deposited on vast deltas that covered much of the central United States. Deposition by streams migrating to and fro across this delta produced important, sometimes abrupt, changes in the kinds of sediment deposited.

For the following reasons the Pennsylvanian rocks warrant special attention in evaluating the suitability and use of land in Rock Island County: (1) they are widespread; (2) they are possible sources of clay and coal; (3) they are commonly unstable on hillslopes; (4) they are commonly a barrier to the downward movement of ground water, thus producing springs and saturated ground on slopes; and (5) they commonly release undesirable sulfurous compounds when they are exposed to the atmosphere.

Certain physical properties of Pennsylvanian shales from Rock Island County are reported by Parmelee and Schroyer (1922), Parham (1961), White (1960), and White and Lamar (1960).

Unconsolidated deposits

The unconsolidated deposits overlying the bedrock of this area have been described by Leverett (1899), Savage and Udden (1921), Horberg (1956), Anderson (1967), Willman, Glass, and Frye (1963, 1966), and Frye, Glass, and Willman (1968). In addition, outlines of the glacial history can be found in Carman (1909), Horberg (1950, 1956), Shaffer (1954), Leighton and Brophy (1961), Frye, Willman, and

Pennsylvanian

Devonian

Silurian

-700- Contour showing elevation of top of bedrock; interval 50 feet (15 m)

Bedrock outcrop (or within 5 feet of the surface)

Well

Contact between bedrock units

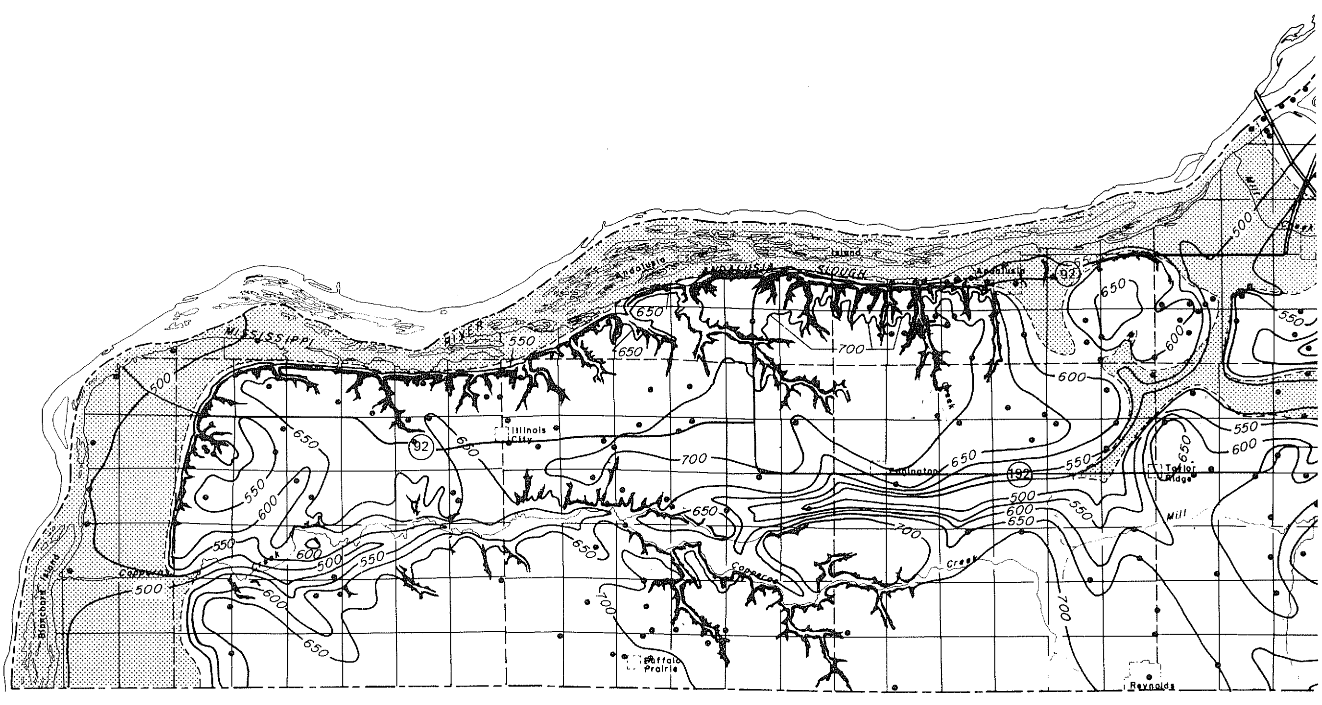
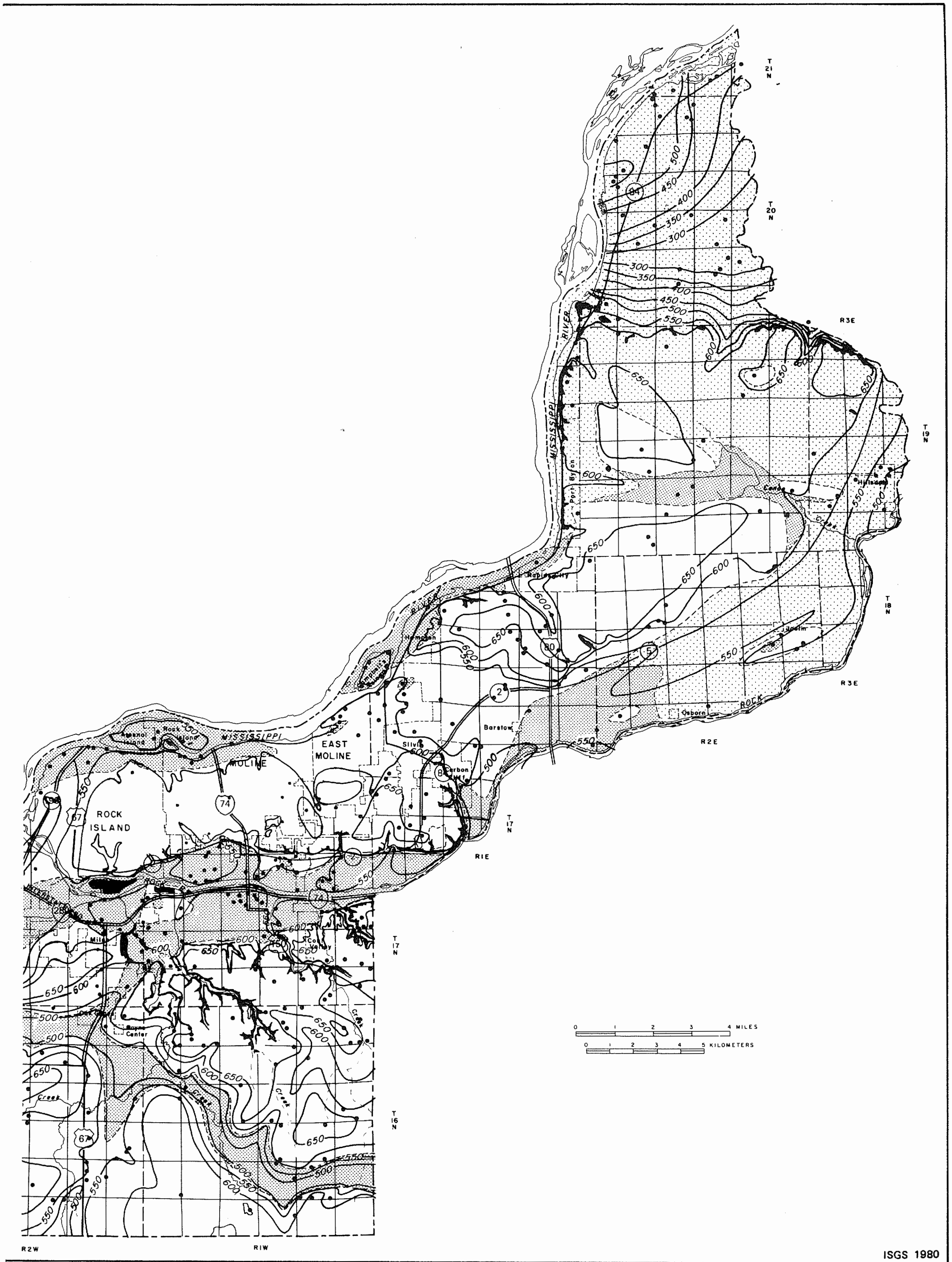


Figure 4. Bedrock topography and geology of Rock Island County, Illinois.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MISSISSIPPI RIVER
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MOLINE
EAST MOLINE
Port Byron
Rapids City
Hampton
Barstow
Silvis
Carbon Cliff
Cordova
Hillsdale
Osborn
Coal Valley
Milan
Rock Island Arsenal
ROCK
Creek
0 1 2 3 4 MILES
0 1 2 3 4 5 KILOMETERS
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Bedrock outcrop

650 Thickness lines; interval 50 feet

25 foot thickness line dashed

Well

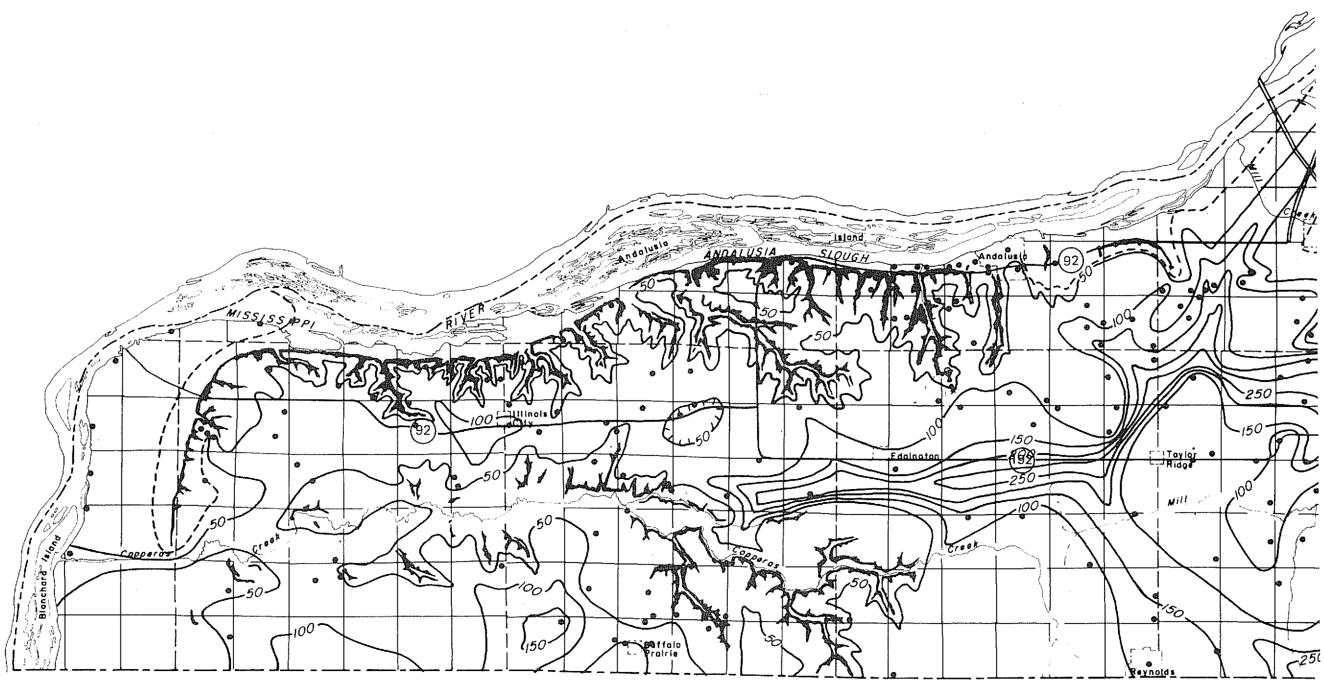

Figure 5. Thickness of unconsolidated deposits in Rock Island County, Illinois

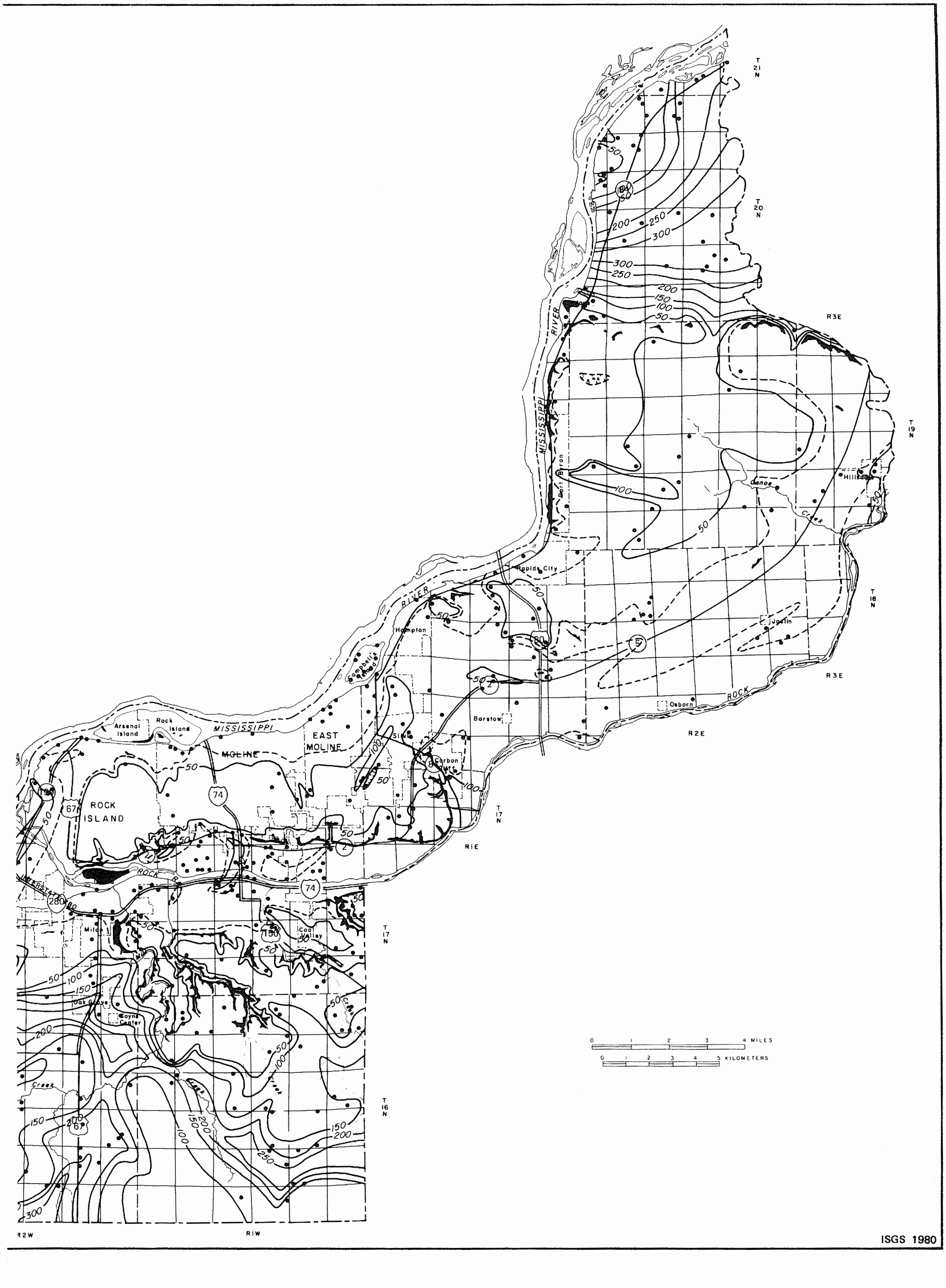
MISSISSIPPI RIVER
ROCK ISLAND
MOLINE
EAST MOLINE
Arsenal Island
Rock Island
Campbell's Island
Hampton
Rapids City
Port Byron
Hillsdale
Canoe Creek
Joslin
Osborn
Barstow
Silvis
Carbon Cliff
Milan
Coal Valley
Oak Grove
Coyne Center
ROCK R
INTERSTATE RD
T 21 N
T 20 N
T 19 N
T 18 N
T 17 N
T 16 N
R3E
R2E
R1E
R2W
R1W
0 1 2 3 4 MILES
0 1 2 3 4 5 KILOMETERS
ISGS 1980

Figure 6. Silurian, Devonian, and Pennsylvanian rocks exposed in the Cleveland Quarry, SW¼ Sec. 31, T. 18 N., R. 2 E., Henry County. The Pennsylvanian rocks occur in a shallow sinkhole.

Black (1965), and Anderson (1968). The nomenclature and general characteristics of the unconsolidated deposits are summarized in table 2.

Because they are the principal materials upon which man's activities occur, the unconsolidated deposits are of primary importance. Formed by the action of glacial ice, running water, and wind, they show great variation in grain size, sorting (uniformity of grain size), and thickness. Though certain generalizations can be made regarding their physical properties, on-site sampling and testing are necessary for determining their suitability for any specific purpose.

Though complex in detail, the unconsolidated deposits can be classified into three basic categories: (1) glacial till—an unsorted unstratified mixture of silt, clay, sand, pebbles, and boulders deposited from glacial ice as the continental glaciers melted; (2) silt, sand and gravel deposited on floodplains by glacial meltwater (outwash) and by post-glacial streams (alluvium); (3) loess and dunes, formed of silt and sand that were derived from water-laid materials of the river floodplains and blown onto the uplands by wind. Thus the unconsolidated deposits of the uplands consist largely of glacial till overlain by loess, whereas water-deposited silt and sand is most common on the floodplains (plate 1).

The oldest unconsolidated materials in Rock Island County were deposited during the Kansan Stage of continental glaciation. Because these materials, assigned to the Banner Formation (table 2), are poorly exposed in Rock Island County, no attempt has been made to map them separately; instead they are included with the Illinoian deposits on plate 1.

Well logs and samples indicate that the Banner Formation is usually present beneath the uplands south of the Mississippi and Rock Rivers and may exceed 200 feet (61 m) in thickness in the Ancient Green River Valley (plates 1 and 2). Till constitutes the bulk of the Banner Formation, but masses of sand and gravel occur both within and beneath the till. The gravel is more than 20 feet (6.1 m) thick in places along the Ancient Green River

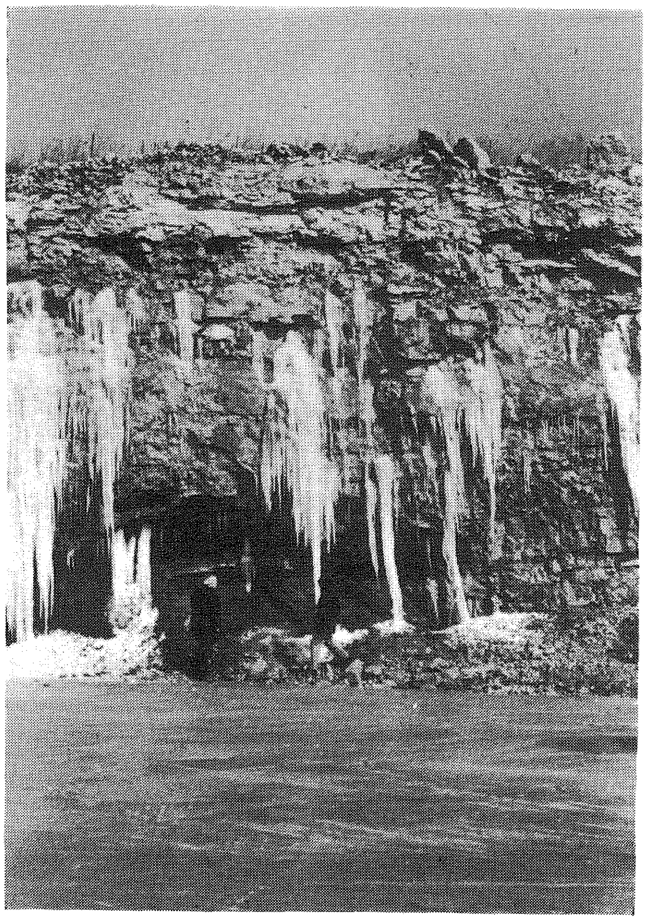

Figure 7. Cave in Wapsipinicon Limestone filled with Pennsylvanian shale. Icicles mark points of ground-water discharge along bedding planes. Allied Stone Company Quarry, SE¼ Sec. 14, T. 17 N., R. 2 W., Rock Island County.

Valley. The well records suggest that more than one layer of till is present within the Banner Formation and that material older than the Banner Formation may occur where the unconsolidated deposits are thick. Positive identification of these subdivisions and older units cannot be made on the basis of existing information, however. Grain-size and mineralogical data from the Banner Formation are summarized in table 3.

Materials of the Illinoian Glacial Stage compose the Petersburg Silt at the base and the Glasford Formation above. The Glasford Formation consists largely of the Kellerville Till Member but includes the Berry Clay Member at the top (table 2). No attempt has been made to map these members individually.

The Petersburg Silt represents outwash and loess deposited in front of the advancing Illinoian glacier and subsequently overridden by the ice and buried by the Kellerville Till. Although the silt is poorly exposed in Rock Island County, it has been encountered in numerous wells particularly along Mill Creek (plate 2). It is similar in mineral composition to the Kellerville Till (table 3).

The Kellerville Till Member is present throughout the county (plates 1 and 2), except where it has been removed by erosion along the major valleys. It is generally less than 50 feet (15 m) thick. Though primarily till (gk-t on plate 1), it contains lenses of sand and gravel (gk-o). Grain size and mineralogical analyses of the Kellerville Till Member are summarized in table 3.

The top of the Kellerville Till Member is marked throughout the county by the presence of a well-developed, widely recognized ancient soil, the Sangamon Soil, which now lies buried beneath younger sediments (plate 2). In most natural exposures in Rock Island County the Sangamon Soil developed under well-drained, oxidizing conditions and displays a typical red-brown color. In flat, upland locations, however, where numerous closed depressions were present on the undulating surface of the Kellerville Till, drainage was poor and reducing conditions prevailed, giving rise to a dark-gray Sangamon Soil. Within these depressions, the Berry Clay, an accretion-gley (Willman and Frye, 1970), was deposited by sheetwash from nearby slopes and forms an integral part of the Sangamon Soil. The grain size of the Berry Clay is similar to that of the Kellerville Till in the samples analyzed, but normally contains a much greater proportion of clay-size material. Since it was derived in large part from pre-existing material deposited in a gleying (reducing) environment, it has an increased proportion of expandable clay minerals (table 3).

The Glasford Formation is overlain by wind-deposited material of Wisconsinan age, the Roxana and Robein Silts, and the Peoria Loess (table 2). Because the Roxana and Robein Silts are generally less than 5 feet (1.5 m) thick, they have been mapped with the Peoria Loess (pr on plate 1). Grain size and mineralogical analyses of these sediments are summarized in table 3.

Though primarily silt, the Peoria Loess contains lenses of fine sand and in places grades both laterally and vertically into the Parkland Sand and the Dolton Member of the Equality Formation. The latter served, at least in part, as the source of the Peoria Loess (table 2). The Peoria Loess is present everywhere on the uplands in Rock Island County (plate 1 and fig. 8), varying in thickness from 15 to 50 feet (4.6 to 15 m). Grain size and mineralogical analyses of the Peoria Loess are summarized in table 3.

The Parkland Sand, also wind-deposited and in places, contemporaneous with the Peoria Loess (table 2), is mapped only where it forms recognizable dunes (pl on plate 1). Almost exclusively fine sand, it was derived primarily from the Dolton Member of the Equality Formation and the Mackinaw Member of the Henry Formation.

Within the valleys of Rock Island County occur a variety of water-laid sediments, some of which form terraces and/or underlie the floodplains—the Equality and

TABLE 2. Sequence, age, and physical character of unconsolidated deposits in Rock Island County

SYSTEM	SERIES	STAGE	SUBSTAGE	FORMATION AND MEMBERS	SEDIMENT TYPE AND THICKNESS ft(m)
QUATERNARY	PLEISTOCENE	WISCONSINAN	Valderan, Twocreekan, Woodfordian	Peoria Loess	Silt 0-50(15)
		WISCONSINAN	Valderan, Twocreekan, Woodfordian	Henry Fm. Mackinaw Mbr.	Sand, silt, gravel 0-50(15)
		WISCONSINAN	Valderan, Twocreekan, Woodfordian	Equality Fm. Dolton and Carmi Mbrs.	Silt, fine gravel 0-30(9)
		HOLOCENE, WISCONSINAN	Valderan, Twocreekan, Woodfordian	Parkland Sand	Fine sand 0-50(15)
		HOLOCENE, WISCONSINAN	Valderan, Twocreekan	Peyton and Lacon Fms.	Mixed deposits inc. bedrock 0-10(3)
		HOLOCENE, WISCONSINAN	Valderan, Twocreekan	Cahokia Alluvium	Silt, clay, sand 0-30(9)
		WISCONSINAN	Farmdalian	*Farmdale Soil* Robein Silt	Silt, sandy silt, organic 0-5(1.5)
		WISCONSINAN	Altonian	Roxana Silt	Silt, pebbles near base 0-5(1.5)
		SANGAMONIAN		Glasford Fm. *Sangamon Soil*	
		ILLINOIAN	Jubileean, Monican	Glasford Fm. Berry Clay Mbr.	Clay, silt, sand, small pebbles 0-5(1.5)
		ILLINOIAN	Liman	Glasford Fm. Kellerville Till Mbr.	Till, sand -0-100(30)
		ILLINOIAN	Liman	Petersburg Silt	Silt 0-5(1.5)
		KANSAN		Banner Fm.	Till, sand 0-100(61)

Henry Formations—and others which occur only as a veneer on the floodplains themselves—the Cahokia Alluvium and Peyton Colluvium (table 2, fig. 9).

The Equality Formation is primarily fine sand (Dolton Member; ed on plate 1) deposited in lakes formed when glacial ice dammed the Mississippi River (Shaffer, 1954; Anderson, 1968). In tributary valleys such as Mill Creek it is primarily silt (Carmi Member, ec on plate 1).The Equality is exposed at the surface only in terraces, although it is possible that silt occurs beneath the Cahokia Alluvium on the floodplains as well. Maximum thickness is about 20 feet (6.1 m), on the south side of the Rock River Valley near Milan.

The Henry Formation (Mackinaw Member) is silt and sand deposited as outwash from the Wisconsinan glacier. It displays considerable variation in texture and composition, a characteristic not adequately reflected in the data of table 3, which includes only 4 samples, all from a single locality (NE¼ NE¼ NW¼, Sec. 21, T. 18N., R. 1E.) where the formation is primarily silt. Most of the Henry Formation is, in fact, pebbly sand and is the material in which all of the large sand and gravel pits of the county are located (Anderson, 1967). The formation reaches thicknesses in excess of 30 feet (9.1 m) at the mouth of the Rock River, southwest of Barstow and in Cordova Township. Over most of its extent it is covered by Cahokia Alluvium and is exposed at the surface only in terraces (hm-e, hm-c, and hm-d in plate 1).

The Cahokia Alluvium, material deposited on the floodplains by present-day streams, ranges in grain size from clay and silt to pebbly sand. Grain size and mineralogical data are summarized in table 3.

Three varieties of Cahokia Alluvium can be recognized: (1) silt and fine sand deposited as river bars and natural levees (c-nb on plate 1), (2) silt and clay with high organic content accumulating in abandoned channels and in poorly-drained low areas between bars (c-cb on plate 1), and (3) fine sand deposited as low arcuate ridges, point bars, on the inside of meander loops (c-pb on plate 1). In Rock Island County, point bars are restricted to an area along the Rock River one mile south of Joslin (Sec. 13 and 24, T. 18 N., R. 2 E., and Sec. 18 and 19, T. 18 N., R. 3 E.). The river bar, natural levee, and abandoned channel deposits occur throughout the county and often contain layers of red-brown silt and clay. Gray and brown usually predominate, however. The maximum thickness of the Cahokia Alluvium is not known with certainty, but it probably does not exceed 10 feet (3 m) in most places, and occasionally it may be seen in shallow excavations resting directly on bedrock. It is distinguished from the under-

TABLE 3. Summary of grain size, carbonate composition, and clay mineralogy of the unconsolidated deposits in Rock Island County

Stratigraphic unit	Grain size (< 2 mm)%				Carbonate compositon		Clay mineralogy (< 2 μm)%			
	No. of samples	Sand	Silt	Clay	No. of samples	Ratio calcite/dolomite[a]	No. of samples	Expandable clay	Illite	Kaolinite and chlorite
CAHOKIA ALLUVIUM										
Calcareous	1	5	65	30			1	83	10	7
Noncalcareous	6	34	44	22			6	67	22	11
Total	7	30	47	23			7	69	20	11
HENRY FORMATION										
Calcareous					1	0.67	2	82	11	7
Noncalcareous							2	54	17	29
Total	4	1	55	44			4	68	14	18
PEORIA LOESS										
Calcareous	7	7	76	17	25	0.76	36	67	21	12
Noncalcareous	17	4	62	34			18	77	13	10
Total	24	5	66	29			54	70	19	11
ROBEIN SILT										
Noncalcareous							4	74	9	17
ROXANA SILT										
Calcareous	2	5	73	22	1	0.50	2	54	29	21
Noncalcareous	4	18	55	27			7	60	19	21
Total	6	14	61	25			9	59	21	20
BERRY CLAY										
Noncalacerous	2	33	35	32			5	80	6	14
KELLERVILLE TILL										
Calcareous	6	43	32	25	23	0.61	33	32	45	23
Noncalcareous	11	30	36	34			20	41	32	27
Total	17	35	35	30			53	35	40	25
PETERSBURG SILT										
Calcareous					7	0.57	7	22	56	22
Noncalcareous							3	49	30	21
Total							10	30	48	22
BANNER Fm. (till)										
Calcareous					1	4.83	7	51	25	24
Noncalcareous							4	56	21	23
Total	1	36	33	31			11	53	23	24

[a]Based on X-ray counts per second

lying Henry Formation primarily on the basis of its fine grain size. Typical field relationships of various flood-plain materials are shown in figure 9.

The Peyton Colluvium is a poorly sorted mixture of silt, clay, sand, and pebbles which has accumulated, largely by creep and slopewash, at the base of steep, unstable slopes. It also includes alluvial fans. The Peyton Colluvium is often found in association with the Lacon Formation, the deposits of large-scale mass-movements on steep slopes. The Lacon Formation is the product of soil and rock creep, slump, and landslides, all common on steep slopes underlain by weak materials such as Pennsylvanian shale, glacial till, and loess. When dry, these materials are firm and stable but when water saturated, they lose strength and then creep, slump, or slide downhill. Such conditions are commonly present on the steep valley sides in Rock Island County, particularly in those areas where Pennsylvanian shale is present. The Lacon Formation is recognizable throughout the county. However, it has not been mapped separately, because some areas are too small to map and

Figure 8. Typical relationship of the Peoria Loess and the Kellerville Till, with the Sangamon Soil at the top of the Kellerville Till. The Robein and Roxana Silts are often found directly above the Sangamon Soil. Cut for Interstate Highway 80 in SE¼ Sec. 3, T. 18 N., R. 1 E., Rock Island County.

other areas do not have definable boundaries. Also the materials which make up the extensive unstable slopes—loess, glacial till, and shale—can usually be distinguished and mapped individually even though they may have moved downslope. The Peyton Colluvium is mapped only where it is extensive and easily recognized on aerial photographs, such as along the bluffs of the Mississippi River downstream from the mouth of the Rock River. It is usually less than 10 feet (3 m) thick.

Bedrock topography

The irregular bedrock surface upon which the unconsolidated deposits lie displays uplands and valleys just as the present landscape does, but these features do not necessarily coincide with those of the present landscape. The topography on the bedrock is the result of erosion both prior to the deposition of Pleistocene glacial materials and during and subsequent to glaciation. Hence in some places present-day valleys bear little relationship to the buried landscape below. The nature of the actual relationship is shown in the cross sections (plate 2). The configuration of the bedrock surface is significant in planning because it determines the location of bedrock outcrops and the thickness of unconsolidated deposits.

The bedrock topography in Rock Island County is shown in figure 4. Subtracting the elevations at any point on figure 4 from the elevation of the corresponding point at land surface gives the thickness of the unconsolidated deposits (fig. 5). In general, the bedrock topography shows the same arrangement of major uplands and valleys found in the surface topography. Beneath the Coe and Moline Uplands, bedrock lies at elevations of 600 to 650 feet (183 to 198 m), and the thickness of unconsolidated deposits ranges from 50 to 100 feet (15 to 30 m). North of Cordova, bedrock descends to elevations less than 450 feet (137 m), and the unconsolidated deposits exceed 200 feet (61 m) in thickness (McGinnes and Heigold, 1973, 1974). The bedrock reaches its highest elevations—over 700 feet (213 m)—in the western end of the county, and it is here that bedrock exposures are most numerous and the unconsolidated deposits rather thin, generally less than

Figure 9. Vertical aerial photograph showing the distribution of unconsolidated deposits of the Rock River floodplain in the vicinity of the Quad-City Airport. Photo taken in 1958. The map units are the same as in plate 1. Dotted lines indicate minor floodplain channels. Dashed lines indicate extent of standard project flood.

100 feet (30 m) thick. In this area, Pennsylvanian bedrock is extensively exposed in the bluffs of the Mississippi River and along Copperas Creek. In contrast, bedrock lies at low elevations along the course of the Ancient Green River valley (Horberg, 1950), which runs eastward from a point about 3 miles west of Edgington to the southeastern corner of the county (plates 1 and 3). Here unconsolidated deposits, mostly fine-grained, water-laid sediments, exceed a thickness of 200 feet (61 m) in many places. Bedrock lies at shallow depth, generally less than 25 feet (7.6 m), along the Mississippi River downstream from Cordova and along the Rock River downstream from Hillsdale. It is in these floodplain areas, where overburden is thin, that most of the quarries of the county are located.

Relationships of rock materials and topography

The landscape-forming processes—weathering, mass-wasting (gravitative movement on slopes), and erosion and deposition by streams and wind—act upon the rock materials at the earth's surface. Earth processes and materials together determine the form of the landscape. In order to use land effectively, it is necessary to understand this relationship. The following discussion together with table 4 describes the considerations necessary for such an understanding.

Uplands

Throughout the upland areas (fig. 3) Peoria Loess lies at the surface, ranging in thickness from about 50 feet (15 m) in the northeast to less than 20 feet (6.1 m) in the southwest. The loess is thickest where it forms elongate ridges, or dunes, called pahas, in the extreme northeast, a few miles southeast of Cordova (plate 1). This is the only place where the loess exhibits a topography of its own (Flemal et al., 1972). Elsewhere it lies as a uniform mantle into which present streams are eroding. Hence, in any local area, it is thickest on the upland divides and thins to a vanishing edge on the surrounding slopes. With few exceptions, the Peoria Loess including Roxana Silt lies on the Glasford Formation.

Steep valley sides

Because the uplands stand significantly higher than the adjoining floodplains, they are vulnerable to erosion by water flowing from the uplands to the floodplains through innumerable ravines and tributary valleys. Two of these tributaries, Copperas Creek and Mill Creek, are large enough to have sizable floodplains of their own, together with a host of tributaries and ravines. Whether tributary to major streams (Mississippi and Rock Rivers) or to secondary streams (Copperas and Mill Creek) these ravines are characteristically short, generally less than four miles long, and steep, having gradients between 50 and 100 feet (15 and 30 m) per mile. The steep sides of these valleys constitute a considerable portion of the total area of the county (fig. 3). Smith et al. (1925) consider 29 percent of the area of the county to be rough enough to be subject to serious soil erosion.

The materials encountered on the steep valley sides are usually more varied and complex than plate 1 indicates. A large amount of the material on the valley sides has slumped or has become dislocated from its initial position and has moved downslope. The dislocated material includes both the Peyton and Lacon Formations. While moving, the dislocated materials may become mixed with the underlying materials. The Pennsylvanian shale, the material most susceptible, has slumped to some degree in most outcrops.

In areas where no visible or significant movement has taken place, the most common stratigraphic sequence found along steep valley sides, from top to bottom, is as follows: (1) the Glasford Formation, primarily the Kellerville Till Member, but including sand and silt; (2) the Banner Formation, mapped with the Glasford Formation; and (3) bedrock, primarily the Pennsylvanian System (plates 1 and 2). The upper reaches of these valleys extend into the upland where they are cut into the Peoria Loess and have relatively low gradients and gently-sloping sides. The contact of the Peoria Loess and the underlying Glasford Formation is usually marked by a distinct steepening of slope. Except in the northeast, this contact is used to mark the boundary between the upland and steep valley-side terrains. Because the Glasford Formation is less permeable than the Peoria Loess, this contact is also often marked by a zone of springs and seeps, particularly during wet seasons. The contact between the Glasford Formation and the underlying Pennsylvanian shale exhibits similar characteristics. Though composed largely of shale, the Pennsylvanian contains coal, claystone, and sandstone and has suffered from extensive slumping on exposure.

Where the top of the bedrock is at low elevations, it may not crop out on the valley sides, as is the case in the middle and upper portions of the Mill Creek drainage basin, where the slopes are less steep and consist entirely of the Glasford Formation (plate 1). Although the Glasford Formation is mostly till, it includes sand and gravel as well. Where sand and gravel is extensive, it is mapped separately as outwash (plate 1). The largest outcrop of Illinoian outwash encountered in this study lies in Sections 1 and 2, T. 16 N., R. 3 W., 1 mile (1.6 km) northwest of Taylor Ridge in the valley sides adjoining Fancy Creek and its tributaries. These deposits lie in the Ancient Green River valley (fig. 4) and might be anticipated, though they are not actually observed, in similar locations along other north-flowing creeks immediately to the east, such as Turkey Hollow Creek, Warren Creek, and Sand Creek.

In places, valleys carved in the bedrock have been filled with unconsolidated deposits which are now being removed by present-day stream action. In the case of the valley of Copperas Creek, for example, the stream has only partially removed the unconsolidated deposits so that in some places bedrock is encountered on the valley sides whereas in other places only till and its associated materials occur.

North of Rapids City, the steep valley sides usually consist either entirely of Peoria Loess or of Peoria Loess overlying Silurian dolomite.

Sand dunes

Sand dunes, though not extensive in Rock Island County, form a distinctive terrain (fig. 3). Dune areas, occurring at both the northeastern and southwestern extremities of the county, consist of fine-grained, well-sorted sand, called the Parkland Sand, and usually overlie sandy materials of the Equality and Henry Formations. Since these formations always form terraces, the sand dunes are also found on terraces. The dunes occur in two distinct topographic positions, suggesting that they formed at two different times. In a few small areas where vegetation is scant dunes are still forming.

The older dunes are built on a terrace at an elevation of about 650 feet (198 m) and are, in fact, a part of the upland itself. These dunes, occuring at the extreme western end of the southwestern upland tract (plate 1), are closely associated with the underlying sands of the Henry Formation, from which they undoubtedly were derived. Likewise, in places they grade into, and are interbedded with, the Peoria Loess which may, in part, represent finer materials blown from the Henry Formation.

The younger dunes occur on the large terraces at an elevation of 610 feet (186 m) at the extreme northeastern end of the county. They overlie, and were derived from, sandy materials of the Henry Formation. Small areas of these dunes are still active and subject to blowing.

River terraces

Flat or gently-sloping areas underlain by sand and silt of the Equality and Henry Formations occur low on the valley sides, next to the floodplains (plate 1). They represent former, higher levels of the valley floors and were deposited in ice-dammed lakes or by glacial meltwater streams. Subsequent erosion has removed most of this material, but remnants (terraces) can be found in many places (plate 1 and fig. 3). Though closely related to the floodplains, these terraces are above the reach of flood waters.

Terraces are recognized at several different elevations in Rock Island County. The highest terrace is the oldest, and successively lower terraces are successively younger. The highest and oldest terrace, at an elevation of about 650 feet (198 m), is composed of fine sand and silt and was the source for the oldest sand dunes in the county, described above. This terrace consists of two parts. The first, composed of fine sand, of the Equality Formation (Dolton Member, ed in plate 1) represents the floor of glacial Lakes Milan and Cordova which occupied the Rock and Mississippi Valleys upstream from Andalusia as the southeast-flowing Ancient Mississippi was dammed by westward-moving glacial ice (Shaffer, 1954; Anderson, 1967, 1968). This fine sand was deposited in slow-moving, ponded water. The other segment of the 650-foot (198 m) terrace (hm-d in plate 1) occurs downstream from the Andalusia spillway of Lake Milan, where sand, representing the Henry Formation (Mackinaw Member), was deposited by the more swiftly-flowing water of the outlet stream. Both of these terraces have a cover of wind-deposited fine sand (Parkland Sand) or silt (Peoria Loess).

A younger terrace at an elevation of 600 to 610 feet (183 to 186 m) (hm-c in plate 1) is widely distributed in the northeast half of the county, particularly in Cordova Township. This terrace, composed of sand, gravel, and silt of the Henry Formation, represents glacial outwash deposited somewhat later than the terraces at 650 feet (198 m). It is equivalent to the "lower terrace" of the Rock River valley (Anderson, 1967). The Erie Terrace (Anderson, 1967), at an elevation of 580 to 590 feet (177 to 180 m), is the youngest terrace in Rock Island County. It is similar in character and origin to the 610-foot (186 m) terraces, but is much less extensive (hm-e in plate 1).

Floodplains

Floodplains, the floors of valleys, are flat areas, found in all but the narrowest valleys of the county, and subject to flooding (plate 1 and fig. 10). They are underlain by the Cahokia Alluvium, composed of river-deposited clay, silt, sand, and minor amounts of gravel, which often contain a significant quantity of organic material. Among the varieties of Cahokia Alluvium, described previously, the channel and backswamp deposits, high in organic matter, occur in the lowest sections of the floodplain, in areas which are usually wet and which may be covered by standing water for weeks at a time. In many places, particularly on the Rock River floodplain, these areas are channels formerly occupied by the river and occasionally reoccupied during time of flood. Slightly higher, and consisting of silt and fine sand with a much lower content of organic materials, are the natural levee and braided stream deposits. These can be considered as types of "sand bars" which are submerged only during severe floods (figs. 9 and 10).

GEOLOGIC INFLUENCES ON LAND USE

Resources

Limestone

Limestone, principally calcium carbonate ($CaCO_3$), is a valuable resource, suitable for a variety of uses. Lamar (1961) lists 70 reported uses for limestone, but most of the limestone produced in Rock Island County is used for crushed rock, concrete aggregate, and agricultural lime, with a small amount used for riprap. Samples from Rock Island County have been reported as satisfactory for the manufacture of portland cement (Bleininger, Lines, and Lyman, 1912; Lamar et al., 1956), produced from limestone at Buffalo, Iowa, across the Mississippi River and two miles upstream from Andalusia. Similar to limestone is dolomite, principally calcium/magnesium carbonate ($CaMg(CO_3)_2$). Limestone and dolomite produced in Rock Island County in 1976 had a value of $3,077,724 (Samson and Dingwell, 1979).

Limestone in Rock Island County is derived from the Wapsipinicon and Cedar Valley Limestones of Devonian age, whereas dolomite is derived from rock of Silurian age (table 1). The distribution of these rocks is shown in plate 1 and figure 4, and the thickness of overburden in figure 5. Operating quarries are listed in table 5. The

Terrain	Topography	Earth materials	Resources: Mineral	Resources: Groundwater
Upland	Upland divides with only slight stream dissection; relief less than 50 feet (15 m) except in places on the Coe Upland	Peoria Loess at surface, generally more than 20 feet (6 m) thick; Glasford (Kellerville Till Member) and Banner Formations lie beneath the Peoria and are in turn underlain by the bedrock sequence; in many places in the Coe Upland the Pennsylvanian is absent and surficial deposits lie on Silurian or Devonian.	Clayey portions of the Peoria Loess have been used for brick manufacture in the past; potential small at present. Loess is used as source of silica in cement manufacturing at Buffalo, Iowa, across Mississippi River from Andalusia, Illinois.	Some domestic supplies from Quaternary and Pennsylvanian. Most wells completed in Silurian at depths ranging from a few feet in north to 400 feet (122 m) in SE. Deep aquifers yield municipal and industrial supplies.
Steep valley sides	Valleys and ravines separated by narrow divides; much of the area is wooded; relief 75-175 feet (23-53 m).	The following rock units are encountered from hillcrest to valley floor: Peoria Loess, Glasford (Kellerville Till Member) and Banner Formations, Pennsylvanian shale and sandstone; Devonian limestone lies at valley floor level in places. South and west of Rapids City hillsides are composed primarily of loess overlying glacial till; in places Pennsylvanian shale is exposed beneath the loess. North and east of Rapids City hillsides are composed primarily of Peoria Loess; Silurian dolomite is encountered near the base of the valley sides upstream from Rapids City and along the northern margin of the Coe Upland.	Clayey portions of the loess have been used for brick manufacture in the past; potential small at present. Pennsylvanian shale has been used for brick and pottery manufacture in the past; coal; limestone; dolomite.	Most wells completed in Silurian at depths ranging from a few feet in the north to 400 feet (122 m) in the south. Deep aquifers yield municipal and industrial supplies.
Sand dunes	Irregular topography with knobs and closed depressions.	Fine-textured Parkland Sand lying on Peoria Loess or sand and gravel of the Henry Formation (Mackinaw Member) or fine sand of the Equality Formation (Dolton Member).	Fine-grained sand for construction aggregate and fill; natural bonded molding sand.	In the extreme western end of the county, domestic and municipal supplies come from Silurian dolomite at depths of about 300 feet (90 m). This aquifer is less than 100 feet (30 m) deep on the north edge of the Coe Upland, but more than 200 feet (61 m) deep over the bedrock valley immediately north. In the latter area, abundant ground water is available from thick sand and gravel in the underlying Henry Formation (Mackinaw Member). Shallow, driven wells will yield modest supplies over most of this area.
River terraces	Areas of low relief lying along and within river valleys and from 10 to 30 feet (3-9 m) above the level of the floodplain.	Primarily sand; silt and clay present in places, mainly along tributaries such as Mill Creek and Copperas Creek; Henry Formation (Mackinaw Member).	Fine to medium sand for construction aggregate and fill; natural bonded molding sand.	Adequate farm and municipal supplies can usually be obtained from the underlying Silurian dolomite aquifer at depths less than 200 feet (61 m).
Floodplains	Low elevation and low relief	Cahokia Alluvium ranging from pebbly sand to clay and muck lying on bedrock at depths less than 50 feet (15 m) except in the extreme west end of the county where bedrock lies between 50 and 100 feet (15 and 30 m) deep and the northern end where bedrock is in excess of 100 feet (30 m) deep. In these areas, the Cahokia Alluvium rests on sand and gravel of the Henry Formation.	Sand and gravel for construction aggregate and fill; limestone and dolomite for construction aggregate, agricultural lime, portland cement.	Adequate farm and municipal supplies can usually be obtained from the Silurian dolomite aquifer at depths less than 200 feet (61 m).

Soil	Construction conditions	Waste-disposal conditions: Individual seepage	Waste-disposal conditions: Landfill	Uses for recreation
Productive; Fayette, Muscatine, Sable, Sylvan, Tama Series.	Loess will provide adequate bearing strength for most construction if provision is made to avoid saturation. Erosion problems in exposed cuts—piping and siltation common; slumps in improperly drained cuts. Ground subsidence is possible over mined-out areas.	Low infiltration rates, absence of shallow aquifers gives little chance for ground-water contamination, except in northern upland where Silurian dolomite is close to the surface.	Low permeability and low water table levels provide satisfactory landfill sites except in northern upland where Silurian dolomite is close to the surface.	Narrow upland divides, not efficiently farmed, provide flat recreational sites adjoining steep, wooded bluff areas.
Low to moderate productivity; too steep to cultivate in places; Coatsburg, Fayette, Hickory, High Gap, Sylvan, Velma Series.	The presence of water-saturated clayey materials on steep slopes promotes instability; provision for drainage may aid stability. Where Silurian dolomite lies at the surface, low on the Mississippi valley walls upstream from Rapids City, foundation conditions are excellent.	Low infiltration rates and steep slopes provide high potential for contamination of surface water, especially where glacial till and /or Pennsylvanian shale lie at shallow depth, south and west of Rapids City. Where Silurian dolomite lies at shallow depth, particularly north and east of Rapids City, contamination of shallow ground water is possible.	Discharge of leachate from the base of the Peoria Loess and from the base of the Glasford Formation (Kellerville Till Member) where it lies on Pennsylvanian shale will promote contamination of surface water. The use of excavations extending downward close to the top of the Silurian dolomite may result in contamination of shallow ground water. Use of abandoned quarries in Silurian dolomite may also result in contamination of shallow ground water.	These steep, wooded slopes are best left in their natural state, as forest preserves. Artificial lakes relatively easily constructed.
Moderately productive; Dickinson and Sparta Series; subject to blowing and wind drifting; droughty.	Good drainage and adequate bearing strength for most construction. Rapid erosion rates in exposed cuts; siltation and piping are common.	High permeability and low relief make contamination of surface water unlikely. Shallow ground water may be affected where Silurian dolomite lies close to the surface.	High permeability may cause contamination of shallow ground water, especially where Silurian dolomite is close to the surface.	Some tracts of uncultivated dunes display unusual plant and animal communities.
Moderately productive; Raddle and Joslin Series.	Sand provides good drainage and adequate bearing strength for most construction. Areas of silt or clayey silt may become unstable unless adequate drainage is provided.	High permeability and low relief make contamination of surface water unlikely. North of Rock River these deposits commonly rest on Devonian or Silurian bedrock at shallow depth, hence contamination of this aquifer is possible.	High permeability and low relief make contamination of surface water unlikely. Contamination of Silurian aquifer possible north of Rock River where Devonian and Silurian underlie these deposits at shallow depth.	Limited possibilities; provide flat areas at foot of wooded slopes and above floodplain which are suitable for picnic and play areas in forest preserves.
Moderately to highly productive; mixed alluvial land, Sawmill and Orion Series; subject to flooding in places.	Compressible materials, high water table, and periodic flooding present excavation problems. Where limestone or dolomite bedrock lies near the surface, foundation conditions are good; although sinkholes and channels filled with Pennsylvanian shale are common.	High water table and variable permeability; contamination of surface water and shallow ground water is possible; periodic floods.	High water table, periodic floods, and shallow bedrock make these undesirable areas for landfill.	Water-based recreation. Wooded areas provide cover for game: deer; rodents, water fowl.

Figure 10. Aerial view of Barstow, looking northwest, April 27, 1973. River bars stand above flood level, whereas abandoned river channels and low areas between bars are inundated. For explanation of symbols see legend of plate 1.

location of both operating and abandoned quarries is shown in plate 1.

Sand and gravel

Sizable quantities of common sand and gravel are produced in Rock Island County for fill and for aggregate for concrete construction. The county formerly was a major producer of natural-bonded molding sand (Busch, 1972; Littlefield, 1925).

Sand and gravel occurs in the Cahokia Alluvium and in the Henry Formation (Mackinaw Member). The 610-foot (186 m) terrace at the northeastern end of the county, for example, is underlain by more than 50 feet (15 m) of gravelly Henry Formation. This deposit is virtually unexploited, but it appears to be an important resource for future development. The material consists primarily of pebbly, medium-grained sand from which the gravel fraction can be extracted by screening. The Erie Terrace, at an elevation of 580 to 590 feet (177 to 180 m) and the terrace at 650 feet (198 m) elevation also consist of pebbly sand, but it is generally finer grained and less extensive than that in the 610-foot (186 m) terrace. In addition to being produced from the Cahokia Alluvium and Henry Formation, sand is also produced from the Equality Formation and from the Parkland Sand, which contain no gravel and include beds of silt in places. The distribution of these formations and the location of operating and abandoned sand and gravel pits are shown on plate 1. Inasmuch as the floodplains are underlain primarily by Cahokia Alluvium and by the Henry Formation, in these areas the thickness of the unconsolidated deposits, as shown in figure 5, is essentially the combined thickness of these gravel-bearing formations. In general, these deposits are coarsest in the larger valleys and consist primarily of silt and clay in the smaller tributary valleys. Operating sand and gravel pits are listed in table 6.

Clay and shale

Although clay products are not presently being manufactured in Rock Island County, brick, drain tile, and stoneware have been produced at several locations in the past (Purdy and DeWolf, 1907; Rolfe and others, 1908; Lines, 1917; Savage and Udden, 1921; Parmelee and Schroyer, 1922); the potential for such an industry still exists (White and Lamar, 1960; Parham, 1961).

TABLE 5. Operating limestone and dolomite quarries in Rock Island County

Name of quarry	Producer	Town near operation	¼	¼	Sec.	Town-ship	Range	Age of rock
Midway	Midway Stone Company	Hillsdale		SW	16	18N	2E	Silurian
Cordova	Cordova Quarry Inc.	Cordova	NW	SE	1	19N	1E	Silurian
Milan	Collinson Stone Co.	Milan	E½	NW	25	17N	2W	Devonian
Vandruff Island	Allied Stone Co.	Milan		SE	14	17N	2W	Devonian

TABLE 6. Operating sand and gravel pits in Rock Island County.

Name of pit	Producer	Town near operation	¼	¼	Sec.	Township	Range
Albany	Moline Consumers Co.	Albany		SW	34	21N	2E
Barstow	General Sand and Gravel Co.	Barstow		NE	34	18N	1E
Big Island	General Sand and Gravel Co.	Milan			16	17N	2W

Chemical and spectrochemical analyses of many of these clays have been compiled by White (1960). Claystones of Pennsylvanian age, which lie directly below beds of coal, particularly the Rock Island Coal, are the most important sources of clay in Rock Island County (Lines, 1917; Parham, 1961). Several claystones in the county are suitable for stoneware, structural clay products, sewer pipe, drain tile, flowerpots, and art pottery (Parham, 1961). In addition, some Rock Island County clay is suitable for producing lightweight aggregate (White, 1960). In places, loess and alluvial clay have been used as raw material, often mixed with Pennsylvanian claystones (Savage and Udden, 1921). The distribution of Pennsylvanian rock is shown in plate 1 and figure 4.

Coal

Coal has been mined in Rock Island County for local use since its earliest settlement (Worthen and Shaw, 1873), but the thin, discontinuous character of the coal beds has precluded extensive mining (Savage and Udden, 1921; Cady, 1952). Nevertheless, numerous small underground mines in the Rock Island (No. 1) Coal Member operated in the area around Coal Valley and in the southeastern portion of the Moline Upland (plate 1). The Rock Island Coal, the basal member of the Spoon Formation (Kewanee Group), is normally only a few inches thick. However, reserves up to 96 inches (244 cm) thick are known to occur in lenticular bodies, somewhat elongate in plane view (Cady, 1952).

No operating mines have been reported in Rock Island County since 1948; however, approximately 3,846,000 tons (3,488,000 metric tons) of coal were mined prior to this date. Total in-place coal reserves of the Rock Island Coal, in beds greater than 28 inches (71 cm) thick, have been estimated at 62,133,000 tons (56,355,000 metric tons) (Cady, 1952). Searight and Smith (1969) mapped 42 million tons (38 million metric tons) of strippable reserves of the Rock Island Coal 18 inches (46 cm) or greater in thickness and less than 150 feet (46 m) in depth. Several other Pennsylvanian coal seams in the report area attain a thickness between 18 and 48 inches (46 and 122 cm); however, data on these deposits are insufficient to estimate reserves (Searight and Smith, 1969).

Oil and gas

The possibility of discovering commercial oil and gas reservoirs in Rock Island County is considered remote, since Rock Island County lacks the system of rocks (Mississippian) that contains most of the oil reservoirs in Illinois. Furthermore, in Rock Island County the other systems of rocks (Pennsylvanian, Devonian, Silurian, and Ordovician) that elsewhere in Illinois contain some oil reservoirs are at relatively shallow depth and contain fresh water.

No known structures within the bedrock offer promise for developing storage reservoirs for natural gas. However, since not much drilling has been done, it would be presumptuous to make any definite conclusions about potential structure for gas storage.

Water

In 1968, the total water use in Rock Island County, excluding industrial use not derived from a municipal system, was estimated at 18,808,000 gallons per day (gpd) (71,196 m^3/day) (Brueckmann and Bergstrom, 1968). The Mississippi River, from which water for the communities of Rock Island, Moline, East Moline, and Hampton is derived, supplied 16,566,000 gpd (62,709 m^3/day), 88 percent of the total. The amount of water available can be determined from the records of stream gages maintained by the U.S. Geological Survey. Pertinent records for Rock Island County are summarized in table 7. The average discharge of the Mississippi River at the upper end of Rock Island County is reported to be 46,820 cubic feet per second (cfs) (1,325 m^3/s), or 6,912,000,000 gallons per day (26,165,000 m^3/day). Thus the daily use of Mississippi River water in Rock Island County amounts to about 0.24 percent of the total available under average flow conditions. Of course, much of this is returned to the river as sewage effluent. Analyses of untreated water at East Moline between 1959 and 1964 show total dissolved solids ranging from 189 to 264 parts per million (ppm) and the average monthly coliform index ranging from 9,448 to 60,233 (Bi-State Metropolitan Planning Commission, 1970). The latter increased steadily during the period of record.

The increasing demand for water-based recreation has, in turn, led to the construction of many artificial lakes and ponds. Rock Island County offers numerous potential reservoir and dam sites, particularly in the western part of the county, because of its topographic relief—steep-walled valleys and tight, impermeable materials (Smith, 1966). Care must be taken, however, to assure that the dam is sited on materials strong enough to support it and that the reservoir has sufficient catchment area and stream flow to maintain the desired water level against loss of seepage and evaporation. Glacial till, provided it contains no sizeable quantities of sand or gravel, and unweathered Pennsylvanian shale are the best materials upon which to develop a reservoir in Rock Island County. Dawes and Terstriep (1967) have identified eight potential reservoir sites of 40 acres (16.2 ha) or more in the county (fig. 3).

Although the Mississippi River is the major source of municipal water supply in Rock Island County, ground water, obtained from wells by pumping, constitutes the only available source for rural areas and for most communities outside the immediate Quad-Cities metropolitan area. In 1968 this consumption was estimated at 2,252 million gpd (8.5 million m^3/day) (Brueckmann and Bergstrom, 1968). Most of this water is obtained from cracks and crevices in the upper 125 feet (38 m) of the Silurian

TABLE 7. Stream gage records from Rock Island County (U.S. Geological Survey, 1976)

Gage	Discharge area (sq. mi.)	Length of record	Daily discharge (CFS)[a] Average	Maximum	Minimum	Flow exceeded 90% of time (CFS)	Flow exceeded 50% of time (CFS)	Gage datum (ft above sea level)
Mississippi River at Clinton, Iowa (at Comanche, Iowa)	85,600	June to Aug. 1873; Oct. 1873 to present	46,890	307,000 4/28/65	6,500 12/25-27/33	Not available		562.68
Rock River near Joslin	9,520	Oct. 1939 to present	5,288	46,200 3/22/48	834 1/3/40	165[bc]	345[bc]	564.06
Mill Creek at Milan	62.5	Oct. 1939 to Sept. 1940 (fragmentary); July 1941 to present	40.4	9,060 4/24/65	No flow at times in 1940-1941, 1953-1957	2.4[b]	14.4[b]	566.23

[a]Records through September 1970; cfs = cubic feet per second

[b]Data from Mitchell, 1957

[c]For Rock River at Como

dolomite, encountered at depths which range from a few feet in the northern part of the county to about 400 feet (122 m) in the southeast. In addition, the deep aquifers, the Glenwood-St. Peter, Eminence, and Ironton-Galesville Formations (table 1), have supplied water for municipal and industrial purposes from depths of 1,100 to 2,100 feet (335 to 640 m). At one time wells located on the floodplains and completed in the deep aquifers flowed under artesian pressure (Udden, 1896; Pratt, 1883). Continued withdrawal of water has reduced the hydrostatic pressure, so that artesian flow no longer occurs in Rock Island County. Analyses of public water supplies from Devonian and Silurian rocks in Rock Island County average 329 parts per million (ppm) total dissolved solids, whereas the deep well at Carbon Cliff, producing from the Galena-Platteville and Glenwood-St. Peter, shows 1,707 ppm total dissolved solids (Brueckmann and Bergstrom, 1968).

Sand and gravel aquifers in the glacial deposits occur at many places in Rock Island County, but generally they are of limited extent and yield only small quantities of water. The Ancient Green River valley beneath the upland in the south-central part of the county, for example, appears to contain only small amounts of sand and gravel and is not an important source of shallow ground water. It has not been adequately explored, however; hence it is possible that at least modest quantities of ground water may be recovered from this source in the future. In contrast the buried valley at the northeastern end of the county (fig. 4) contains thick and extensive sand and gravel deposits which, though largely unexploited, could yield substantial quantites of water. Sandstones within the Pennsylvanian sequence yield water limited in both quantity and quality; they are not considered favorable aquifers.

Soil

The soils of Rock Island County are suitable for a variety of agricultural purposes—the raising of corn, soybeans, and livestock being most important. However, steep slopes and generally acid soils over much of the county make careful soil management necessary to achieve maximum productivity and to reduce soil erosion. The soils of Rock Island County have been grouped into eight "associations," or landscapes that have distinctive assemblages of soils (fig. 11) (Rehner, 1977). They normally consist of one or more major soils and at least one minor soil and are named for the major soils. Their characteristics are summarized in table 8.

The Fayette-Sylvan-Hickory association, upland soils developed on loess and glacial till, is the most extensive in the county and occurs on 41 percent of the area (table 8). The Muscatine-Tama association is also found in upland locations, is developed in loess, and covers 15 percent of the county. Bottomland, or floodplain, soils are included in the Sawmill-Coffeen and Raddle-Joslin associations and constitute about 24 percent of the total area. Thus, the major upland and floodplain soil associations cover about 80 percent of the county.

The engineering properties of the soils of Rock Island County are summarized by Rehner (1977).

Waste disposal

The conditions for solid-waste disposal in Rock Island County are summarized in table 4. Many factors in addition to geology, such as cost of land and distance of transport of refuse, must be considered when evaluating solid-waste disposal sites (Hughes, Landon, and Farvolden, 1971; Hughes, 1972). This report considers only geologic factors, whose importance may be outweighed by other, primarily economic, factors. The natural conditions for solid-waste disposal are shown on plate 3.

Contamination from a sanitary landfill results largely from the production of leachate, water mineralized by contact with refuse. Thus, the potential of a landfill site for creating pollution is determined largely by its hydrogeology, the relationship of the underlying earth materials to the flow of subsurface water. In short, a landfill must be sited and operated in such a way that pollution of surface and subsurface water by leachate is either avoided or reduced to acceptable levels. The most favorable hydrogeologic conditions are at sites in materials of low permeability above the zone of saturation. Probably all upland areas underlain by Pennsylvanian bedrock satisfy these requirements in Rock Island County (plate 3). Even where the water table is high and the landfill lies within the zone of saturation, the possibility of contamination of surface and ground water is low because of the low permeability of the earth materials. In upland areas in the northeastern part of the county, where glacial till is thin and the Pennsylvanian rocks are absent, the risk of contamination of the Silurian dolomite aquifer is high. Landfills in the nearby sandy terraces also have a high risk for contamination of ground water. Landfills in terraces underlain by Pennsylvanian bedrock appear to pose little threat to either surface or subsurface water supplies. Likewise, landfills near the rivers on floodplains are usually no threat to ground-water supplies because these are areas of ground-water discharge. Such sites must be protected from flood waters, however, and the seepage of leachate into the river must be avoided. Since the details of ground-water movement in Rock Island County are unknown, sanitary landfill should be avoided in areas where the Devonian and Silurian are close to the surface (plate 3).

Individual septic systems are subject to the same geologic constraints as those for solid-waste disposal. These are summarized in table 4.

Disposal of liquid wastes into specially constructed deep wells has been considered by some industries as an alternative to surface disposal. In Rock Island County, however, the conditions for such wells are marginal at best, inasmuch as most formations which might be considered as

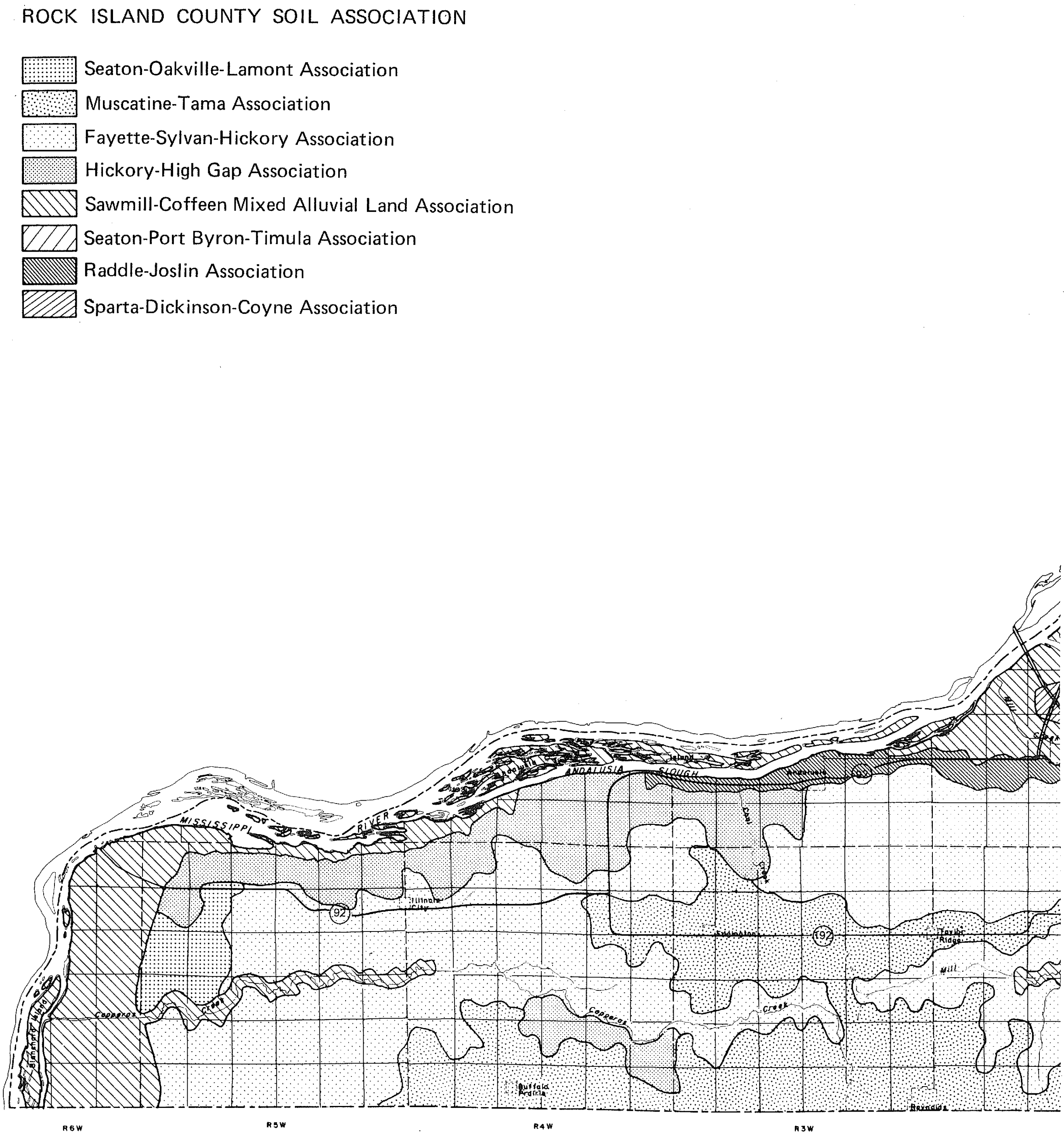

Figure 11. General soil map of Rock Island County, Illinois, (Rehner, 1977).

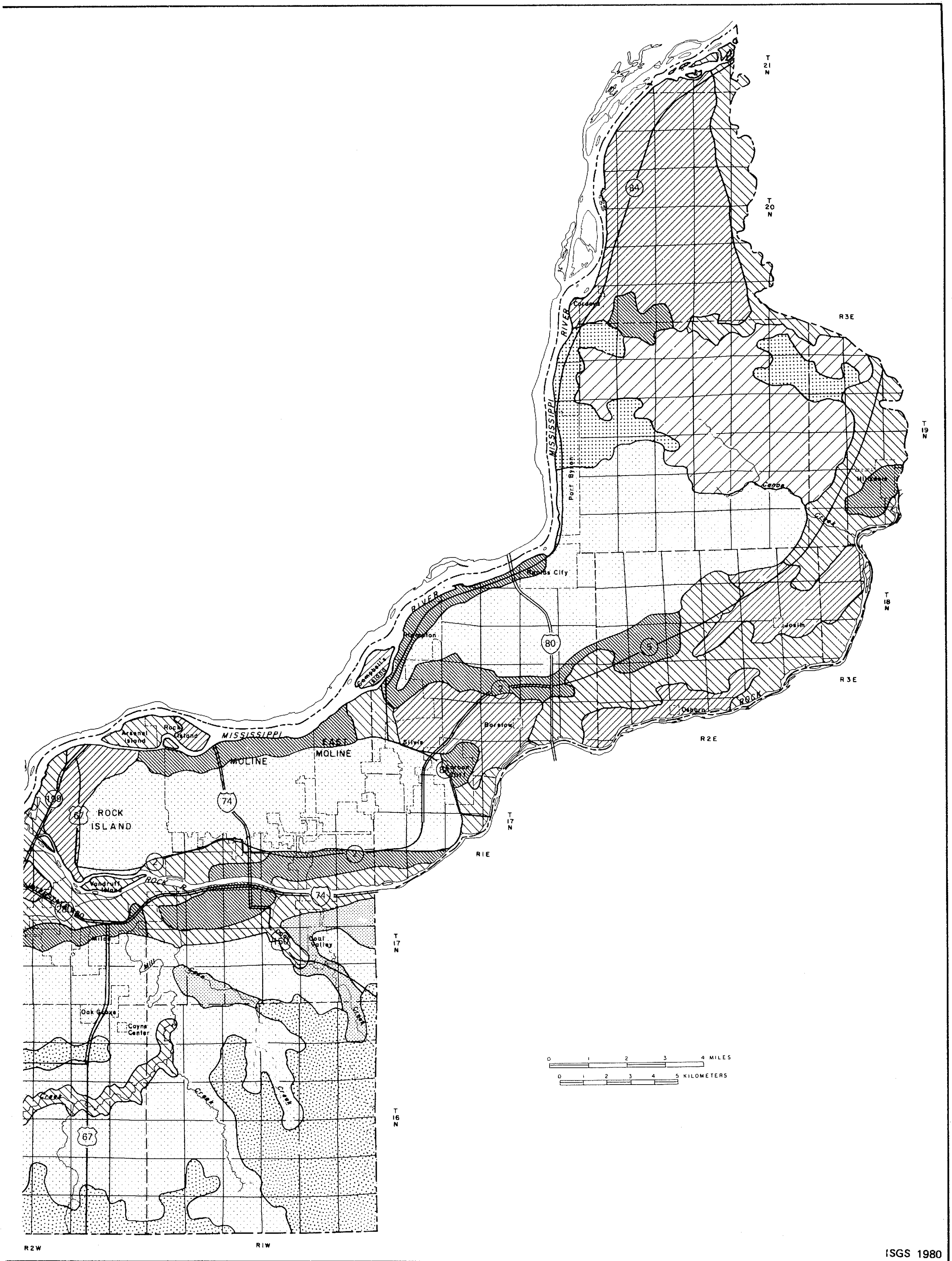
T 21 N
T 20 N
T 19 N
T 18 N
T 17 N
T 16 N
R3E
R2E
R1E
R2W
R1W
MISSISSIPPI RIVER
Cordova
Port Byron
Rapids City
Hampton
Barstow
Silvis
Osborn
Joslin
Hillsdale
ROCK ISLAND
MOLINE
EAST MOLINE
Arsenal Island
Rock Island
Milan
Oak Grove
Coyne Center
Coal Valley
84
80
74
67
0 1 2 3 4 MILES
0 1 2 3 4 5 KILOMETERS
ISGS 1980

TABLE 8. Characteristics of soil associations in Rock Island County (Rehner, 1977)

Association	Topographic position	Drainage	Parent material	Area of county (% of total)	Crops	Remarks
Fayette-Sylvan-Hickory	Gently sloping to very steep in uplands and valley sides	Good to moderately good	Loess and glacial till	41	Mostly corn, but also soybeans, small grains, clovers and alfalfa	Contains most of the urbanized area of the county
Muscatine-Tama	Nearly level to strongly sloping in uplands and valley sides	Good to somewhat poor	Loess	15	Corn and soybeans	
Hickory-High Gap	Moderately steep to very steep on valley sides	Good to moderately good	Glacial till and shale	4	Pasture and woodland	
Seaton-Oakville-Lamont	Gently sloping to very steep uplands and valley sides	Good	Loess and sand	2	Corn	
Seaton-Port Byron-Timula	Nearly level to steep on uplands and valley sides	Good to moderately good	Loess	5	Corn	
Sawmill-Coffeen mixed alluvial land	Nearly level on floodplains	Good to poor	Sandy, silty, clayey alluvium	20	Corn and soybeans	Subject to flood
Sparta-Dickinson-Coyne	Nearly level to strongly sloping on terraces	Good to excessive	Sand	8	Corn and soybeans	Irrigated in places
Raddle-Joslin	Nearly level to moderately sloping on terraces	Good to moderately good	Sandy, silty, clayey alluvium	4	Corn and soybeans	

disposal zones either contain potable ground water or are not protected by suitable confining beds. Bergstrom (1968) discusses the geologic and hydrologic feasibility of disposal wells in Illinois.

Construction conditions

Unstable earth materials

The geologic materials in Rock Island County provide adequate foundation for most types of construction, but problems are consistently encountered in certain situations. The geologic conditions affecting general construction in Rock Island County are summarized on plate 3.

The steep valley sides tend to be unstable where glacial till and/or Pennsylvanian shale underlies the loess. These materials not only are incoherent and weak but are often saturated with water so that their strength is greatly reduced. Since each member of the loess-till-shale sequence is less permeable than the one above, downward-percolating water tends to collect at the top of each of these units; hence the material above the contact becomes saturated and the water moves laterally, often reappearing at the surface as seeps or springs along valley sides. Repeated freezing and thawing during the late winter and spring, when water content is high, adds to the instability of such locations (fig. 12).

Man may inadvertently aggravate this inherent instability by excavating at the base of the slope, thus removing support for materials above, or by overloading the slope by building structures or placing fill on it which exceeds the bearing strength of the material. Likewise, any circumstance which increases the water content of this material—such as increased precipitation or surface drainage, leaky water or sewer lines, lawn watering, or septic systems—increases the instability of the slopes. It should be emphasized, however, that gravity-induced movement on slopes is a natural process and will take place wherever the necessary conditions prevail. Moreover, slopes which appear firm and stable during a dry season may become

Figure 12. Cut bank along Case Creek, SE¼ NE¼ Sec. 30, T. 17 N., R. 1 W., Rock Island County, showing Lacon Formation (slump). The slump consists of recognizable Cahokia Alluvium and Pennsylvanian shale. The entire block extending from the foreground to the scar just beyond the figures in the upper right has moved toward the creek and has broken into numerous smaller pieces. Arrows show movement of the block. Photo taken December 20, 1971.

mobile and unstable during a wet season (DuMontelle and others, 1971). The telltale signs of instability on slopes are: surface irregularities, slump scars, lobes of debris at the foot of slopes, and tilted trees and structures. These relationships are clearly shown in figure 12 where the hillside has failed due to weak materials, excessive ground water, and undercutting of the slope by the nearby stream. Even in these places, however, movement is periodic, occurring primarily in early spring. Construction on valley sides can safely be made only if these potential problems are recognized so that the structure can be designed to overcome them.

Several types of problems can be anticipated when floodplains are used for construction in Rock Island County: (1) the site may be subject to floods; (2) excavation may encounter bedrock at shallow depth, thus requiring blasting; (3) the limestone which underlies the floodplain in many places, though itself an excellent foundation material, is honeycombed with channels, caves, and sinkholes which are filled with weak Pennsylvanian shale, thereby creating abrupt changes in foundation materials which can often be detected only by closely-spaced borings; (4) the alluvium of the floodplain, particularly the channel and backswamp deposits, often contain compressible organic materials—peat and muck—which do not provide adequate bearing strength for many types of construction.

Underground coal mines pose some land-use problems. For example, in the late summer or fall of 1964 rapid subsidence produced a roughly circular hole 30 to 40 feet (10 to 13 m) in diameter and up to 12 feet (4 m) deep in a hillside corn field about 2 miles (3 km) south of Coal Valley (SW¼, Sec. 10, T. 16N., R. 1W.). The cause of this subsidence is unknown. Existing maps do not show underground coal mines at this location, but mines may exist which have gone unrecorded. An almost exact repetition of this subsidence occurred in mid-August, 1976, in Henry County, 3 miles (4 km) north of Osco (Sec. 9, T. 16N., R. 2E.).

Upland sites, on loess, usually present no problems to construction if provision is made to keep the loess unsaturated. Deep excavations may encounter water-saturated material near the base of the loess.

Several upland areas have been undermined for coal in the vicinity of Coal Valley (plate 1). The potential for land subsidence exists in these areas, but none has been reported to date.

The effect of earthquakes is given little consideration in design and construction in the north-central United States because this is an area of low seismicity. Earthquakes in northern Illinois have been infrequent and nondestructive (Heigold, 1972). The nearest source of large earthquakes lies 400 miles (644 km) to the south, in extreme southeastern Missouri and adjacent areas, but it has produced no major earthquake since 1811-1812. Though the potential for earthquake damage in Rock Island County exists, it is small.

Floods

Floods are a frequent threat to the floodplain areas. Serious floods have occurred in the past, and there is no reason to suppose that damaging floods with stages higher than any thus far experienced will not occur in the future. The limit of the "standard project flood" which is "an estimate of the reasonable upper limit of possible flood flows" (Corps of Engineers, 1969a, 1969b), is shown on plate 3. It is larger than any recorded flood, having a recurrence interval of more than 100 years, but it could occur any year. In addition, the Illinois Department of Transportation (1978) has prepared detailed maps of the Rock River floodplain below the mouth of the Green River showing the extent of the "regulatory floodplain," the area which would be covered by the "regulatory flood." "The regulatory flood is that flood with an estimated one percent chance of being equalled or exceeded in any given year" (Illinois Department of Transportation, 1978).

The most damaging floods along the Mississippi River usually occur in March and April, when warmer temperatures, often accompanied by rain, cause rapid melting of snow within the drainage basin. This was the case during the record flood of 1965 when the Mississippi River rose to a stage of 22.48 feet (6.85 m) on April 28 at Lock and Dam 15 at Rock Island, 7.48 feet (2.28 m) above flood stage. The Quad-City metropolitan area, including the portion of Iowa, suffered $12 million in damage and 12,000 people were driven from their homes (Anderson and Burmeister, 1970).

The Rock River below Joslin is particularly susceptible to ice-jam floods which may occur at any time during the cold season, most often between the early part of January and the end of April. The duration of these floods ranges from a few days to as long as a month (Corps of Engineers, 1969a, 1969b). Although the smaller streams rise in response to floods in the larger streams to which they are tributary, they are also directly and immediately affected by intense thunderstorm rains of short duration which may cause flash floods, usually during the warmer part of the year. Such floods may cover the entire floodplain of the tributary stream, but they usually are of short duration, a few hours to a few days. Nevertheless, where development has taken place on the floodplain, even these minor floods can result in sizable property damage. The lower reaches of Mill Creek on the east side of the village of Milan is a prime example, though complicated somewhat by its position on the Rock River floodplain and by modifications of the stream at the time the Illinois and Michigan canal was built.

Recreation

The Mississippi and Rock Rivers, extensive bottomland (subject to flood and hence best left in open space), and steep, wooded bluffs provide opportunities for a variety of outdoor recreational activities. In addition, topographic and geologic conditions are favorable in the southwest upland for the building of earthfill dams and artificial lakes for recreational purposes (Hanson, Healy, and Dondanville, 1968). The needs and potential of the area for outdoor recreation and open space have been studied in detail, and recommendations have been proposed by the Bi-State Metropolitan Planning Commission (1968).

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